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Enhancing productivity of onion seed through fertigation scheduling in western Maharashtra

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Abstract

A field experiment was conducted on clay loam soil in Western Maharashtra during *Rabi* 2009 and 2010 to study effect of fertigation scheduling through drip on growth and yield of onion seed. The drip fertigation resulted into 39 per cent water saving with 12 to 73 per cent increase in productivity of onion seed as compared to band placement of conventional fertilizer with surface irrigation. The study revealed that all the growth parameters and yield of onion seed (602 kg/ha) was higher when fertigation applied with 100 % WSF in 12 splits up to 2 months duration from planting which was followed by 8 splits up to 2 months duration. Significant decrease in growth and seed yield was recorded when fertigation applied upto 3 months from planting. The lowest value of growth and seed yield was recorded when irrigation applied by surface method with band placement of conventional fertilizer (347 kg/ha). Higher water use efficiency was obtained in drip fertigation (1.16 kg/ha-mm) and was more than 2.5 times as compared to control treatment (0.41 kg/ha-mm). The total uptake of nutrients, net seasonal income (Rs. 3,00,247 per ha) and B:C ratio (5.94) was also found maximum when water soluble fertilizers were applied in 12 splits up to 2 months from planting as compared to other treatments.

Key words: Fertigation, onion seed, water soluble fertilizers

Introduction

The application of water soluble fertilizers through drip (fertigation) is gaining importance in precision farming. Various research conducted suggest that drip fertigation is one such method, which not only produces higher yield and saves fertilizer but also gives quality produce (Savitha *et al*., 2010). Nitrogen can be applied easily with drip irrigation because the urea, main source of N is completely water soluble. The fertigation is more efficient means of applying nutrients that are liable to leaching such as NO_3 and K_2O than conventional broadcasting. However, phosphorous can also be applied through drip irrigation system if available in soluble form (Hebbar *et al.,* 2004). Similar to frequent application of water through drip, optimum split applications of fertilizer improves the quality and yield of crop than the conventional practice. In recent years, liquid, solid or water soluble fertilizers are used as a strong alternative to conventional fertilizers. The major advantage of these water soluble fertilizers is that they can be applied through drip system in many splits with an ease.

Onion (*Allium cepa* L.) is the most imported vegetable crop grown in India. The productivity if onion in our country is low (15.6 t/ha) as compared to other countries, like China, USA (Sankar *et al*., 2008). Being a shallow rooted crop, the seed yield of onion is greatly influenced by method of irrigation and fertilizer application. Therefore, right combination of water and nutrients through drip irrigation (fertigation) seems to be a better alternative for high yield of onion seed. It has been established that growth, yield and quality parameters of onion seed increase by N-fertigation (Tiwari *et al.,* 2002; Tomar *et al.,* 2004). The water soluble fertilizer also increased the available N, P and K content in onion seed and decreased the accumulation of salts in the root zone as compared to surface method (Chopade *et al*., 1998). Fertigation can efficiently place the nutrients in the wetted zone, which avoids potential nutrient deficiencies and losses. The fertilizer requirement of onion seed was reduced by 20-40 per cent by applying drip fertigation as compared to conventional method of fertilizer application (Dumbare *et al.,* 1997; Bhakare and Fatkal, 2008). Though, water soluble fertilizers proved their superiority over conventional fertilizers but they are costly from economic point of view. With the increasing prices of fertilizers it has become necessary to save fertilizers to reduce cost of cultivation. However,

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research studies on standardization of fertigation schedule and duration for onion seed production are meager. This study was conducted to find out the response of growth, yield, nutrient uptake and economics of onion crop grown for seed purpose with respect to fertigation schedule under drip irrigation.

Material and methods

The field experiment was conducted for two consecutive *Rabi* seasons of 2009 and 2010 at research farm of Inter-Faculty Department of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri. Agroclimatically, the area falls under the scarcity zone of Maharashtra with annual average rainfall of 520 mm, which is mostly erratic and uncertain in nature. The experimental plot had plain topography. The soil texture was sandy clay loam having 17.54% coarse sand, 39.12% fine sand, 21.14% silt and 22.20% clay with medium depth. The soil was alkaline in nature with pH of 8.2 and electrical conductivity of 0.26 dSm^{-1}. The bulk density and organic carbon of soil were 1.43 g/ cm^3 and 0.65%, respectively. The soil was low in available N (141 kg/ha) and P (12.62 kg/ha) and high in available K (296.30 kg/ha) content. The soil was having good drainage with moisture contents at field capacity, permanent wilting point, and available soil moisture as 29.17, 15.37, and 13.80 %, respectively.

The planting of onion bulb 'N-2-4-1' was done on raised beds with 1.20 m top width and 1.50 bottom width with four rows of onion bulbs on each bed were planted at spacing of 30 cm. The spacing between two bulbs in a row was kept as 15 cm. The recommended fertilizer dose 100:50:50 NPK, kg/ha was applied as per fertigation schedule in all the treatment. The water soluble fertilizers (WSF) *viz*., urea (46 % N), urea phosphate (17:44) and muriate of potash (60 % K_2O) were used for fetigation. The field experiment was laid out in randomized block design (RBD) with nine treatments replicated thrice. The treatment details were as follows:

1. Drip fertigation in 4 splits upto 2 months duration
2. Drip fertigation in 8 splits upto 2 months duration
3. Drip fertigation in 12 splits upto 2 months duration
4. Drip fertigation in 4 splits upto 3 months duration
5. Drip fertigation in 8 splits upto 3 months duration
6. Drip fertigation in 12 splits upto 3 months duration
7. Drip with conventional fertilizer (N in 2 splits through fertigation, P, K through soil)
8. Drip with conventional fertilizer (N, P, K through soil)
9. Surface irrigation at 50 mm CPE with conventional fertilizer

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 on every three day interval was calculated by the following formulae (Doorenbous 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) (mm)

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, liter

W_a = Wetted area = Ð r^2

r = Radius of wetting front of dripper (35 cm)

E = Efficiency of the system (91 %)

The single 16 mm diameter lateral with inbuilt dripper was laid in between four rows of planted bulbs. The spacing between two adjacent lateral 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 = (F. C. - PWP)/100 x Bulk density x root zone x MAD

Effective root zone for onion seed was considered as 0.50 m and maximum allowable deficiency (MAD) was considered as (50 %). In order to evaluate the economics of experiment total cost of cultivation, net seasonal income from produce, total net income and other relevant parameters were estimated.

Results and discussion

Growth contributing parameters

The growth parameters viz. plant height, number of umbels per plant and diameter of umbel were found significantly influenced by different fertigation splits and duration of fertigation (Table 1). The fertigation in 12

splits upto 2 months duration showed significantly maximum plant height (81.40 cm) and number of umbels/plant (12.96) followed by fertigation in 8 splits applied upto 2 months. The plant height in treatment T_5 (fertigation in 8 splits up to 3 months) and treatment T_6 (fertigation in 12 splits up to 3 months) were found at par. However, number of umbels/plant in treatment T_1 (fertigation in 4 splits up to 2 months) was at par with T_5 (fertigation in WSF 8 splits up to 3 months) which emphasized that nutrients applied within 2 months after planting was utilized more efficiently by onion plant. Long irrigation and fertilizer application interval resulted into lowest plant height (75.35 cm) and number of umbels (7.16) in treatment T_9 (conventional method). The diameter of umbel was also recorded maximum (7.75 cm) in treatment T_3 (fertigation in 12 splits up to 2 months) which was at par with T_2 (fertigation in 8 splits up to 2 months) and T_1 and T_5. Splitting doses of water soluble fertilizer up to 2 months increased the uptake of nutrients and therefore enhanced diameter of umbels in these treatments were obtained. The lesser diameter of umbels (5.95 cm) was recorded in T_9 (conventional method) which was at par with T_7 (N fertigation in two splits through drip, P and K through soil) and T_8 (drip with 100 % CF). This could be due to water and nutrients were not available in the crop root zone as and when required by the plant in these treatments. Significantly less number of days were required for 25 per cent and 50 per cent flowering in treatment T_3 (fertigation in 12 splits up to 2 months) and treatment T_2 (fertigation in 8 splits up to 2 months) which was at par with T_1 (fertigation in 4 splits up to 2 months). The treatments received nutrients in more number of splits in first two months had better utilization of nutrient and hence, emerging of flower was early than other treatments. Application of conventional fertilizer at a once without splits resulted in late flowering of onion seed in treatment T_9 (conventional method).

Yield and yield contributing characters

The observations regarding seed yield/umbel and seed yield/plant as influenced by drip under different fertigation schedules under drip are presented in Table 1. The data revealed that seed yield per umbel (1.87 gm) and per plant (21.02 gm) was maximum in T_3 (fertigation in 12 splits up to 2 months) followed by T_2 (fertigation in 8 splits up to 2 months). The treatments T_5, T_6 and T_4 in which number of fertigation splits applied upto three months registered lower seed yield per umbel and per plant. The treatment T_9 registered minimum seed yield per umbel (1.43 gm) and per plant (15.30 gm) amongst all treatments.

In case of onion seed yield, all drip fertigated treatments recorded more yield over surface irrigation with conventional fertilizers. The maximum seed yield (601 kg/ha) was recorded when fertigation was applied in 12 splits up to 2 months (T_3) followed by treatment T_2 (fertigation in 8 splits up to 2 months) i.e. 588.26 kg/ha. The conventional method registered minimum seed yield per hectare i.e. 346.54 kg/ha. The straw yield of onion was also showed similar trend. It was observed that treatments receiving frequent supply of water soluble fertilizers in more number of splits upto two months after planting reflected into increase in seed and straw yield of onion. This shows 2 months duration after planting can be considered as the optimum period for fertigation for onion seed. The yield obtained in

Table 1. Growth and yield contributing characters of onion seed production as influenced by fertigation scheduling

Details	Plant height at harvest (cm)	No. of umbels/plant	Diameter of umbels (cm)	Days to 25 % flowering	Days to 50 % flowering	Seed yield/of umbel (g)	Seed yield/plant(g)
4 splits up to 2 months through drip	77.51	11.17	7.38	46.90	62.90	1.67	18.34
8 splits up to 2 months through drip	79.35	12.33	7.61	45.70	61.52	1.73	19.16
12 splits up to 2 months through drip	81.40	12.96	7.75	44.20	60.30	1.87	21.02
4 splits up to 3 months through drip	77.27	9.28	6.33	50.48	66.70	1.57	17.39
8 splits up to 3 months through drip	78.20	10.76	7.28	48.10	64.15	1.64	17.84
12 splits up to 3 months through drip	78.10	9.60	6.67	49.36	65.40	1.63	17.20
N in two splits through drip, P and K through soil	77.20	8.23	6.27	51.72	68.00	1.55	16.80
Drip with C.F. (N, P, K through soil)	76.80	7.73	6.10	52.86	69.90	1.49	15.90
Surface irrigation with C.F.	75.35	7.16	5.95	53.08	72.00	1.43	15.30
SEm ±	0.480	0.309	0.203	0.37	0.39	0.08	0.12
CD (P=0.05)	1.439	0.925	0.609	1.12	1.18	0.24	0.36

treatments T_7 and T_8 were at par. The nitrogen applied in only two splits through drip irrigation in T_7 did not affect onion seed yield. The low uptake of nutrients and stress of water resulted into lowest yield (346.5 kg/ha) in treatment T_9 (conventional method).

Water use

The seasonal water requirement was found more i.e. 840 mm in control and 520 mm in drip irrigation treatments, which resulted into 38.9 per cent saving over the control (Table 2). The highest field water use efficiency (FWUE) was observed in treatment T_3 (1.16 kg/ha-mm) followed by T_2 (1.12 kg/ha-mm) among all fertigated treatments. The minimum FWUE was recorded in T_9 (0.41 kg/ha-mm). This shows that drip fertigation in onion can increase water use efficiency more than 2.5 times as compared to conventional method.

Nutrient concentration in onion seed and straw

Nutrient concentration in onion seed and straw at harvest was significantly influenced by scheduling of fertigation and method of application. The fertigation showed significantly more nutrient concentration in onion seed than conventional method. The nutrient concentration was also found to be influenced by different splits of water soluble fertilizer given through drip. Maximum N, P and K concentration was obtained in T_3 (fertigation in 12 splits up to 2 months) which was at par with T_2 (fertigation in 8 splits up to 2 months). The treatment T_1 (fertigation in 4 splits up to 2 months) and T_5 (fertigation in 8 splits up to 3 months) recorded closer values of N, P, K concentration in seed and straw of onion. The application of conventional fertilizers with surface irrigation recorded less N, P, K concentration in T_9 (conventional method). The fertigation resulted into more concentration of nutrients readily and continuously available in the plant.

Total uptake of NPK

The significantly maximum uptake of nutrients was registered in treatment T_3 (fertigation in 12 splits up to 2 months) followed by T_2 (fertigation in 8 splits up to 2 months) and T_1 (fertigation in 4 splits up to 2 months). It revealed that onion seed utilized more NPK nutrients for its growth in first two months (Table 3). The treatment T_7 (drip with 100 % N in two splits through drip, P and K through soil) recorded lower value of nutrient uptake as compared to fertigation treatments with more splits. The treatment T_9 (conventional method) registered minimum value of nutrient uptake. Surface irrigation and conventional fertilizer application may be the reason for low uptake. Hence in all situations fertigation splits applied up to two months duration showed improved nutrient uptake in onion seed production.

Available NPK content in soil at harvest

The data regarding residual nitrogen, phosphorus and potassium available in soil after harvest showed significant variation in values due to different fertigation treatments. It was observed that higher soil available N was recorded in treatment T_3 (fertigation in 12 splits up to 2 months) which was at par with T_2 (fertigation in 8

Table 2. Water use studies of onion seed production under different fertigation scheduling through drip

Details	Seed yield (kg/ha)	Straw yield (kg/ha)	Water applied (mm)	Field water use efficiency (kg/ ha/mm)	Water saving (%)	Increase in yield (%)
4 splits up to 2 months through drip	547.2	513.06	520	1.05	38.9	57.9
8 splits up to 2 months through drip	588.3	535.64	520	1.13	38.9	69.8
12 splits up to 2 months through drip	601.7	553.74	520	1.16	38.9	73.6
4 splits up to 3 months through drip	414.3	458.44	520	0.80	38.9	19.6
8 splits up to 3 months through drip	465.9	498.76	520	0.90	38.9	34.4
12 splits up to 3 months through drip	428.6	472.33	520	0.82	38.9	23.7
N in two splits through drip, P and K through soil	399.9	436.14	520	0.77	38.9	14.5
Drip with C.F. (N, P, K through soil)	397.1	425.06	520	0.76	38.9	11.7
Surface irrigation with C.F.	346.5	368.88	840	0.41	-	0.0
SEm ±	3.39	2.54				
CD (P=0.05)	10.18	7.62				

C.F. = Conventional fertilizer * saving of water over T_9 * * Increase in yield over T_9

splits up to 2 months), T_1 (fertigation in 4 splits up to 2 months) and T_5 (fertigation in 8 splits up to 3 months). The treatments containing minimum number of splits like T_8 (drip with N, P, K through soil), T_9 (conventional method) recorded lower value of soil available N. Almost similar trend was observed in respect of P and K.

Cost economics

The pooled data of two years regarding net seasonal income, benefit: cost ratio, total net income and net extra income over surface as influenced by different treatments are presented in Table 4. The total cost of cultivation was computed by adding the fixed cost on drip irrigation per season and operational cost. The fixed cost of drip system for onion was estimated as Rs. 9580/ considering 6 months crop period. It is revealed from Table 4, that more cost of cultivation (Rs. 60, 785.16/ha) was estimated in fertigation treatments (T_1-T_6) because of high market cost of water soluble fertilizers whereas, the cost of cultivation for treatments T_7 and T_8 were Rs. 60, 255.4 ha. The cost of surface irrigation treatment was lowest among all treatments (Rs. 52,618.4/ha).

Net seasonal income and B : C ratio

The maximum net seasonal income of Rs. 3,00,246.8 per ha was obtained in treatment T_3 (fertigation in 12 splits up to 2 months) followed by T_2 (Rs. 292170.8). The lowest seasonal income (Rs.1, 55, 305.6) was obtained in control as lowest yield obtained with conventional fertilizer with surface irrigation. The computed values of B: C ratios in various treatments were found in the range of 3.95 to 5.94. Amongst all treatments, highest B: C ratio was obtained in T_3 (fertigation in 12 splits up to 2 months) followed by T_2 (fertigation in 8 splits up to 2 months). This indicated that frequent application of water soluble fertilizer for onion seed production can increase B: C ratio up to 1.5 times than conventional method. However, due to high initial cost of drip irrigation B: C ratios were lower in T_7 and T_8 than T_9 (3.95).

Total net income

Drip irrigation for onion resulted into 38.9 % water saving (average of 2 years), which can bring 0.62 ha additional area under irrigation. Taking into consideration

Table 3. Total nutrient uptake and availability at harvest of onion for seed as influenced by different treatments

Treatments	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total K uptake (kg/ha)	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)
4 splits upto 2 months through drip	27.29	13.98	29.90	222.90	14.22	330.30
8 splits upto 2 months through drip	28.13	12.92	27.86	229.10	13.40	327.20
12 splits upto 2 months through drip	31.68	14.75	31.36	230.90	14.80	339.90
4 splits upto 3 months through drip	19.90	9.21	19.97	214.80	18.75	328.60
8 splits upto 3 months through drip	23.21	12.31	24.70	220.20	22.70	336.60
12 splits upto 3 months through drip	21.77	10.67	22.38	227.63	15.78	356.80
N in two splits through drip, P and K through soil	18.83	9.11	18.88	211.33	19.24	324.26
Drip with C.F. (NPK through soil)	17.39	8.33	17.90	206.83	20.63	327.10
Surface irrigation with C.F.	16.05	9.02	14.55	161.96	13.59	344.20
SE $\pm$	0.512	0.267	0.397	4.58	1.99	3.74
CD at 5 %	1.535	0.799	1.191	16.96	5.97	11.52

C.F. = Conventional fertilizer

Table 4. Economic analysis of onion for seed (Rupees per ha) as influenced by different treatments (pooled data of 2 years)

Treatments	Cost of cultivation (Rs./ha)	Net seasonal income (Rs./ha)	B : C ratio	Total net income (Rs./ha)	Net extra income over control (Rs./ha)
4 splits upto 2 months through drip	60785.16	267504.8	5.40	432123.2	112198.8
8 splits upto 2 months through drip	60785.16	292170.8	5.81	471968.3	136864.8
12 splits upto 2 months through drip	60785.16	300246.8	5.94	485014.1	144940.8
4 splits upto 3 months through drip	60785.16	187800.8	4.09	303370.6	32494.8
8 splits upto 3 months through drip	60785.16	218766.8	4.60	353392.6	63460.8
12 splits upto 3 months through drip	60785.16	196392.8	4.23	317250.0	41086.8
N in two splits through drip, P and K through soil	60255.4	179690.6	3.98	290269.4	24384.6
Drip with C.F. (N, P, K through soil)	60255.4	178022.6	3.95	287575.0	22716.6
Surface irrigation with C.F.	52618.4	155305.6	3.95	155305.6	0.0

C.F. = Conventional fertilizer

the additional net income due to this additional area, the total net income was found maximum in treatment T_3 (Rs. 4,85,014.10) followed by T_2 (Rs. 4,71,968.30) as compared to Rs 1,55,305.60 in conventional method of irrigation.

Net extra income

Drip irrigation (T_1 to T_8) resulted into per ha additional net income over surface method (Table 4). The maximum net extra income (Rs. 1,44,940.80) was obtained in treatment T_3 (fertigation in 12 splits up to 2 months) followed by T_2 (fertigation in 8 splits up to 2 months. Treatment (T_8) resulted about Rs. 22,716.6 per ha additional net income over surface method. This emphasized utility of drip irrigation on onion seed production irrespective of using water soluble fertilizers.

It can be concluded that for rabi onion (cv. Phule Samarth) cultivated in sandy clay loam soil, the fertigation with 100 % water soluble fertilizers in 12 splits up to 2 months duration after planting is best suited to obtain higher growth, yield and economic returns from onion seed production.

सारांश

प्याज में टपकाव विधि से फर्टिगेशन शेड्यूलिंग का विकास एवं बीज उपज पर प्रभाव का अध्ययन वर्ष 2009–2010 में पश्चिम महाराष्ट्र की चिकनी बलुई मिट्टी में रबी मौसम में किया गया। टपकाव विधि से 39 प्रतिशत पानी की बचत हुई जिनसे 12 से 73 प्रतिशत वृद्धि रेखीय विधि से पारम्परिक दशा में उर्वरक प्रयोग व सतही सिंचाई की तुलना में पायी गयी। अध्ययन से पता चला कि सभी विकास मानकों तथा प्याज की बीज उपज (602 किलोग्राम/हे.) अधिकतम थी जब फर्टीगेशन 100 प्रतिशत डब्ल्यू एस एफ को 12 भागों में 2 माह की रोपण अवधि काल में की गयी इसके बाद पुनः 8 भागों में 2 माह अवधि काल में किया गया। विकास में सार्थक गिरावट देखी गयी तथा फर्टीगेशन प्रयोग रोपण से 3 माह तक बीज का आकलन किया गया। सबसे कम विकास मूल्य तथा बीज उपज को अंकित किया गया जब सतही विधि से सिंचाई किया गया तथा रेखीय व पारम्परिक विधि से उर्वरक (347 किलोग्राम/हे.) प्रयोग किया गया। अधिकतम जल उपयोग दक्षता टपकाव फर्टीगेशन (1.16 किलोग्राम/हे. मि.मी.) और यह 2.5 गुना ज्यादा था नियंत्रक की तुलना (0.41 किलोग्राम/हे. मि.मी.)। कुल पोषक तत्वों का अवशोषण कुल मौसमी आय (3,00,247 प्रति/हे.) व लाभ–लागत अनुपात (5.94) भी अधिकतम था जब जल विलेय उर्वरक को 12 भागों में बाटकर रोपण के दो माह तक दिया गया जो पारम्परिक विधि से ज्यादा है।

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