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Productivity, water use and quality of onion (*Allium cepa*) seed production under different irrigation scheduling through drip

S.K. DINGRE[1], D.D. PAWAR[2] AND K.G. KADAM[3]

Mahabma Phule Krishi Vidtyapeeth, Rahuri, Maharasthra 413 722

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ABSTRACT

A field experiment was conducted for three consecutive years from 2008 to 2010 to study the different irrigation scheduling through drip irrigation for onion (*Allium cepa* L.) seed production. The experiment comprised of twelve treatments under drip method of irrigation with combination of three irrigation regimes viz. 75 %, 100 % and 125 % of cumulative pan evaporation (CPE) and four irrigation intervals viz. 1, 3, 7, and 10 days and conventional irrigation at 50 mm CPE as an control treatment. The study showed that drip resulted into 41 to 62 % water saving with 4 to 26 % increase in yield of onion seed as compared to surface irrigation. The growth and yield attributes in drip irrigated treatments showed decreasing trend with increase in irrigation interval and CPE. When drip irrigation applied daily at 100 % of CPE, the yield increased upto 26 % as compared to control. These results were on par with drip irrigation applied daily and at every 3 days with 75 % of cumulative pan evaporation (CPE) with 20-24 % increase in yield as compared to seed yield obtained from surface irrigation at 50 mm CPE. The application of drip at 7 days interval did not increase the seed yield whereas, drip at 10 days interval resulted into 14 % reduction in yield as compared to surface irrigation yield. The water use efficiency was found maximum (16.9 kg/ha/cm) in drip irrigation with 75 per cent of cumulative pan evaporation (CPE) at 3 days interval. The economics revealed that higher benefit: cost ratio was obtained under drip irrigation at daily and 3 days application. The drip application at every 3 days interval with 75 % CPE was found to be optimum and effective for growth, yield, and quality as well as economically viable for onion seed production.

Key words : Cumulative pan evaporation, Drip irrigation, Irrigation interval, Onion seed, Water use efficiency

In India, onion is grown over an area of 0.95 million ha, producing about 12.16 million tonnes of bulbs. The average yield of onion in India is about 12.8 t/ha, which is utilized for local consumption as well as export. Among the onion producing states, Maharashtra is the leading state with an area of 0.20 million ha and 3.15 million tonnes of production. In spite of large area under cultivation/ha productivity of onion in India is very low when compared with the global average of 17.2 t/ha (Anonymous, 2010). With increase in area under onion cultivation, the demand for seed has also increased tremendously. As per the estimates of National Seed Corporation, India needs about 4,000 tonnes of certified seed of onion/year while the yearly production of onion seed is about 600 tonnes (Singh, 2003). There is a wide gap between demand and production of onion seed. Therefore, it is essential to boost up the good quality onion seed production to bridge the gap between production and demand. Onion crop is very sensitive to irrigation, since it has got relatively shallow root zone and requires more frequent irrigation. The low yields of such a valued crop could also be attributed to surface irrigation method predominantly adopted by farmers. Micro- irrigation with limited water application seems to be a better alternative to improve onion seed production with reduced water (Bekele and Tilahub, 2007). Among various factors responsible for higher seed yield, the irrigation quantity and method of irrigation plays a pivotal role in enhancing the growth and productivity of onion (Tomar *et al.* (2004). The water requirement for onion seed is reduced to the extent of 39.88% when irrigation is applied by drip as compared to conventional surface methods (Bhakare *et al.* 2008). However, research studies on standardization of schedule for drip irrigation in onion seed production are meager. Thus, it was attempted to assess the effect of irrigation scheduling through drip on onion for seed purpose.

[1]Corresponding author email: sachindingre@rediffmail.com
[1]Assistant professor of irrigation & Drainage Engineering;
[2]Professor and Head, Inter-Faculty Department of Irrigation Water Management; [3]Associate Professor of Horticulture

MATERIAL AND METHODS

A field experiment was conducted to study the effects of different irrigation schedules through drip irrigation for onion seed production at Mahatma Phule Krishi Vidyapeeth, Rahuri, during three consecutive rabi seasons of 2008, 2009 and 2010. Agroclimatically, the area falls under the water scarcity zone of Maharashtra with annual average rainfall of 520 mm, which is mostly erratic and uncertain in nature. The soil texture of experimental plot was sandy clay loam having 17.28% coarse sand, 38.57% fine sand, 22.14% silt and 23.54% clay. The soil was slightly alkaline in nature with pH of 7.93 and electrical conductivity was 0.06/dSm. The bulk density of soil was 1.47 g/cm^3. The soil was low in available N (143 kg/ha) and P (11.8 kg/ha) and high in available K (255.3 kg/ha) content. The soil was having good drainage with moisture contents at field capacity (FC), permanent wilting point (PWP) and available soil moisture as 30.32, 13.37 and 16.95 %, respectively.

The planting of onion bulb 'N-2-4-1' was done on raised beds with 1.20 m top width & 1.50 bottom width and on each bed four rows of onion bulbs were planted at a spacing of 30 cm. The spacing between two bulbs in a row was also kept as 30 cm. The recommended fertilizer dose 100:50:50 NPK, kg/ha was applied. The basal dose of phosphorous, potassium and half dose of nitrogen (through soil) were applied at the time of planting. The field experiment was conducted in a randomized block design (RBD) with thirteen treatment combinations replicated thrice. The main plot treatments comprised of three depths of irrigation viz. 75, 100 and 125% of cumulative pan evaporation values. The four sub-plot treatments comprised of different irrigation intervals viz. daily, every 3, 7 and 10 days. The surface irrigation was also included in the experiment as control. The irrigation was applied as per treatment on the basis of climatological approach. The daily pan evaporation data was recorded from USWB class A Pan. The quantity of water applied through drip irrigation as per treatment was calculated by the formula (Doorenbos and Pruitt 1976).

$$ET_c = Ep \times Kp \times Kc \quad \text{.....(1)}$$

$$V = \frac{ET_c \times Wa}{E} \quad \text{.....(2)}$$

Where,

ET_c = Evapotranspiration of onion (seed); E_p = Cumulative pan evaporation (mm); K_p = Pan coefficient (0.7), K_c= Crop coefficient (Allen *et al.* 1994); V = Crop water requirement/emitter; W_a = Wetted area = Πr^2; r = Radius of wetting front of dripper (35 cm); E=Efficiency of the system (91%).

The single 16 mm lateral with inbuilt dripper was laid in between four rows of planted bulbs. The spacing between two adjacent laterals and emitter within plot was 1.50 m and 0.5 m, respectively. The average emission uniformity of drip irrigation system was estimated as 91 per cent for all treatments. In surface irrigation, 5 cm depth of irrigation was applied at 50 mm cumulative of pan evaporation using the relationship given below (Michel 2008).

Net depth of irrigation = (FC-PWP)/100 × Bulk density × root zone × MAD

For onion effective root zone was considered as 0.40 m and maximum allowable deficiency (MAD) was considered as (50 %). In surface irrigation, the water was carried to the respective plots using PVC pipes. In order to evaluate the effectiveness of each treatment the data on quality such as thousand seed weight, germination percentage and seed vigour index were recorded. For measuring seed vigour index five normal seedlings from each replication were selected randomly and vigour index was estimated by using the formula (Abdul-Baki, 1973).

Vigour index =Ave. seedling length (cm) + Ave. root length (cm) × Germination %

Similarly, Economics of experiment such as total cost of cultivation, total income from produce, total net income and other relevant parameters were estimated.

RESULTS AND DISCUSSION

Growth attributes

The growth parameters viz. plant height, number of tillers/plant, number of umbels/plant, diameter of umbels and number of seeds/umbel were found maximum in drip irrigation equal to 100% of CPE applied daily (Table 1). However, these values were at par when irrigation quantity of 75% of CPE was applied daily and three day irrigation and 100% CPE at 3 days interval. The irrigation application through drip equal to 125% CPE did not show much increase in the growth parameters as compared to surface irrigation. This revealed that excess moisture availability caused adverse effect on growth parameters of onion seed production.

The data also indicated that increase in irrigation interval upto every 3 days had not affected growth parameters significantly. The values of most of the growth attributes were found on par for daily, 3 and 7 days interval. However, when the interval is increased upto 10 days, the growth characters were adversely affected by moisture stress. The 10 days irrigation interval with irrigation equal to 75% of CPE showed minimum values of growth parameters which revealed that both reduced depth and long irrigation interval caused sharp decrease in growth of onion seed crop.

Yield

The results revealed that drip irrigation gave the higher yield as compared to conventional method of irrigation (Table 2). The yield attributes showed decreasing trend with increase in irrigation interval. The daily application through drip equal to 100% of CPE gave maximum seed yield and showed 26% increase in yield of onion seed (478 kg/ha) over surface irrigation. It was on par to yield obtained from drip irrigation equal to 75% of CPE at daily and 3 days interval (470.3 kg/ha and 457.0 kg/ha, respectively). It indicated that slight increase in irrigation interval with reduced depth of application can be a suitable option for onion seed production under drip irrigation.

The drip application at 3 days interval equal to 75% and 100% CPE gave 20% and 10% more yield than surface irrigation respectively. It showed that application of water at increased interval of 3 days is considered suitable irrigation scheduling for onion seed through drip. However, the yield under 7 and 10 days interval resulted into significantly reduced seed yield; indicated that moisture status in root zone was not maintained at optimum level under these treatments and thus, irrigation interval as high as 7 or 10 days is not preferred for onion seed production under drip. Similarly, application of water equal to 125% CPE at all irrigation interval resulted into reduction of onion seed yield. Onion being a sensitive crop to moisture availability in root zone, reacted adversely to over irrigation. The daily application of water also increased the biomass in onion seed. The straw yield was observed higher in daily irrigation with 100% and 75% of cumulative pan evaporation as compared to other treatments of drip and surface irrigation at 50 mm CPE.

Water use

The seasonal water requirement was higher in surface irrigation at 50 mm of cumulative pan evaporation (65.5 cm) as compared to irrigation applied by drip irrigation treatments (Table 2). The overall water saving in drip irrigation ranged from 29 to 62%. using the water saved due to drip irrigation, upto 1.60 ha additional area can be brought under onion seed production and additional economical benefits can be derived. The water use efficiency was found lowest as 5.90 kg/ha/cm in surface irrigation at 50 mm CPE. The water use efficiency was increased almost 2-3 times when drip was applied for onion seed production. Bhakare *et al.* 2008 also have reported the results of same trend. The highest water use efficiency was found (16.9 kg/ha/cm) when drip irrigation equal to 75% of cumulative pan evaporation was applied daily, which was closer to water use efficiency obtained when irrigation equal to 75% of CPE applied at 3 days interval.

The 7 and 10 days irrigation interval plots under drip, which produced significantly reduced yield than surface irrigation, also gave higher water use efficiency due to economical water use.

Quality parameters of onion seed

Quality parameters such as thousand seed weight, germination percentage and seed vigour index were significantly superior in drip irrigation equal to 100% CPE followed by 75 and 125% CPE application (Table 1). Amongst the irrigation interval, the quality parameters deteriorated as the interval was increased from 1 to 10 days; though the difference was not significant. The values of all quality parameters viz. thousand seed, germination per-

Table 1. Growth and quality characters of onion for seed production as influenced by irrigation scheduling (Pooled data of 3 years)

Treatment	Plant height (cm)	Tillers/ plant (Nos)	Umbels/ plant (Nos)	Diameter of umbels (cm)	Seeds/ umbel	1,000-seed weight (gm)	Germination (%)	Seed vigour index
75% CPE at daily	82.5	11.0	7.6	6.5	549.0	3.9	92.7	1436.7
75% CPE at every 3 days interval	82.1	11.0	7.1	6.5	534.7	3.7	91.7	1410.0
75% CPE at 7 days interval	77.6	9.7	7.1	6.0	476.7	3.6	90.0	1341.0
75% CPE at 10 days interval	75.0	8.3	6.5	5.7	407.0	3.2	84.0	1111.3
100% CPE at daily	82.7	11.3	7.4	6.7	578.0	3.9	93.3	1469.3
100% CPE at every 3 days interval	82.2	10.7	7.0	6.1	489.3	3.8	92.0	1398.7
100% CPE at 7 days interval	77.7	9.7	6.7	6.3	480.3	3.7	91.0	1367.7
100% CPE at 10 days interval	75.4	8.7	6.3	5.8	437.3	3.3	86.3	1186.0
125% CPE at daily	77.5	9.3	6.5	6.0	476.7	3.5	88.3	1289.3
125% CPE at every 3 days interval	75.7	9.3	6.8	6.2	472.0	3.5	87.7	1264.7
125% CPE at 7days interval	75.4	9.0	6.7	5.9	445.7	3.3	87.0	1214.3
125% CPE at 10 days interval	75.4	8.3	6.6	5.8	415.7	3.3	85.0	1134.7
Surface irrigation at 50 mm CPE	75.5	9.0	6.7	6.0	446.0	3.4	87.7	1249.7
SEm+	1.1	0.5	0.3	0.1	29.3	0.0	0.6	12.3
CD (P=0.05)	3.4	1.5	0.8	0.2	85.8	0.1	1.9	35.9

centage and vigour index was found maximum in drip irrigation treatment where water equal to 100% CPE was applied daily. However, it was on par with drip irrigation equal to 75% CPE applied daily and three days interval. It indicated that water application at slightly reduced depth with little increase in irrigation interval did not affect the quality of onion seed. The quality parameters were found inferior for 125% of CPE application at 7 days and 10 days interval. It revealed that prolonged irrigation interval resulted into inferior quality of onion seed.

Economics

The data regarding the cost of cultivation, gross and net returns and benefit: cost ratio for cultivation of onion seed are presented in Table 3. Among the different treatments, the cost of cultivation was found higher (₹ 54,843/ha) in surface irrigation at 50 mm CPE due to more number of irrigations and labours. Whereas, total seasonal cost which is sum of operational cost and seasonal cost of irrigation system was found more in all drip irrigated treatments. The maximum gross monetary returns (₹ 2,86,800/ha) and net income (₹ 2,25,555/ha) was observed in daily application equal to 100% CPE treatment as more yield of seeds was obtained. However, these values were on par with daily application equal to 75% CPE and application at 3 days interval equal to 75% CPE. The computed values of B: C ratio in various treatments were in the range of 1.8 to 3.50. Amongst all the treatments the highest B : C ratio

Table 2. Water used by onion seed production under different irrigation scheduling of drip (Pooled data of 3 years)

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Water applied (cm)	Field water use efficiency (kg/ha/cm)	Water saving (%)*	Increase in yield (%)**
75% CPE at daily	470	452	28	16.8	57	24
75% CPE at every 3 days interval	457	404	27	16.9	59	20
75% CPE at 7 days interval	401	294	26	15.4	60	06
75% CPE at 10 days interval	326	158	25	13.0	62	-14
100% CPE at daily	478	471	37	12.9	43	26
100% CPE at every 3 days interval	419	392	36	11.6	45	10
100% CPE at 7 days interval	396	335	35	11.3	46	04
100% CPE at 10 days interval	334	213	34	9.8	48	-12
125% CPE at daily	377	275	46	8.2	29	-1
125% CPE at every 3 days interval	377	275	45	8.3	31	-1
125% CPE at 7days interval	341	243	44	7.8	32	-10
125% CPE at 10 days interval	300	181	42	7.1	35	-21
Surface irrigation at 50 mm CPE	380	264	65	5.9	--	--
SEm+	17.6	28.9	--	--		
CD (P=0.05)	51.3	84.2	--	--		

* Saving of water over T_{13}; **Increase in yield over T_{13}

Table 3. Cost economics of onion for seed as influenced by different treatments (pooled data of 3 years)

Treatment	Cost of cultivation ($\times 10^3$ ₹/ha)	Total seasonal cost ($\times 10^3$ ₹/ha)	Gross income ($\times 10^3$ ₹/ha)	Net seasonal income ($\times 10^3$ ₹/ha)	Net B:C ratio
75% CPE at daily	51.1	64.1	282.2	218.1	3.4
75% CPE at every 3 days interval	51.1	64.1	274.2	210.1	3.3
75% CPE at 7 days interval	51.1	64.1	240.6	176.5	2.8
75% CPE at 10 days interval	51.1	64.1	195.4	131.3	2.0
100% CPE at daily	51.2	64.2	286.8	222.6	3.5
100% CPE at every 3 days interval	51.2	64.2	251.5	187.3	2.9
100% CPE at 7 days interval	51.2	64.2	237.8	173.6	2.7
100% CPE at 10 days interval	51.2	64.2	200.4	136.2	2.1
125% CPE at daily	51.4	64.4	226.2	161.8	2.5
125% CPE at every 3 days interval	51.4	64.4	226.0	161.7	2.5
125% CPE at 7days interval	51.4	64.4	204.5	140.1	2.2
125% CPE at 10 days interval	51.3	64.3	179.9	115.5	1.8
Surface irrigation at 50 mm CPE	54.8	56.3	228.0	171.7	3.0
SEm+	--	--	11.7	--	0.2
CD (P=0.05)	--	--	36.5	--	0.6

Table 4. Projected Cost economics of onion for seed as influenced by different treatments (pooled data of 3 years)

Treatment	Additional area (ha)	Additional seasonal cost (×10³ ₹/ha)	Additional income (×10³ ₹/ha)	Additional Net seasonal income	Net extra income over control (×10³ ₹/ha)
75% CPE at daily	1.3	84.7	372.9	288.2	334.6
75% CPE at every 3 days interval	1.4	90.2	385.9	295.7	334.1
75% CPE at 7 days interval	1.5	96.2	360.9	264.7	269.6
75% CPE at 10 days interval	1.6	102.6	312.7	210.1	169.8
100% CPE at daily	0.8	48.6	217.0	168.4	219.3
100% CPE at every 3 days interval	0.8	51.7	202.6	150.9	166.5
100% CPE at 7 days interval	0.9	55.1	203.8	148.8	150.6
100% CPE at 10 days interval	0.9	58.6	182.7	124.2	88.7
125% CPE at daily	0.4	26.6	93.4	66.8	57.0
125% CPE at every 3 days interval	0.4	28.6	100.5	71.8	61.8
125% CPE at 7days interval	0.5	30.7	97.6	66.9	35.3
125% CPE at 10 days interval	0.6	35.2	98.5	63.3	7.1
Surface irrigation at 50 mm CPE	0.0	0.0	0.0	0.0	0.0
SEm+					29.3
CD (P=0.05)					85

was obtained in the treatment daily application equal to 100% CPE; however, it was on par with daily application 75% CPE, 100% CPE and 75% CPE application at 3 days interval. The B:C ratio in surface irrigation at 50 mm CPE was found lower (3.0) as compared to superior drip irrigated treatments which attributed to higher yields.

Considering additional area which can be brought under irrigaitn by water saved through drip irrigation, the projected economics are given in table 4. Using saved water maximum additional area up to 1.6 ha can be brought under onion seed production and additional economical benefits can be derived. The extra expenditure which is to be incurred for additional area was computed by multiplying actual seasonal cost for respective treatments. The highest additional income (₹3,85,911) and additional net income (₹2,95,865) can be obtained in application at 3 days interval equal to 75% CPE followed by daily application 75% CPE. Considering income in actual and from projected figures, the net extra income over surface irrigation were estimated higher in 75% CPE application at daily and 3 days interval.

The drip irrigation treatments were found suitable for onion seed cultivation as it resulted into 29 to 62% water saving with 4 to 26% increase in the seed yield. All the growth characters and seed yield of onion increased in drip irrigation applied daily or once in 3 days than other longer intervals. The irrigation application equal to 75% cumulative pan evaporation with 3 days interval was found optimum scheduling criteria for onion seed production. The application of water at higher interval viz. 7 and 10 days resulted into inferior growth, yield and quality of onion seed. The higher benefit: cost ratios were obtained in drip irrigated treatments as it increased the yield.

It can be concluded that, for onion 'N-2-4-1' cultivated for seed purpose in sandy clay loam soil, the drip irrigation application equal to 75% of cumulative pan evaporation at 3 days interval was best to obtain better growth, yield, quality and economics of onion seed.

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