International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 2442-2448

Received: 14-07-2019
Accepted: 18-08-2019

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Effect of drip irrigation levels on physico-chemical properties of growing medium in Alstroemeria (*Alstroemeria hybrida*)

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Abstract
The present study was carried out at the experimental farm of the Department of Floriculture and Landscape Architecture of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan under naturally ventilated polyhouse conditions during 2014-16. The experiment was laid out in Randomized Block Design having 10 treatments of drip irrigation levels replicated thrice. The observations on various physico-chemical properties of growing medium were recorded. The results revealed that treatment T_{10} was found successful in ensuring higher availability of NPK content. The said treatment recorded maximum values for available nitrogen (398.97 Kg ha^{-1}), available phosphorus (61.14 Kg ha^{-1}) and available potassium (253.23 Kg ha^{-1}).

Keywords: Drip irrigation, nitrogen, phosphorus, potassium and alstroemeria

Introduction

Alstroemeria (*Alstroemeria hybrida* L.) is an important bulbous ornamental plant of great commercial value and belongs to family alstroemeriaceae. It is native to South America and commonly known as 'the Peruvian Lily' or 'Lily of Incas'. Alstroemeria is a rhizomatous monocot plant and prefers to grow more luxuriantly and flower profusely in the cool and moist climatic conditions. So, it warrants continuously for requisite level of nitrogen, phosphorus and potassium throughout the growing medium uniformly for its better growth and flowering. Therefore, physico-chemical properties of growing medium need to be worked out to increase the yield and quality of cut flowers of alstroemeria. Among all the irrigation methods, the drip irrigation is the most efficient and it can be practised in a large variety of crops, especially in vegetables, orchard crops, flowers and plantation crops. In drip irrigation, water is applied near the plant roots through emitters or drippers, on or below the soil surface, at a low rate varying from 2 - 20 litres per hour. Drip irrigation results in a very high water application efficiency of about 90-95 per cent. There is a scanty information on the effect of drip irrigation level(s) on physico-chemical properties of growing medium in alstroemeria particularly in Indian conditions. So, keeping in view the above facts, the present investigation was undertaken.

Materials and Methods

The present investigation entitled, "Effect of drip irrigation levels on physico-chemical properties of growing medium in alstroemeria (*Alstroemeria hybrida* L.)" was carried out at the experimental farm of Department of Floriculture and Landscape Architecture, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) for growing of lstroemeria under naturally ventilated polyhouse conditions during 2014-2016. The experiment was laid out in a randomized block design consisting of 10 treatments replicated thrice. The details of treatments were T_1 = Surface irrigation (October- September), T_2 = 4 litres/m^2 (October- September), T_3 = 6 litres/m^2 (October- September), T_4 = 8 litres/m^2 (October-September), T_5 = 10 litres/m^2 (October- September), T_6 = Surface irrigation (Oct- Feb) and 125% surface irrigation (March- September), T_7 = 4 litres/m^2 (Oct- Feb) and 5 litres/m^2 (March-September), T_8 = 6 litres/m^2 (Oct- Feb) and 7.5 litres/m^2 (March-September), T_9 = 8 litres/m^2 (Oct- Feb) and 10 litres/m^2 (March-September) and T_{10} = 10 litres/m^2 (Oct- Feb) and 12.5 litres/m^2 (March-September). The selected healthy and disease free plants of alstroemeria (*Alstroemeria hybrida*) cv. 'Capri' were planted at a spacing of 50 cm × 50 cm with a density of four plants per plot having a size of 1×1 m, containing a sterilized growing substrate in the poly house on 30 August, 2014. The application of NPK @ 150: 100: 150 ppm through fertigation was applied uniformly after the establishment of plants continuously starting *w.e.f.* 30th September, 2014 up to 10th August, 2016. To maintain the good plant health and obtaining best quality flowering stems, standard plant protection measures were adopted which included fortnightly drenching and spraying with Dithane M-45 @ 2g/l and Bavistin @ 1g/l, alternatively. Besides it, to check the infestation of various insect-pests, a spray of endosulfan @ 2 ml/l, polytrin @ 0.5ml/l and decis @ 1 ml/ l, respectively was practiced alternatively at an interval of 15 days. The standard cultural practices were followed to raise a successful crop which included irrigation, netting, weeding, hoeing and removal of unwanted stems/shoots etc.

Physico-chemical properties of growing medium

Before laying out the experiment, random samples of growing medium were collected from the different spots of the experimental field at 0-15 cm depth and the composite sample was prepared which was analyzed for various physico-chemical properties. The data obtained on physico-chemical properties of growing medium are enumerated in Table 1 and the procedures followed for their estimation in Table 2, respectively.

Table 1: Physico-chemical properties of growing medium before the start of experiment

Properties	Value
pH (1:2)	6.80
EC (dS m^{-1})	0.27
Available N (kg ha^{-1})	295.63
Available P (kg ha^{-1})	48.17
Available K (kg ha^{-1})	193.58

Analysis of growing medium for various physico-chemical properties

Collection and preparation of samples

The representative samples of growing medium from 0-15 cm depth were collected treatment wise after harvesting during both the years of study. The treatment wise samples of growing medium were collected, air dried in shade and ground with the help of pestle and mortar. Thereafter, the samples were passed through 2 mm sieve and stored in polyethylene bags for further analysis of growing medium as per the methods given in Table 2.

Table 2: Methods followed for the analysis of various physico- chemical properties of growing medium

Sr. No.	Parameters	Methods/ Reference used
1.	pH	1:2 Soil : water suspension, measured with digital pH meter (Jackson, 2005) [2]
2.	EC	1:2 Soil : water suspension, measured with digital EC meter (Jackson, 2005) [2]
3.	Available N	Alkaline potassium permanganate method (Subbiah and Asija, 1956) [8]
4.	Available P	Olsen's method (Olsen *et al*., 1954) [5]
5.	Available K	Ammonium acetate method (Merwin and Peech, 1951) [4]

Results and Discussion

pH of growing medium

The data on average and pooled values of pH have been enumerated in Table 3. The data reveal that application of various drip and surface irrigation levels, though, slightly increased the pH of growing medium, the effect however, in both years were noted to be statistically non- significant. However, the individual effect of treatments in pooled data was found to be significant. In the present study, the pH of growing medium ranged from 6.78 to 6.92 for different irrigation treatments which is considered to be within the safer limits for the cultivation of most of the crops including alstroemeria. Our results are in agreement with the findings of Gautam (2002) [1] who investigated the effect of various drip irrigation and mulch materials on soil hydrothermal regimes, water requirement, yield and quality of strawberry cv. 'Chandler' and reported that pH of the soil was not affected much by the various treatments throughout the study period and pH ranged from 6.7-7.0 which is the safer limit for growing of various crops.

Table 3: Effect of drip irrigation levels on pH of growing medium in alstroemeria cv. 'Capri'

Treatments	pH of growing medium								
	1st year (2014-15)			2nd year (2015-16)			Pooled		
	B_1	B_2	Mean	B_1	B_2	Mean	B_1	B_2	Mean
T_1	6.81	6.81	6.81	6.82	6.82	6.82	6.81	6.82	6.82
T_2	6.79	6.79	6.79	6.80	6.81	6.80	6.79	6.80	6.80
T_3	6.80	6.80	6.80	6.81	6.81	6.81	6.80	6.80	6.80
T_4	6.82	6.82	6.82	6.82	6.83	6.82	6.82	6.82	6.82
T_5	6.86	6.88	6.87	6.87	6.88	6.87	6.86	6.88	6.87
T_6	6.81	6.81	6.81	6.81	6.82	6.82	6.81	6.81	6.81
T_7	6.78	6.78	6.78	6.78	6.78	6.78	6.78	6.78	6.78
T_8	6.81	6.81	6.81	6.81	6.82	6.82	6.81	6.82	6.81
T_9	6.82	6.82	6.82	6.82	6.83	6.83	6.82	6.83	6.82
T_{10}	6.89	6.90	6.89	6.90	6.92	6.91	6.90	6.91	6.90
Mean	6.82	6.82	6.82	6.82	6.83	6.83	6.82	6.83	
CD (0.05)									
T (Treatments)							0.05		
B (Flushes)							NS		
T×B	NS			NS			NS		
Y (Year)	NS			NS			NS		
Y×T	NS			NS			NS		
Y×B							NS		
T×B×Y							NS		

Treatments:
T1 = Surface irrigation (October - September)
T2 = 4 litres/m2 (October - September)
T3 = 6 litres/m2 (October - September)
T4 = 8 litres/m2 (October - September)
T5 = 10 litres/m2 (October - September)
T6 = Surface irrigation (Oct - Feb) and 125% surface irrigation (March - September)
T7 = 4 litres/m2 (Oct - Feb) and 5 litres/m2 (March - September)
T8 = 6 litres/m2 (Oct - Feb) and 7.5 litres/m2 (March - September)
T9 = 8 litres/m2 (Oct - Feb) and 10 litres/m2 (March - September)
T10 = 10 litres/m2 (Oct - Feb) and 12.5 litres/m2 (March - September) Flushes:
B1 = 1st flush (October - May)
B2 = 2nd flush (June - September)

Electrical conductivity

The data on average and pooled values of EC have been enumerated in Table 4 and indicated that the application of higher levels of drip irrigation and surface irrigation, though, slightly increased the EC, but the effects were noted to be statistically non- significant in both the years. However, the treatment effect in pooled data was found to be significant. In the present study, electrical conductivity ranged from 0.29 to 0.38 (dS m^{-1}) for different treatments which is considered to be within the safer limits and suitable for the cultivation of most of the crops including alstroemeria. Our results are in agreement with the findings of Gautam (2002) [1] who investigated the effect of various drip irrigation and mulch materials on soil hydrothermal regimes, water requirement, yield and quality of strawberry cv. 'Chandler'. He reported that EC of the soil was not affected much by the various treatments throughout the study period and ranged from 0.33 to 0.44.

Table 4: Effect of drip irrigation levels on electrical conductivity (dS m^{-1}) of growing medium in alstroemeria cv. 'Capri'

Treatments	EC (dS m^{-1})								
	1st year (2014-15)			2nd year (2015-16)			Pooled		
	B_1	B_2	Mean	B_1	B_2	Mean	B_1	B_2	Mean
T_1	0.31	0.32	0.32	0.33	0.33	0.33	0.32	0.33	0.32
T_2	0.28	0.28	0.28	0.30	0.31	0.30	0.29	0.29	0.29
T_3	0.30	0.31	0.31	0.32	0.31	0.32	0.31	0.31	0.31
T_4	0.33	0.34	0.34	0.34	0.35	0.35	0.34	0.35	0.34
T_5	0.36	0.37	0.37	0.38	0.38	0.38	0.37	0.38	0.37
T_6	0.33	0.34	0.33	0.35	0.35	0.35	0.34	0.35	0.34
T_7	0.28	0.32	0.30	0.29	0.29	0.29	0.29	0.31	0.30
T_8	0.31	0.32	0.32	0.31	0.34	0.33	0.31	0.33	0.32
T_9	0.35	0.36	0.36	0.36	0.37	0.37	0.36	0.37	0.36
T_{10}	0.36	0.37	0.37	0.39	0.38	0.39	0.37	0.38	0.38
Mean	0.32	0.33	0.33	0.34	0.34	0.34	0.33	0.34	
CD (0.05)									
T (Treatments)								0.04	
B (Flushes)								NS	
T×B		NS			NS			NS	
Y (Year)		NS			NS			NS	
Y×T		NS			NS			NS	
Y×B								NS	
T×B×Y								NS	

Treatments:
T1 = Surface irrigation (October - September)
T2 = 4 litres/m2 (October - September)
T3 = 6 litres/m2 (October - September)
T4 = 8 litres/m2 (October - September)
T5 = 10 litres/m2 (October - September)
T6 = Surface irrigation (Oct - Feb) and 125% surface irrigation (March - September)
T7 = 4 litres/m2 (Oct - Feb) and 5 litres/m2 (March - September)
T8 = 6 litres/m2 (Oct - Feb) and 7.5 litres/m2 (March - September)
T9 = 8 litres/m2 (Oct - Feb) and 10 litres/m2 (March - September)
T10 = 10 litres/m2 (Oct - Feb) and 12.5 litres/m2 (March - September) Flushes:
B1 = 1st flush (October - May)
B2 = 2nd flush (June - September)

Available nitrogen (kg ha^{-1})

A perusal of data presented in Table 5 indicated that the application of different irrigation treatments (Both drip and surface irrigation) and flower flushes had exhibited significant effects on available nitrogen in the growing medium in both the years. In the 1st year (2014-15), maximum available nitrogen (396.81 kg ha^{-1}) was recorded in treatment T_{10} i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be at par with T_5 (395.76 kg ha^{-1}) and T_9 (394.89 kg ha^{-1}), both treatments applied through drip. Whereas, minimum available nitrogen (380.11 kg ha^{-1}) was observed in T_2 i.e. 4 litres/m^2 (October-September) applied through drip and found to be statistically at par with the T_7 (381.25 kg ha^{-1}) which was also applied through drip.

As regards the effect of flushes, maximum available nitrogen (388.72 kg ha^{-1}) was obtained in 2nd flush and it was found to be minimum (387.44 kg ha^{-1}) in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on available nitrogen.

Similar trends were also observed in the 2nd year (2015-16). The maximum available nitrogen (401.14 kg ha^{-1}) in the growing medium was recorded in T_{10} treatment i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be at par with T_5 (399.64 kg ha^{-1}) and T_9 (398.66 kg ha^{-1}), both the treatments applied through drip. Whereas, minimum available nitrogen (382.07 kg ha^{-1}) was observed in T_2 i.e. 4 litres/m^2 (October- September) applied through drip and found to be at par with the T_7 (384.33 kg ha^{-1}) also applied through drip system.

The different flushes had also exhibited significant effects on available nitrogen in the 2nd year too. The maximum availability of nitrogen (391.94 kg ha^{-1}) was reported in 2nd flush and it was found to be significantly higher over 1st flush. Whereas, minimum available nitrogen (390.56 kg ha^{-1}) was observed in 1st flush, irrespective of the methods and levels of irrigation applied. The interaction between irrigation treatments and flushes had exhibited non-significant effects on available nitrogen of the growing medium.

Pooled data also revealed significant effects of different levels of drip and surface irrigation as well as flower flushes on the available nitrogen present in the growing medium. Maximum available nitrogen (398.97 kg ha^{-1}) was recorded in T_{10} treatment i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be at par with T_5 (397.70 kg ha^{-1}) and T_9 (396.78 kg ha^{-1}) which were also applied through drip. Whereas, minimum available nitrogen (381.09 kg ha^{-1}) was observed in T_2 i.e. 4 litres/m^2 (October- September) applied through drip and found to be statistically at par with the T_7 (382.79 kg ha^{-1}) which was also applied through drip.

The different flushes had also exhibited significant effects on available nitrogen. The maximum available nitrogen (390.33 kg ha^{-1}) in the growing medium was present in 2nd flush and it was found to be significantly higher over 1st flush. Whereas, minimum available nitrogen (389.00 kg ha^{-1}) was found in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on available nitrogen of the growing medium.

Both the years had also showed significant differences in availability of nitrogen in the growing medium. Maximum available nitrogen (391.25 kg ha^{-1}) was observed in 2nd year and found to be significantly higher. Whereas, it was minimum (388.08 kg ha^{-1}) in 1st year. The interaction between years, flushes and irrigation treatments were found to be non-significant.

It is clear that availability of nitrogen in the growing medium increased linearly with the corresponding increase in irrigation water applied especially through drip and could be ascribed to the fact that with the application of higher amount of water applied through drip might have ensured requisite and uniform level of moisture content in the growing medium and consequently the availability of nitrogen contents in the growing medium was increased uniformly throughout.

Kruger *et al*. (1999) [3] studied the irrigation levels in strawberry that were scheduled on the basis of tensiometric measurement and climatic water balance model. They reported that available N content in non-irrigated strawberries varied from 42-118 kg ha^{-1} and with irrigation there was an increase in available N content up to 76 kg/ha in tensiometric based irrigation and up to 104 kg ha^{-1} with irrigation based upon the climatic water balance model.

The results of present study are also in agreement with the findings of Sathya *et al*. (2008) [7] who studied the effects of fertigation on availability of nutrients (N, P and K) in soil. The results obtained indicated that the availability of N, P and K nutrient was found to be higher in root zone area of drip fertigated plots. Similar findings had also been reported by Panigrahi and Sahu (2013) [69] who reported that there was an increase in available N, P, K content in okra at 0 to 0.2 m as well as 0.2 to 0.4 m soil depth with the application of higher levels of irrigation in comparison to lower levels of water.

Table 5: Effect of drip irrigation levels on available nitrogen (Kg ha^{-1}) of growing medium in alstroemeria cv. 'Capri'

Treatments	Available Nitrogen (kg ha^{-1})								
	1st year (2014-15)			2nd year (2015-16)			Pooled		
	B_1	B_2	Mean	B_1	B_2	Mean	B_1	B_2	Mean
T_1	386.57	387.44	387.01	389.04	390.04	389.54	387.80	388.74	388.27
T_2	379.07	381.15	380.11	381.09	383.04	382.07	380.08	382.09	381.09
T_3	381.20	383.23	382.22	385.64	386.78	386.21	383.42	385.03	384.21
T_4	388.81	389.45	389.13	392.02	393.19	392.60	390.42	391.32	390.87
T_5	395.27	396.24	395.76	399.14	400.14	399.64	397.21	398.19	397.70
T_6	386.61	387.62	387.11	389.28	391.28	390.29	387.94	389.45	388.70
T_7	380.71	381.79	381.25	383.78	384.87	384.33	382.25	383.33	382.79
T_8	385.84	387.19	386.52	387.47	388.58	388.025	386.66	387.89	387.27
T_9	394.20	395.59	394.89	397.99	399.33	398.66	396.10	397.46	396.78
T_{10}	396.15	397.47	396.81	400.15	402.13	401.14	398.15	399.80	398.97
Mean	387.44	388.72	388.08	390.56	391.94	391.25	389.00	390.33	
CD $_{(0.05)}$									
T (Treatments)							1.67		
B (Flushes)							0.75		
T×B	1.96			2.77			NS		
Y (Year)	0.88			1.24			0.75		
Y×T	NS			NS			NS		
Y×B							NS		
T×B×Y							NS		

Treatments:
T1 = Surface irrigation (October - September)
T2 = 4 litres/m2 (October - September)
T3 = 6 litres/m2 (October - September)

T4 = 8 litres/m2 (October - September)
T5 = 10 litres/m2 (October - September)
T6 = Surface irrigation (Oct - Feb) and 125% surface irrigation (March - September)
T7 = 4 litres/m2 (Oct - Feb) and 5 litres/m2 (March - September)
T8 = 6 litres/m2 (Oct - Feb) and 7.5 litres/m2 (March - September)
T9 = 8 litres/m2 (Oct - Feb) and 10 litres/m2 (March - September)
T10 = 10 litres/m2 (Oct - Feb) and 12.5 litres/m2 (March - September) Flushes:
B1 = 1st flush (October - May)
B2 = 2nd flush (June - September)

Available phosphorus (kg ha^{-1})

A perusal of data presented in Table 6 indicated that the applications of different irrigation treatments and flower flushes had exhibited significant effect on available phosphorus in the growing medium during both the years. In the 1st year (2014-15), maximum available phosphorus (60.15 kg ha^{-1}) was observed in treatment T_{10} i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be statistically at par with T_5 (59.51 kg ha^{-1}). Whereas, minimum available phosphorus (54.92 kg ha^{-1}) was observed in T_2 i.e. 4 litres/m^2 (October-September) and found to be statistically at par with the T_7 (55.03 kg ha^{-1}), both T_2 and T_7 applied through drip.

As regards the influence of flower flushes, the availability of phosphorus was found to be maximum (58.17 kg ha^{-1}) in 2nd flush and found to be significantly higher over 1st flush. Whereas, minimum available phosphorus (57.03 kg ha^{-1}) was observed in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on available phosphorus.

Similar trends were also observed during the 2nd year (2015-16). The maximum available phosphorus (62.14 kg ha^{-1}) in the growing medium was reported in T_{10} treatment i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be statistically at par with T_5 (61.51 kg ha^{-1}) through drip. Whereas, minimum available phosphorus in the growing medium (56.92 kg ha^{-1}) was recorded in T_2 i.e. 4 litres/m^2 (October-September) and found to be statistically at par with the T_7 (57.04 kg ha^{-1}), both treatments applied through drip.

As regards the flushes, the maximum available phosphorus (60.17 kg ha^{-1}) in the growing medium was present in 2nd flush and found to be significantly higher over 1st flush. However, minimum available phosphorus (59.03 kg ha^{-1}) was observed in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on availability of phosphorus in the growing medium.

Pooled data also revealed significant effect of different levels of irrigation and flushes on the available phosphorus present in the growing medium. Maximum available phosphorus (61.14 kg ha^{-1}) was present in the treatment T_{10} i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) and found to be significantly higher in comparison to all other irrigation treatments. Whereas, minimum available phosphorus (55.92 kg ha^{-1}) was recorded in T_2 i.e. 4 litres/m^2 (October- September) and found to be statistically at par with the T_7 (56.03 kg ha^{-1}), both T_2 and T_3 were applied through drip.

The different flushes had also exhibited significant effect on available phosphorus in growing medium. The maximum available phosphorus (59.17 kg ha^{-1}) was present during 2nd flush and found to be significantly higher over 1st flush. Whereas, minimum available phosphorus (58.03 kg ha^{-1}) was observed in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on available phosphorus of growing medium.

Both the years also showed significant differences in available phosphorus content of the growing medium. Maximum available phosphorus (59.60 kg ha^{-1}) was observed in 2nd year and found to be significantly higher. Whereas, it was minimum (57.60 kg ha^{-1}) in 1st year. The interaction between years, flushes and irrigation treatments were found to be non-significant.

Available phosphorus in the growing medium increased linearly with the corresponding increase in irrigation water applied, irrespective of methods of application. However, the availability of the phosphorus in the growing medium was higher with the application of more amount of water in general and particularly through drip. This could be ascribed to the fact that with the higher amount of water applied through drip might have ensured requisite and uniform level of moisture content in the growing medium which could have ultimately increased the mobility of phosphorus. So, availability of more phosphorus in the growing medium throughout.

Table 6: Effect of drip irrigation levels on available phosphorus (kg ha^{-1}) of growing medium in alstroemeria cv. 'Capri'

Treatments	Phosphorus (kg ha^{-1})								
	1st year (2014-15)			2nd year (2015-16)			Pooled		
	B_1	B_2	Mean	B_1	B_2	Mean	B_1	B_2	Mean
T_1	57.51	58.59	58.05	59.52	60.58	60.05	58.52	59.59	59.05
T_2	54.47	55.36	54.92	56.47	57.37	56.92	55.47	56.37	55.92
T_3	55.35	56.57	55.96	57.35	58.56	57.96	56.35	57.57	56.96
T_4	57.52	58.65	58.08	59.52	60.64	60.08	58.52	59.65	59.08
T_5	58.98	60.04	59.51	60.98	62.05	61.51	59.98	61.04	60.51
T_6	57.53	58.65	58.09	59.52	60.65	60.09	58.53	59.65	59.09
T_7	54.45	55.60	55.03	56.47	57.61	57.04	55.46	56.60	56.03
T_8	56.39	57.54	56.96	58.39	59.54	58.97	57.39	58.54	57.96
T_9	58.96	59.58	59.27	60.97	61.50	61.28	59.97	60.58	60.27
T_{10}	59.13	61.17	60.15	61.13	63.14	62.14	60.13	62.16	61.14
Mean	57.03	58.17	57.60	59.03	60.17	59.60	58.03	59.17	
CD $_{(0.05)}$									
T (Treatments)	0.85			0.84			0.59		
B (Flushes)	0.38			0.37			0.26		

T×B	NS	NS	NS
Y (Year)			0.26
Y×T			NS
Y×B			NS
T×B×Y			NS

Treatments:
T1 = Surface irrigation (October - September)
T2 = 4 litres/m2 (October - September)
T3 = 6 litres/m2 (October - September)
T4 = 8 litres/m2 (October - September)
T5 = 10 litres/m2 (October - September)
T6 = Surface irrigation (Oct - Feb) and 125% surface irrigation (March - September)
T7 = 4 litres/m2 (Oct - Feb) and 5 litres/m2 (March - September)
T8 = 6 litres/m2 (Oct - Feb) and 7.5 litres/m2 (March - September)
T9 = 8 litres/m2 (Oct - Feb) and 10 litres/m2 (March - September)
T10 = 10 litres/m2 (Oct - Feb) and 12.5 litres/m2 (March - September) Flushes:
B1 = 1st flush (October - May)
B2 = 2nd flush (June - September)

The results of the present study in general are in agreement with the findings of Sathya *et al*. (2008) [7] who had investigated the effects of fertigation on availability of nutrients (N, P and K) in soil. They reported that the availability of N, P and K nutrients was found to be higher in root zone area of drip fertigated plots in comparison to conventional methods of irrigation.
Similar findings had also been reported by Panigrahi and Sahu (2013) [6] and they also concluded that there was an increase in available N, P, K content in okra at 0 to 0.2 m and 0.2 to 0.4 m soil depths with higher levels of water application as compared to lower levels of irrigation.

Available potassium (kg ha^{-1})
A perusal of data enumerated in Table 7 indicated that the application of different irrigation treatments (through drip and surface irrigation methods) and flushes had shown significant effects on availability of potassium in the growing medium in both the years. In the 1st year (2014-15), maximum available potassium (252.14 kg ha^{-1}) in the growing medium was observed in T_{10} treatment i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be significantly higher over other treatments. Whereas, minimum available potassium (233.75 kg ha^{-1}) was recorded in T_2 i.e. 4 litres/m^2 (October- September) applied through drip.
As regards the effect of flushes, maximum available potassium (244.08 kg ha^{-1}) was present in 2nd flush and found to be significantly higher over 1st flush. Whereas, minimum available potassium (243.16 kg ha^{-1}) was observed in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on available potassium in the growing medium.
Similar trends were also observed in the 2nd year (2015-16). The maximum available potassium (254.33 kg ha^{-1}) in the growing medium was reported with the application of T_{10} treatment i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be significantly higher over other treatments. Whereas, minimum available potassium (238.84 kg ha^{-1}) was recorded in T_2 i.e. 4 litres/m^2 (October- September) and found to be statistically at par with the T_7 (240.47 kg ha^{-1}), both treatments applied through drip.
The different flushes had exhibited significant effect on available potassium in the 2nd year too. The maximum available potassium (247.82 kg ha^{-1}) in the growing medium was present in 2nd flush and found to be significantly higher over 1st flush. Whereas, minimum available potassium (246.55 kg ha^{-1}) was observed in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on availability of potassium in the growing medium.
Pooled data also revealed significant effect of different levels of irrigation treatments and flower flushes on the available potassium present in the growing medium. Maximum availability of potassium (253.23 kg ha^{-1}) was recorded in T_{10} treatment i.e. 10 litres/m^2 (October- February) and 12.5 litres/m^2 (March-September) applied through drip and found to be significantly higher over other treatments. Whereas, minimum available potassium (236.29 kg ha^{-1}) was observed in T_2 i.e. 4 litres/m^2 (October- September) applied through drip.
The different flushes had also exhibited significant effect on available potassium of the growing medium. The maximum available potassium (245.95 kg ha^{-1}) was present in 2nd flush and found to be significantly higher over 1st flush. Whereas, minimum available potassium (244.86 kg ha^{-1}) in the growing medium was observed in 1st flush. The interaction between irrigation treatments and flushes had exhibited non-significant effects on available potassium in the growing medium.
Both the years also showed significant differences in available potassium of growing medium. Maximum availability of potassium (247.19 kg ha^{-1}) present in the growing medium was observed in 2nd year and it was found to be minimum (243.62 kg ha^{-1}) in 1st year. The interaction between years, flushes and irrigation treatments were found to be non-significant.
The availability of potassium in the growing medium increased linearly with the corresponding increase in irrigation water applied and it was found to be maximum when the irrigation was given with the application of higher amount of water particularly through drip. This could be ascribed to the fact that irrigation of plants with the higher amount of water applied especially through drip might have ensured requisite and uniform level of moisture content which had ultimately increased the availability of potassium content in the growing medium throughout. The results of present study are in agreement with the findings of Sathya *et al*. (2008) [7] who studied the effect of fertigation on availability of nutrients (N, P and K) in soil. They reported that the availability of N, P and K nutrient was found to be higher in the root zone area of drip fertigated plots in comparison to the conventional method of irrigation.
Similar findings had also been reported by Panigrahi and

Sahu (2013) [6] and they concluded that there was an increase in available N, P, K content in okra at 0 to 0.2 m as well as 0.2 to 0.4 m soil depths with the application of higher levels of irrigation in comparison to lower levels of water.

Table 7: Effect of drip irrigation levels on available potassium (kg ha^{-1}) of growing medium in alstroemeria cv. 'Capri'

Treatments	**Potassium (kg ha^{-1})**								
	1st year (2014-15)			**2nd year (2015-16)**			**Pooled**		
	B_1	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**
T_1	245.39	246.42	245.90	247.39	248.43	247.91	246.39	247.42	246.91
T_2	233.28	234.23	233.75	237.84	239.83	238.84	235.56	237.03	236.29
T_3	236.09	237.15	236.62	242.37	243.61	242.99	239.23	240.38	239.80
T_4	246.63	247.43	247.03	248.64	249.43	249.04	247.63	248.44	248.04
T_5	250.63	251.43	251.03	252.63	254.01	253.32	251.63	252.72	252.17
T_6	245.41	246.29	245.85	247.41	248.29	247.85	246.41	247.29	246.85
T_7	235.23	236.16	235.70	239.92	241.03	240.47	237.58	238.59	238.08
T_8	238.85	239.57	239.21	245.19	246.67	245.93	242.02	243.12	242.57
T_9	248.51	249.52	249.02	250.52	251.86	251.19	249.52	250.69	250.10
T_{10}	251.63	252.64	252.14	253.63	255.03	254.33	252.63	253.82	253.23
Mean	243.16	244.08	243.62	246.55	247.82	247.19	244.86	245.95	
CD $_{(0.05)}$									
T (Treatments)							0.43		
B (Flushes)	0.58						0.19		
T×B	0.26			0.65			NS		
Y (Year)	NS			0.29			0.19		
Y×T				NS			0.12		
Y×B							NS		
T×B×Y							NS		

Treatments:
T1 = Surface irrigation (October - September)
T2 = 4 litres/m2 (October - September)
T3 = 6 litres/m2 (October - September)
T4 = 8 litres/m2 (October - September)
T5 = 10 litres/m2 (October - September)
T6 = Surface irrigation (Oct - Feb) and 125% surface irrigation (March - September)
T7 = 4 litres/m2 (Oct - Feb) and 5 litres/m2 (March - September)
T8 = 6 litres/m2 (Oct - Feb) and 7.5 litres/m2 (March - September)
T9 = 8 litres/m2 (Oct - Feb) and 10 litres/m2 (March - September)
T10 = 10 litres/m2 (Oct - Feb) and 12.5 litres/m2 (March - September) Flushes:
B1 = 1st flush (October - May)
B2 = 2nd flush (June - September)

Conclusion
From the present study, it is concluded that pH and EC of growing medium is considered to be within the safer limits and suitable for the cultivation of most of the crops. The treatment T_{10} recorded maximum values for available nitrogen (398.97 Kg ha^{-1}), available phosphorus (61.14 Kg ha^{-1}) and available potassium (253.23 Kg ha^{-1}) and therefore was found successful in ensuring higher availability of NPK content.

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