Influence of drip fertigation on yield and water use efficiency of aggregatum onion in western zone of Tamil Nadu

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ABSTRACT

A field experiment was carried out at the Agricultural Research Station, Bhavanisagar, Tamil Nadu during kharif season of 2015-16 to 2016-17 to evaluate and optimize the drip fertigation on water use efficiency, yield attributes and yield and economics of aggregatum onion under different fertigation levels. The research was carried out in randomized block design with four replications. The treatments comprised nine fertigation levels combination with basal application compared to absolute control. Drip fertigation with 100 per cent N, P and K through fertigation (T_3) registered higher water use efficiency (60.46 and 78.44 kg/ha mm) and water productivity (6.046 and 7.841 kg/m^3) followed by 75 per cent N, P and K through fertigation (T_7). Lower water use efficiency (44.75 and 58.05 kg/ha mm) and water productivity (4.475 and 5.803 kg/m^3) were recorded in 75 per cent N through fertigation with75 per cent P and K applied as basal (T_5). Significantly higher yield attributes like bulb weight and bulb number/clump were registered in T_3 which was on par with T_7. Perceptively higher yield was also recorded in T_3 (23.82 and 22.99 tonnes/ha) that was at par with T_7 (23.31 and 22.49 tonnes/ha). Strikingly lower yield was recorded in T_5 (17.63 and 17.01 tonnes/ha) except absolute control (T_{10}). However T_7 registered higher net return of Rs 1,76,302/ha and B-C ratio of 2.84 followed by 100 per cent N and K through fertigation with 100 per cent P applied as basal (T_2) with net return of Rs 1,54,139/ha and B-C ratio of 2.80.

Keywords: Drip fertigation; yield; WUE; aggregatum onion

INRODUCTION

Aggregatum onion (*Allium cepa* L var *aggregatum* Don) is widely grown and consumed in southern states of India viz Tamil Nadu, Andhra Pradesh, south Karnataka and some parts of Odisha and Kerala. Tamil Nadu accounts for five per cent of country's area under onion and more than 70 per cent of the area is cultivated by small onion. Around 90 per cent of country's small onion is produced in Tamil Nadu and 10 per cent in Karnataka. However the productivity is low in India mainly due to lack of inappropriate water management practices. The total water availability in Tamil Nadu is 5.5 million hectare meter (MHM) against the demand of 6.8 MHM resulting in a supply-demand gap of 24 per cent. Today lot of emphasis is being given on improving the irrigation practices to increase the water use efficiency and crop productivity and to sustain the production levels. Though India has the largest irrigation network in the world, its irrigation efficiency has not been more than 40 per cent. One of the reasons for the low irrigation efficiency is the predominant use of surface (conventional) irrigation where water use efficiency is very low which is only about 35 to 40 per cent because of huge conveyance and distribution losses (Dinar et al 1997).

By introducing micro-irrigation, it is possible to increase the yield potential of crops by three-fold with the same quantity of water. All these emphasize the need for water conservation and improvement in water use efficiency to achieve 'more crop per drop of water'. India's average productivity of onion is 16.41 tonnes/ha which is lower than world's average of 20.08 tonnes/

ha (Anon 2009). One of the reasons for this low productivity is surface irrigation method predominantly adopted by farmers which results in low productivity. Onion being a shallow rooted (30 cm) crop requires frequent irrigation for achieving better productivity. The water use efficiency is low when surface irrigation methods are followed. By adopting drip irrigation system, high water use efficiency and better productivity can be achieved by always maintaining moisture near the root zone at field capacity. Dingre et al (2012) reported that in onion crop total irrigation water applied through surface and drip system was 840 and 520 mm respectively indicating 39 per cent water saving whereas field water use efficiency of drip irrigation was more by 2.5 times as that of control.

Drip irrigation is the system for accurate application of water to synchronize with the plant needs. Moreover three dimensional water flows with drip irrigation maintain soil moisture around field capacity or slightly above as compared to surface irrigation with moisture content between field capacity to available water capacity due to dominance of unidirectional vertical flow. Drip irrigation is often preferred over other irrigation methods because of the high water application efficiency (40-70%) on account of reduced losses.

The present investigations were done to evaluate and optimize the drip fertigation in aggregatum onion to study the effect of drip fertigation on water use efficiency, yield attributes and yield and economics of aggregatum onion.

MATERIAL and METHODS

The soil of the experimental field was sandy loam with a pH of 7.12 and 6.97 and electrical conductivity of 0.30 and 0.28 dS/m during 2015-16 and 2016-17 respectively. The infiltration rate of soil was 1.85 and 1.86 cm/h, field capacity 23.1 and 23.3 per cent, permanent wilting point 12.5 and 12.3 per cent, bulk density 1.37 and 1.39 mg/m^3 and the organic carbon content was 0.48 and 0.50 per cent during both the years respectively. The nutritional status of the soil was low in available nitrogen (238 and 234 kg/ha), medium in available phosphorus (23 and 22.4 kg/ha) and medium in available potassium (387 and 396 kg/ha) respectively. The experiment consisted of ten fertigation levels viz 100 per cent N through fertigation with 100 per cent P and K applied as basal (T_1), 100 per cent N and K through fertigation with 100 per cent P applied as basal (T_2), 100 per cent N, P and K through fertigation (T_3), 75 per cent N, P and K through fertigation and 25 per cent N, P and K applied as basal (T_4), 75% N through fertigation with 75 per cent P and K applied as basal (T_5), 75 per cent N and K through fertigation with 75 per cent P applied as basal (T_6), 75 per cent N, P and K through fertigation (T_7), 75 per cent N, P and K through fertigation and 25 of 75 per cent N, P and K applied as basal (T_8), 50 per cent N and 100 per cent P and K applied as basal and 50 per cent N applied on 30 DAT (T_9) and absolute control (T_{10}). N, P and K basal application was done through urea, single super phosphate (SSP) and muriate of potash (MoP) and NPK fertigation through 19:19:19 and/or 12:61:0 and/or 0:0:50 or other commonly available water soluble fertilizers.

Drip irrigation was given on alternate days at 100 per cent crop evapo-transpiration (ETc). Irrigation water was pumped through 7.5 HP motor and conveyed to the mainline of 63 mm OD PVC pipes after filtering through sand and disc filters. Ventury was installed in the main line for fertigation. Sub-mains of 40 mm OD PVC pipes were drawn from the main pipes. Laterals of 12 mm LLDPE pipes were drawn at an interval of 1.2 m within line emitters spaced at 50 cm and at a discharge rate of 4 lph from the sub-main. Individual control valves were provided for each treatment for imposing different fertigation treatments. Single lateral was used for each bed containing four rows of onion crop. The wetting diameter of a single dripper was 0.5 m. Sub-mains and laterals were closed at the end with end cap. After installation, trial run was conducted to assess mean dripper discharge and irrigation efficiency. This was taken into account for fixing the irrigation water application time. During the irrigation period an average irrigation efficiency of 90 per cent was observed.

Seeds of Co 5 onion variety were sown in raised beds of 1.2 m width and 5 m length at the rate of 8 kg/ha in a separate field which was surface irrigated and the seedlings of 15 to 20 cm height were transplanted after 50 DAS. Fifty days old healthy seedlings were used for transplanting and one seedling per hill was planted adopting a spacing of 20 cm x 15 cm. Before transplanting, the field was completely made wet by drip irrigation.

The crop was raised with all recommended package of practices except the irrigation and fertilizer application. Treatment-wise onion yield was recorded and total water used, water use efficiency, water

productivity, yield attributes, yield and economics were driven out.

RESULTS and DISCUSSION

Effect of drip fertigation on WUE and water productivity in onion

Drip fertigation treatments significantly influenced the water use efficiency and water productivity of onion and the data are presented in Table 1.

The amount of water required to meet the demand of evapo-transpiration and metabolic activity of onion constituted the consumptive use of water including the effective rainfall during the crop growing season. During both the years 2015-16 and 2016-17, water use efficiency was higher in 100 per cent N, P and K through fertigation (T_3) (60.46 and 78.44 kg/ha mm) followed by 75 per cent N, P and K through fertigation (T_7) (58.62 and 76.72 kg/ha mm) as compared to absolute control (T_{10}) (36.20 and 46.96 kg/ha mm) respectively. The treatments behaved similarly in case of water productivity. Higher water productivity of 6.046 and 7.841 kg/m^3 was recorded in case of T_3 followed by T_7 (5.862 and 7.670 kg/m^3) as against 3.620 and 4.695 kg/m^3 in control in 2015-16 and 2016-17 respectively.

Significantly higher WUE and water productivity were registered in T_3 and T_7. This might be due to higher yield and frequent application of irrigation water through drip irrigation system that helped in maintaining the soil moisture of crop root zone near field capacity and reduced the movement of water beyond root zone. Similar findings were also reported by Ankush and Sharma (2017). Rajput and Patel (2002) found that WUE was higher for daily and alternate days drip irrigation.

Table 1. Effect of water use, water use efficiency (WUE) and water productivity by drip fertigation treatments in onion for 2015-16 and 2016-17

Treatment	Total water use (mm)		WUE (kg/ha mm)		WP (kg/m^3)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	384.5	296.4	48.76	61.08	4.876	6.106
T_2	384.5	296.4	52.06	67.54	5.206	6.752
T_3	384.5	296.4	60.46	78.44	6.046	7.841
T_4	384.5	296.4	53.64	69.59	5.364	6.957
T_5	384.5	296.4	44.75	58.05	4.475	5.803
T_6	384.5	296.4	49.93	64.77	4.993	6.475
T_7	384.5	296.4	58.62	76.72	5.862	7.670
T_8	384.5	296.4	52.95	68.70	5.295	6.868
T_9	384.5	296.4	46.68	59.87	4.668	5.985
T_{10}	384.5	296.4	36.20	46.96	3.620	4.695

T_1- 100% N through fertigation with 100% P and K applied as basal, T_2- 100% N and K through fertigation with 100% P applied as basal, T_3- 100% N, P and K through fertigation, T_4- 75% N, P and K through fertigation and 25% N, P and K applied as basal, T_5- 75% N through fertigation with 75% P and K applied as basal, T_6- 75% N and K through fertigation with 75% P applied as basal, T_7- 75% N, P and K through fertigation, T_8- 75% of 75% N, P and K through fertigation and 25% of 75% N, P and K applied as basal, T_9- 50% N and 100% P, K applied as basal and 50% N applied on 30 DAT, T_{10}- Absolute control; Total water use included effective rainfall also; Data not statistically analysed

Effect of drip fertigation on yield attributes and yield of onion

Drip fertigation treatments significantly influenced bulb number/clump, bulb weight and bulb yield during 2015-16 and 2016-17 and the data are presented in Table 2.

During 2015-16 and 2016-17, T_3 resulted in higher number of bulbs per clump (5.340 and 5.153) followed by T_7 with 4.625 and 4.463 number of bulbs per clump as compared to T_{10} (control) with 2.768 and 2.671 number of bulbs per clump respectively.

During 2015-16 and 2016-17, T_3 resulted in higher bulb weight (77.12 and 74.42 g/plant) and bulb yield (23.82 and 22.99 tonnes/ha) which were at par with T_7 with bulb weight 75.66 and 73.01 g/plant and bulb yield 23.31 and 22.49 tonnes/ha as compared to T_{10} (control) with bulb weight 49.20 and 47.48

g/plant and bulb yield 14.26 and 13.76 tonnes/ha respectively.

Significantly higher yield, bulb weight and number of bulbs/plant were registered in 100 per cent N, P and K through fertigation (T_3) and 75 per cent N, P and K through fertigation (T_7). The increase in yield might be due to higher number of bulbs and bulb weight. Fertigation with water soluble fertilizers could have resulted in higher availability of all the three (NPK) major nutrients in the soil solution which led to higher uptake and better translocation of assimilates from source to sink thus in turn increased the yield. Hebbar et al (2004) reported that fertigation with 100 per cent water soluble fertilizers (WSF) increased the tomato fruit yield significantly over drip irrigation without fertigation. Rajput and Patel (2006) also recorded higher onion yield in both daily and alternate day fertigation.

Economics of onion under drip fertigation

Evaluation of drip fertigation treatments including seasonalised drip cost with respect to economics was done during 2015-16 and 2016-17 for onion crop and the data are presented in Table 3.

Table 2. Yield attributes and yield of onion during 2015-16 and 2016-17 as influenced by drip fertigation treatments

Treatment	Number of bulbs/clump		Bulb weight (g/plant)		Bulb yield (tonnes/ha)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	3.741	3.610	64.06	61.82	18.55	17.90
T_2	3.917	3.779	67.65	65.28	20.51	19.79
T_3	5.340	5.153	77.12	74.42	23.82	22.99
T_4	4.593	4.432	70.01	67.56	21.14	20.40
T_5	3.630	3.502	59.45	57.37	17.63	17.01
T_6	3.845	3.710	65.60	63.30	19.67	18.98
T_7	4.625	4.463	75.66	73.01	23.31	22.49
T_8	4.562	4.403	69.19	66.77	20.87	20.14
T_9	3.649	3.521	62.01	59.84	18.18	17.55
T_{10}	2.768	2.671	49.20	47.48	14.26	13.76
SEd	0.200	0.193	3.00	2.90	1.08	1.04
$CD_{0.05}$	0.420	0.406	6.31	6.09	2.27	2.19

T_1- 100% N through fertigation with 100% P and K applied as basal, T_2- 100% N and K through fertigation with 100% P applied as basal, T_3- 100% N, P and K through fertigation, T_4- 75% N, P and K through fertigation and 25% N, P and K applied as basal, T_5- 75% N through fertigation with 75% P and K applied as basal, T_6- 75% N and K through fertigation with 75% P applied as basal, T_7- 75% N, P and K through fertigation, T_8- 75% of 75% N, P and K through fertigation and 25% of 75% N, P and K applied as basal, T_9- 50% N and 100% P, K applied as basal and 50% N applied on 30 DAT, T_{10}- Absolute control

Table 3. Economics (mean of 2015-16 and 2016-17) of onion as influenced by drip fertigation treatments

Treatment	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B-C ratio
T_1	77,955.00	2,15,815.00	1,37,860.00	2.74
T_2	84,491.00	2,38,630	1,54,139.00	2.80
T_3	1,01,965.00	2,77,133.00	1,75,167.00	2.69
T_4	96,521.00	2,45,866.00	1,49,345.00	2.52
T_5	76,216.00	2,05,099.00	1,28,883.00	2.67
T_6	81,248.00	2,28,856.00	1,47,608.00	2.79
T_7	94,776.00	2,71,077.00	1,76,302.00	2.84
T_8	89,645.00	2,42,719.00	1,53,074.00	2.68
T_9	77,955.00	2,11,524.00	1,33,569.00	2.69
T_{10}	71,019.00	1,65,917.00	94,899.00	2.31

T_1- 100% N through fertigation with 100% P and K applied as basal, T_2- 100% N and K through fertigation with 100% P applied as basal, T_3- 100% N, P and K through fertigation, T_4- 75% N, P and K through fertigation and 25% N, P and K applied as basal, T_5- 75% N through fertigation with 75% P and K applied as basal, T_6- 75% N and K through fertigation with 75% P applied as basal, T_7- 75% N, P and K through fertigation, T_8- 75% of 75% N, P and K through fertigation and 25% of 75% N, P and K applied as basal, T_9- 50% N and 100% P, K applied as basal and 50% N applied on 30 DAT, T_{10}- Absolute control; Cost of cultivation includes seasonalised drip cost; Data not statistically analysed

T_3 involved higher cost of cultivation (Rs 1,01,965.00) followed by T_4 (75% N, P and K through fertigation and 25% N, P and K applied as basal) (Rs 96,521.00) and T_7 (Rs 94,776.00) as compared to T_{10} (control) (Rs 71,019.00) during both the years together.

There was higher gross return due to treatment T_3 (Rs 2,77,133.00) followed by T_7 (Rs 2,71,077.00) as against lowest in T_{10} (control) (Rs 1,65,917.00). As a result higher net return was recorded in T_7 (Rs 1,76,302.00) followed by T_3 (Rs 1,75,167.00) against lowest in T_{10} (control) (Rs 94,899.00).

Benefit-cost ratio was found to be higher in T_7 (2.84) followed by T_2 (2.80) and the minimum was registered in T_{10} (control) (2.31).

CONCLUSION

The outcome of the investigations indicated the advantage of drip fertigation over conventional method. In aggregatum onion, the treatment comprising 75 per cent N, P and K through fertigation using water soluble fertilizers at weekly interval was found to be the best fertigation treatment for achieving higher water use efficiency, yield and economic returns.

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