Plant Archives Vol. 18 No. 1, 2018 pp 365-371 ***ISSN 0972-5210***

STUDY ON PULSE IRRIGATION (DRIP) INFLUENCING THROUGH DIFFERENT IRRIGATION LEVELS ON GROWTH, YIELD AND QUALITY PARAMETERS OF WHITE ONION (*ALLIUM CEPA* L.)

D. A. Madane[a1*], M.S. Mane[b2], U.S. Kadam[b3], R.T. Thokal[c4], S. B. Nandgude[d1], S. T. Patil[b3] and J. S. Dhekale[e1]

[a1]Department of Soil Science, School of Agriculture, Lovely Professional University, Phagwara-144 411 (Punjab), India.
[b]Department of Irrigation and Drainage Engineering, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli - 415 712, Ratnagiri (Maharashtra), India.
[d1]Department of Soil and Water Conservation, College of Agricultural Engineering and Technology, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli - 415 712, Ratnagiri (Maharashtra), India.
[c]All India co-ordinated Irrigation and Water Management, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli - 415 712, Ratnagiri (Maharashtra), India.
[e1]College of Agriculture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli - 415 712, Ratnagiri (Maharashtra), India.

Abstract

The field experiment was conducted during two *rabi* seasons from 12th November, 2014 to 26th April, 2015 and 23rd November, 2015 to 4th May 2016, on sandy clay loam soil. The experiment was arranged in twelve treatment combinations with strip plot design as horizontal factor (main treatment) one continuous irrigation (P_1), two pulses (P_2), three pulses (P_3) and four pulses (P_4), while vertical factor (sub treatment) as irrigation levels *viz*. I_1 (0.80 ET_C), I_2 (1.0 ET_C) and I_3 (1.20 ET_C) treatments. It was revealed that the average seasonal water applied to white onion under pulse irrigation (drip) through different irrigation levels varied from 283.3 mm for I_1 (0.8 ET_C) to 417.5 mm for I_3 (1.2 ET_C) irrigation levels. The interaction effect revealed that geometric mean diameter (59.51 mm), average bulb weight (112.05 g) and yield (38.52 $t.ha^{-1}$) of white onion was found in treatment combination I_2P_4 followed by I_3P_4. Average water use efficiency was found maximum for I_1P_4 (11.93 $q.ha^{-1}.cm^{-1}$) treatment combination followed by I_1P_3 (11.33 $q.ha^{-1}.cm^{-1}$) and I_2P_4 (10.99 $q.ha^{-1}.cm^{-1}$) treatment combination. It was concluded that use of 100 percent crop water requirement with four pulse irrigation (drip) found superior under agronomic and climatic conditions of Dapoli in Konkan region of Maharashtra, India.

Key words : Pulse irrigation (drip), irrigation scheduling, water use efficiency, yield, quality, net returns and B C ratio.

Introduction

The global land area is 13.2 billion ha, out of this 12 percent (1.6 billion ha) is currently in use for cultivation of agricultural crops, 28 per cent (3.7 billion ha) is under forest and 35 per cent (4.6 billion ha) comprises grassland and world land ecosystems (FAO, 2015). India has total geographical area of 328.70 M.ha, out of this cultivable land area is about 182 M.ha, comprising of this net sown area of about 141.40 M.ha. Total gross cropped area is 200.90 M.ha with cropping intensity of 142 per cent. The net sown area works out to be 43 per cent of the total geographical area (Anonymous, 2016).

***Author for correspondence :** E-mail: dnyaneshwar.22722@lpu.co.in

Pulse irrigation (drip) is the concept where small part of the per day water requirement is given in fraction with a predetermined time of fraction (Dole, 1994). Pulsing irrigation refer to the practice of irrigating for a short period then waiting for another short period, and repeating this on-off cycle until the entire irrigation water is applied (Eric *et al*., 2004). In case of sandy soil under pulse irrigation (drip) horizontal spread of soil moisture is increased than the vertical spread. High irrigation frequency provides desirable conditions for water movement in the soil and uptake by roots (Segal *et al*., 2000). Increased vertical spreading may be undesirable because water moving below the active root zone can result in wastage of water, loss of nutrients and ground water pollution. Application of high amount of irrigation water in single irrigation event may resulted in deep percolation losses in the root zone of growing plants.

Splitting of irrigation depth in to six pulses with interval of fifty minutes increased the yield by 5.78% with 25% of water saving in lettuce crop under sandy soils (Willian *et al.*, 2015). Under pulse irrigation (drip) productivity of potato increased from 10.44 $t.ha^{-1}$ for continuous drip irrigation to 15.60 $t.ha^{-1}$ for four pulse irrigation (drip) recording an increase yield of 49% (Abdelraouf *et al.*, 2012). Average maximum green bean yield was obtained under four pulses 4.78 $t.ha^{-1}$, while minimum yield was obtained in treatment of continuous irrigation 4.78 ton. ha^{-1} (Mohamed *et al.*, 2012). White onion crop can be cultivated effectively in South Konkan region comprising of Ratnagiri and Sindhudurg district having predominant lateritic soil. The lateritic soil is having high infiltration rates resulting in increased vertical movement of water (Mane *et al.*, 2011). Pulse irrigation (drip) can be used effectively for increasing the horizontal spread in heavy infiltrating soils (Abdelraouf *et al.*, 2012).

Materials and Methods

The field experiment was conducted during two *rabi* seasons from 12th November, 2014 to 26th April, 2015 and 23rd November, 2015 to 4th May 2016, in the Instructional Farm of Department of Irrigation and Drainage Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The experimental site is situated at 17^0 45' 13.1" N latitude and 73^0 10' 47.4" E longitudes and altitude of 174 m. Climatic conditions are humid with average annual rainfall at Dapoli region is 3635 mm (Mandale, 2016). The average minimum and maximum temperatures are 18.5^0C to 31.0^0C, respectively. The relative humidity ranges from 55 percent to 99 percent (Gaikwad, 2013). The experimental design was strip plot and replicated four times. The unit plot size was 27.50 m × 9.70 m having single bed of 3 m × 1.20 m. Onion seedlings were transplanted in the plots on 15 January 2015 and 24 January 2016 at the age of six weeks. Plant to plant and row to row spacing were 10 cm and 15 cm, respectively (Anonymous, 2014 and Kamboj *et al.*, 2016). The soil type of experimental field was sandy clay loam in texture having pH- 6.5, EC- 6.0 $cm.hr^{-1}$, bulk density- 1.68 $g.cm^{-3}$, basic infiltration rate- 6.0 $cm.hr^{-1}$, field capacity- 26.01% and permanent wilting point- 12.50%.

In the horizontal strips (main treatments), there were four pulse (drip) irrigation treatments

P_1 = Continuous irrigation

P_2 = Two pulses irrigation

P_3 = Three pulses irrigation

P_4 = Four pulses irrigation

Time interval between successive pulse treatments was 30 minutes. In the vertical strips (sub treatment), there were three irrigation levels.

$$I_1 = 0.8\ ET_C$$
$$I_2 = 1.0\ ET_C$$
$$I_3 = 1.2\ ET_C$$

Where,

ET_C = Crop evapotranspiration ($mm.day^{-1}$)

The plots were fertilized with recommended dose of soluble fertilizer 150- 75- 25 $Kg.ha^{-1}$ N, P_2O_5 and K_2O, respectively (Anonymous, 2012). The nine and twelve millimetre of irrigation water has applied immediately after planting to establish the seedlings during the year 2014-2015 and 2015-2016, respectively. The soil moisture samples were taken 2 hrs before and 2 hrs after irrigation at fortnight interval starting from 30 DAT to 75 DAT for all treatment combinations sequentially in all replications. The moisture content was determined by using gravimetric method. The inline lateral of 16 mm with 4 Lph discharge having 30 cm spacing at 1.0 $kg.cm^{-2}$ operating pressure was used. The daily water requirement of white onion (*Alium cepa* L.) under pulse irrigation (drip) was worked out based on Penman Monteith method (Allen *et al.*, 1998). The available discharge and emission uniformity of the drip system was recorded as 3.94 $L.ha^{-1}$ and 96.0 in year 2015 and 3.96 $L.ha^{-1}$ and 94.50 in year 2016, respectively. Irrigation was stopped before 15 days of harvesting. The onion bulbs were harvested on 2nd May 2015, in the first year and 9th May 2016, in the 2nd year, respectively. The various periodic biometric observations were recorded on five randomly selected plants of white onion at 20 days interval from 30 DAT to 70 DAT from each plot of treatments. The statistical analysis was done by "Analysis of variance" appropriate for the 'strip plot design'. The data regarding each character was statistically computed by using SAS software. The results for critical difference (CD) at five percent level of significance were worked out.

Results and Discussion

A. Gross depth of white onion applied

It was contemplated that reference evapotranspiration, crop evapotranspiration, gross depth of water applied during the year 2014-15 and 2015-16 are represented in the table 1.

It was observed from the table 1 that total reference evapotranspiration during the crop growth period in year 2014-15 and 2015-16 was 375.0 mm and 387.6 mm, respectively. The crop evapotranspiration during the year 2014-15 and 2015-16 was varied from 327.7 mm to 340.5 mm. From the table 1 that total water applied under treatment I_1 (0.8 ET_C) varied from 276.8 mm to 289.8 mm in the year 2014-15 and 2015-16, while it was 341.0 mm to 359.9 mm and 406.1 mm to 429.0 mm for irrigation treatments I_2 (1.0 ET_C) and I_3 (1.2 ET_C).

B. Biometric observations of white onion

It was evident from the table 2 that crucial characteristics of biometric observation such as number of leaves, plant height and neck diameter increases with increasing number of pulse treatments. Individual effect of number of leaves, plant height and neck diameter were found significant. The highest number of leaves, plant height and neck diameter were found in P_4 (four pulse) treatment followed by P_3 (three pulse) treatment, respectively.

Table 1 : Month wise gross depth of water applied and seasonal irrigation applied for white onion under different irrigation treatments.

Irrigation levels	Season	January*	January**	February	March	April#	Seasonal ET_O/ ET_C/ Gross depth (mm)
ET_O	2015	12.1	41.5	109.8	134.3	77.3	375.0
ET_C		9.0	29.1	85.5	129.2	75.4	327.7
I_1 (0.8 ET_C)		9.0	23.2	71.2	111.1	62.8	276.8
I_2 (1.0 ET_C)		9.0	30.3	89.1	134.6	78.5	341.0
I_3 (1.2 ET_C)		9.0	36.3	106.9	161.5	92.9	406.1
ET_O	2016	17.1	7.1	108.9	141.9	112.6	387.6
ET_C		12.0	7.5	79.7	130.7	110.6	340.5
I_1 (0.8 ET_C)		12.0	6.0	67.5	110.6	93.7	289.8
I_2 (1.0 ET_C)		12.0	7.9	84.3	138.4	117.3	359.8
I_3 (1.2 ET_C)		12.0	9.5	101.1	165.9	140.5	429.0

* - General irrigation for establishment of the crop from 15th January to 18th January, 2015 and from 24th January to 29th January, 2016. ** - Pulse treatments were imposed on 19th Jan 2015 and 29th Jan 2016. # - Water application terminated on 16th April 2015 and 23th April 2016

Table 2 : Individual effect of biometric observation of white onion (Pooled).

Pulse/ irrigation treatments	Number of leaves DAT			Plant height (cm) DAT			Neck diameter (mm) DAT		
	30	50	70	30	50	70	30	50	70
Continuous (P_1)	4.60	5.61	6.27	34.61	50.73	59.97	7.54	12.26	15.68
Two (P_2)	4.72	5.80	6.61	35.82	51.86	63.58	8.14	12.53	17.13
Three (P_3)	5.39	6.17	7.11	39.83	54.91	67.07	9.07	13.35	18.66
Four (P_4)	5.60	6.43	7.53	45.58	58.00	68.97	9.82	14.17	19.95
S.E.	0.10	0.06	0.07	1.60	0.62	0.55	0.20	0.15	0.18
C.D. at 5 %	0.29	0.18	0.20	4.76	1.85	1.62	0.59	0.45	0.55
I_1 (0.8) ET_C	4.92	5.83	6.55	38.16	51.50	63.47	8.06	12.61	16.69
I_2 (1.0) ET_C	5.27	6.03	6.97	40.06	55.31	64.42	8.93	13.38	18.54
I_3 (1.2) ET_C	5.04	6.15	7.12	38.65	54.81	66.81	8.95	13.25	18.33
S.E.(m) ±	0.10	0.08	0.18	0.92	0.38	0.51	0.18	0.20	0.27
C.D. at 5%	NS	0.245	0.55	2.84	1.18	1.58	0.56	0.61	0.83

The highest number of leaves (5.60, 6.43 and 7.53, respectively), plant height (45.58 cm, 58.00 cm and 68.97 cm, respectively) and neck diameter (9.82 mm, 14.17 mm, 19.95 mm, respectively) was found for P_4 at 30, 50 and 70 DAT during the pooled data. These results are related with number of leaves, plant height and neck diameter of white onion which is corroborated with findings of Abdelraouf *et al.* (2013) and Mohamed *et al.* (2012).

It was observed from the table 2 that irrigation levels revealed significant in number of leaves, plant height and neck diameter of white onion at 30, 50 and 70 DAT, respectively.

The effect of irrigation levels revealed that maximum number of leaves, plant height and neck diameter were recorded for I_3 (1.2 ET_C) irrigation levels, which were found 7.12, 66.81 cm and 18.33 mm, respectively at 70 DAT (Hanchinmani and Imamsaheb, 2016). The number of leaves were varied from 4.92 for I_1 (0.8 ET_C) to 7.12 for I_3 (1.2 ET_C) irrigation levels at 30 DAT and similar trends were found for plant height and neck diameter of white onion at 30, 50 and 70 DAT, respectively. These similar trends are corroborated by the findings of Bagali *et al,* (2012) that the irrigation interval of one day (M_1) and two days (M_2) at 100% percent PE increased the plant height significantly and this may be due to increased neck girth and number of leaves of white onion crop.

The interaction effect of irrigation levels and pulse irrigation (drip) on number of leaves, plant height and neck diameter are presented in table 3. The interaction effect of number of leaves at 50 DAT and 70 DAT was found non-significant, while significant at 30 DAT. In case of plant height at 50 DAT was found non-significant while significant at 30 DAT and 70 DAT, respectively.

The effect of interaction for neck diameter at 30 and 50 DAT was found non-significant while significant at 70 DAT, respectively. The interaction effect revealed that highest number of leaves (6.08, 6.55 and 7.83), plant height (47.57, 62.20 and 70.20 cm) and neck diameter of onion (10.14, 14.84 and 21.52 mm) at 30, 50 and 70 DAT was found in treatment combination I_2P_4, respectively followed by I_3P_4.

C. Yield contributing parameters of white onion

The data in the table 4 revealed that influencing different irrigation levels through pulse treatment P_2, P_3 treatments and continuous irrigation (P_1) increased significantly the yield parameters like bulb diameter, average bulb weight and yield of white onion. The highest polar diameter (61.30 mm), geometric mean diameter (58.41 mm), equatorial diameter (60.86 mm), average bulb weight (107.38 g) and yield (36.50 $t.ha^{-1}$) of a white onion was found in P_4 (four pulse treatment), respectively.

The data in the table 4 revealed that influencing irrigation levels I_1 (0.8 ET_C), I_2 (1.0 ET_C) and I_3 (1.2 ET_C) significant increased the yield parameters like bulb diameter, average bulb weight and yield of white onion. The highest geometric mean diameter (54.24 mm), equatorial diameter (55.53 mm), average bulb weight (95.97 g) and yield (33.15 $t.ha^{-1}$) of white onion was found in I_3 (1.2 ET_C) irrigation level, except mean polar diameter (57.07 mm) in I_2 (1.0 ET_C) irrigation level, respectively. Similar trends of irrigation on size of onion bulb was

Table 3 : Interaction effect of biometric observation of white onion (Pooled).

Pulse/ irrigation treatments	Number of leaves DAT			Plant height (cm) DAT			Neck diameter (mm) DAT		
	30	50	70	30	50	70	30	50	70
I_1P_1	4.50	5.58	6.05	33.63	48.17	61.10	7.10	11.88	14.02
I_1P_2	4.60	5.70	6.23	34.78	49.51	60.42	7.19	12.17	15.87
I_1P_3	5.18	5.85	6.78	40.38	53.02	65.19	8.46	12.86	18.14
I_1P_4	5.40	6.20	7.15	43.86	55.29	67.16	9.48	13.52	18.72
I_2P_1	4.66	5.65	6.10	34.08	53.07	55.62	7.68	12.61	16.35
I_2P_2	4.83	5.73	6.73	36.89	52.60	64.48	8.46	12.56	17.43
I_2P_3	5.53	6.20	7.23	41.71	55.38	67.37	9.44	13.51	18.87
I_2P_4	6.08	6.55	7.83	47.57	60.20	70.20	10.14	14.84	21.52
I_3P_1	4.65	5.61	6.66	36.13	50.94	63.19	7.86	12.30	16.68
I_3P_2	4.73	5.98	6.88	35.79	53.46	65.83	8.78	12.85	18.08
I_3P_3	5.48	6.45	7.33	37.40	56.32	68.65	9.32	13.69	18.98
I_3P_4	5.33	6.55	7.60	45.31	58.50	69.56	9.85	14.15	19.61
S.E.(m)±	0.10	0.40	0.47	0.47	2.64	0.95	0.33	0.39	0.34
C.D. at 5 %	0.27	NS	NS	0.44	NS	2.74	NS	NS	0.97

Table 4 : Individual effect of yield parameters of white onion (Pooled).

Pulse/irrigation treatments	Polar diameter (mm)	Geometric mean diameter (mm)	Equatorial diameter (mm)	Average bulb weight (g)	Yield (ton per ha.)	TSS (^{0}Brix)
Continuous (P_1)	49.12	46.90	48.07	68.92	27.26	7.11
Two (P_2)	53.09	49.53	50.52	83.22	28.89	7.80
Three (P_3)	57.10	54.53	55.55	98.97	33.64	9.14
Four (P_4)	61.30	58.41	60.86	107.38	36.50	9.81
S.E.	0.86	0.43	0.40	1.27	0.91	0.15
C.D. at 5 %	2.56	1.27	1.19	3.76	2.70	0.44
I_1 (0.8) ET_C	51.80	49.41	50.92	77.94	29.30	7.55
I2 (1.0) ET_C	57.07	53.38	54.79	94.96	32.27	8.82
I3 (1.2) ET_C	56.59	54.24	55.53	95.97	33.15	9.03
S.E.(m) ±	0.93	0.67	0.33	0.78	0.25	0.15
C.D. at 5 %	2.86	2.05	1.03	2.39	0.78	0.46

Table 5 : Interaction effect of yield parameters of white onion (Pooled).

Pulse/irrigation treatments	Polar diameter (mm)	Geometric mean diameter (mm)	Equatorial diameter (mm)	Average bulb weight (g)	Yield (ton per hectare)	TSS (^{0}Brix)
I_1P_1	46.84	44.30	45.49	57.07	25.24	6.65
I_1P_2	48.80	46.56	47.26	65.13	26.26	6.81
I_1P_3	53.68	51.40	53.67	88.82	31.99	8.33
I_1P_4	57.87	55.37	57.27	100.75	33.71	8.44
I_2P_1	49.70	47.89	48.94	71.81	27.25	7.23
I_2P_2	56.44	50.50	51.16	88.64	29.64	7.90
I_2P_3	58.25	55.64	55.91	107.32	33.66	9.70
I_2P_4	63.88	59.51	63.16	112.05	38.52	10.44
I_3P_1	50.82	48.52	49.77	77.88	29.29	7.47
I_3P_2	54.02	51.53	53.13	95.90	30.76	8.70
I_3P_3	59.38	56.56	57.09	100.77	35.28	9.40
I_3P_4	62.14	60.35	62.15	109.34	37.26	10.56
S.E.(m)±	0.71	0.71	0.74	2.19	0.81	0.10
C.D. at 5 %	2.04	NS	NS	NS	NS	0.28

observed by Olalla *et al*. (2004).

Increase in the bulb yield is mainly attributed to positive association between yield and yield contributing parameters like bulb weight and size in terms of equatorial and polar diameter of the bulb. The shorter interval of irrigation ensures optimum growth of the crop by assuring balanced water and nutrient supply throughout the crop growth period. Similar result for bulb yield was reported by Quadir *et al*. (2005).

It was evident from the table 5 that among the different treatment combination I_2P_4 treatment combination was found significantly superior over I_1P_1 and at par with I_3P_4. It was evident from the table 5 that interaction effect revealed that highest polar diameter (63.88 mm), geometric mean diameter (59.51 mm), equatorial diameter (63.16 mm), average bulb weight (112.05 g) and yield (38.52 $t.ha^{-1}$) of white onion was found in treatment combination I_2P_4 followed by I_3P_4, respectively. These results corroborated by findings of Zin El-Abedin (2006), Feng- Xin, *et al*. (2000), Beenson (1992).

D. Quality parameters of white onion

It was contemplated from the table 4 that highest TSS at 1.2 ET_C (9.03 ÚBrix) probably due to fulfilment of optimum demand of crop for moisture and their proper utilization (Shailendra Kumar Singh *et al.*, 2012). This corresponds to earlier finding of Vagen and Slimestad, (2008). From pooled data reported in the table 5 that effect of interaction inferred maximum T.S.S was found 10.56 (^{0}Brix) in treatment combination I_3P_4, which was significantly more than other treatment combination.

Table 6 : Average water use efficiency of white onion crop.

Treatment combination	Yield of white onion ($q.ha^{-1}$)		Average yield of white onion($q.ha^{-1}$)	Depth of water applied (cm)		Average depth of water applied (cm)	Average water use efficiency ($q.ha^{-1}cm^{-1}$)
	2015	2016		2015	2016		
I_1P_1	288.62	216.3	252.46	27.46	29.06	28.25	8.94
I_1P_2	300.78	224.53	262.66	27.46	29.06	28.25	9.30
I_1P_3	348.32	291.58	319.95	27.46	29.06	28.25	11.33
I_1P_4	355.08	319.16	337.12	27.46	29.06	28.25	11.93
I_2P_1	307.5	237.51	272.51	34.09	35.96	35.04	7.78
I_2P_2	327.94	256.24	292.09	34.09	35.96	35.04	8.34
I_2P_3	371.58	301.75	336.67	34.09	35.96	35.04	9.61
I_2P_4	394.06	376.39	385.23	34.09	35.96	35.04	10.99
I_3P_1	329.52	246.92	288.22	40.87	42.96	41.92	6.88
I_3P_2	337.7	277.41	307.56	40.87	42.96	41.92	7.34
I_3P_3	362.56	343.05	352.81	40.87	42.96	41.92	8.42
I_3P_4	384	361.21	372.61	40.87	42.96	41.92	8.89

E. Water use efficiency

It was contemplated from the table 6 that average water use efficiency was found maximum for I_1P_4 (11.93 $q.ha^{-1}cm^{-1}$) treatment combination followed by I_1P_3 (11.33 $q.ha^{-1}cm^{-1}$) and I_2P_4 (10.99 $q.ha^{-1}cm^{-1}$) treatment combination, respectively. The trend of water use efficiency with depth of water applied was varies as the yield of white onion. The reason is that amount of water applied was not same for all treatments.

Conclusion

In conclusion of present study indicated that among the different treatment combination I_2P_4 was found significantly superior over I_1P_1 and at par with I_3P_4 treatment combination. The average seasonal water applied to white onion under pulse irrigation (drip) through different irrigation levels was varied from 283.3 mm for I_1 (0.8 ET_C) to 417.5 mm for I_3 (1.2 ET_C) irrigation levels. The interaction effect revealed that highest polar diameter (63.88 mm), geometric mean diameter (59.51 mm), equatorial diameter (63.16 mm), average bulb weight (112.05 g) and yield (38.52 $ton.ha^{-1}$) of white onion was found in treatment combination I_2P_4 (irrigation level 1.0 ET_C and four pulse treatment) followed by I_3P_4 (irrigation level 1.2 ET_C and four pulse treatment), respectively. Average water use efficiency was found maximum for I_1P_4 (11.93 $q.ha^{-1}cm^{-1}$) treatment combination followed by I_1P_3 (11.33 $q.ha^{-1}cm^{-1}$) and I_2P_4 (10.99 $q.ha^{-1}cm^{-1}$) treatment combination.

References

Abdeleaouf, R. E., S. D. Abou-Hussein, A. M. Abd-Alla and Abdallah (2012). Effect of short irrigation cycles on soil moisture distribution in root zone, fertilizer use efficiency and productivity of potato in new reclaimed lands. *Journal of Applied Science Research*, **8(7)** : 3823-3833.

Abdelraouf, R. E., S. D. Abou-Hussein, M. Neema and Marzouk (2013). Effect of pulse drip irrigation and mulching systems on yield, quality traits and irrigation water use efficiency of Soybean under sandy soil conditions. *Journal of Agricultural Sciences*, **4(5)** : 249-261.

Allen, R. G., R. Dirk and S. Martien (1998). Crop evapotranspiration guidelines for computing crop water requirement – FAO Irrigation and Drainage Paper 56, Food and Agriculture Organizations of the United Nations Rome.

Anonymous (2012). Recommendation release report of the Joint Agresco of State Agricultural Universities in Maharashtra.

Anonymous (2014). Report on area production and productivity of onion (*Allium cepa* L) in India and Maharashtra, NRCOG, Rajgurunagar, Maharashtra, India. [site: www.dogr.org.in/database]

Anonymous (2016). *Agricultural statistics at a Glance Government of India*. Ministry of Agriculture and Farmers Welfare Directorate of Economics and Statistics.

Bagali, A. N., H. B. Patil, M. B. Guled and R. V. Patil (2012). Effect of scheduling of drip irrigation on growth yield and water use efficiency of onion (*Allium cepa* L.). *Karnataka Journal of Agricultural Science*, **25(1)** : 116-119.

Beenson, R. C. (1992). Restricting overhead irrigation to dawn limits growth container ornamentals. *Horticultural Science*, **27** : 996-999.

Dole, J. M. (1994). Comparing poinsettia irrigation methods. *The Poinsettia*, **10** : 4-9.

Eric, S., S. David and H. Robert (2004). To pulse or not to pulse drip irrigation that is the question UF/IFAS – Horticultural Sciences Department. Florida, USA NFREC-SV-Vegetarian (04-05).

FAO (2015). The state of the Worlds Land and Water Resources for food and Agriculture Managing systems at risk. The Food and Agriculture Organization of the United Nations and Earth Scan.

Feng-xin, W., Y. Kang and L. Shi-Ping (2006). Effects of drip irrigation frequency on soil wetting pattern and potato growth in north china plain. *Journal of Agricultural Water Management*, **79** : 248-264.

Gaikwad, M. A. (2013). Estimation of crop water requirement under varying climatic conditions for Dapoli Tahsil. *Unpublished Thesis* College of Agricultural Engg. and Tech., Dr. B.S.K.K.V., Dapoli, Maharashtra.

Hanchinmani, C. N. and S. J. Imamsaheb (2016). Performance of different onion verities in *Kharif* season under north estern transition zone of Karnataka. *New Agriculturist*, **27 (2)** : 253-258.

Kamboj, N., M. K. Rana, V. K. Batra and Navjot Singh Brar (2016). Adjustment of plant spacing and fertilizer dose in relation to quality onion (*Allium cepa* L) seed. *New Agriculturist Journal*, **27 (2)** : 227-232.

Mane, M. S., U. V. Mahadkar, D. J. Dabake and T. N. Thorat (2011). Study efficiency of different sealant material for lateritic soils of Konkan region. *Journal of Indian Society Agric. Res*., **29(2)** : 82-83.

Mane, M. S., G. G. Kadam and S. T. Patil (2014). Effect of irrigation levels on vegetative growth and yield characteristics in white onion (*Allium cepa* L.) in Konkan region. *International Journal of Agricultural Engineering*, **7(2)** : 422-226.

Mandale, V. (2016). Trend analysis of rainfall in Konkan region of Maharashtra. *Unpublished Thesis* College of Agricultural Engg. and Tech. Dr. B.S.K.K.V. Dapoli, Maharashtra.

Michael, A. M. (1978). *Irrigation theory and practices text book.* ISBN: 978-81259-1867-7.

Mohamed, M. E., E. A. Mohamed and L. A. Amal (2012). Response of Green bean to pulse surface drip irrigation. *Journal of Horticultural Science and Ornamental Plants*, **4(3)** : 329-334.

Olalla, F. M., A. Dominguez-Padilla and R. Lopez (2004). Production and quality of onion crop (*Allium cepa* L.) cultivates in semi acid climate. *Agricultural Water Management*, **68** : 77-89.

Quadir, M., A. Bulton, J. Ekman, M. Hickey and H. Robert (2005). Influence of drip irrigation on onion yield and quality IREC Farmers' News letter, No. 170, spring.

Segal, E., A. Ben-Gal and U. Shani (2000). Water availability and yield response to high frequency micro irrigation in sunflowers. 6th International Micro-irrigation Congress. 'Micro-irrigation Technology for Developing Agriculture'. South Africa, 22-27 October. E-mail alonben-gal@rd.ardom.co.in.

Singh, Shailendra Kumar, Balaji Vikram, V. M. Prasad and Atul Anand Mishra (2012). Effect of integrated nitrogen management on total soluble solids and ascorbic acid content of onion. *New Agriculturist Journal*, **23(1)** : 41-43.

Vagen, I. M. and R. Slimestad (2008). Amount of characteristic compounds in 15 cultivars of onion (*Allium cepa* L.) in controlled field trials. *Journal of the Science of Food and Agriculture*, **88** : 404-411.

Willian, F. D., E. Almeida, L. A. Lima and M. P. Geraldo (2015). Drip pulses and soil mulching effect on American cripshead lettuce yield. *Journal of the Brazilian Association of Agricultural Engineering*, **35n6p (V)** : 1009-1018.

Zin El-Abedin, T. K. (2006). Effect of pulse drip on soil moisture distribution and maize production in clay soil. *Journal of Irrigation and Drainage Engineering* 'new trends in Agricultural Engineering': 1032-105.