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Study of white onion (*Alium cepa* L.) on yield and economics under pulse irrigation (drip) for different irrigation levels

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■ **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 at Instructional Farm of Department of Irrigation and Drainage Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidypeeth, Dapoli, India (latitude 17^0 45' N and longitude 73^0 10' E and altitude of 250 m). 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 276.8 mm for I_1 (0.8 ET_C) to 429.0 mm for I_3 (1.2 ET_C) irrigation levels. Among the different treatment combination I_2P_4 (irrigation level I_2 (1.0 ET_C) with four pulse treatment P_4) was found 38.52 $t.ha^{-1}$ and significantly superior over I_1P_1 (irrigation level I_1 (0.8 ET_C) with continuous irrigation P_1). The production cost of Rs. 4,47,366 and Rs. 4,42,962 ha^{-1}, gross returns of Rs. 9,63,000 and Rs. 9,31,500 ha^{-1}, net returns of Rs. 5,15,634 and Rs. 4,88,538 ha^{-1} and B C ratio of 2.15 and 2.10, were observed for I_2P_4 and I_3P_4 treatment combinations, 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 combinations, respectively.

■ **KEY WORDS :** Pulse irrigation (drip), Irrigation scheduling, Water use efficiency, White onion, Cost of production, Net returns, B : C ratio

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Water is the most important natural resource. World irrigated area covers 299 M.ha out of which India is having irrigated area of 62 M.ha (ICID, 2016). Water resources can be divided into two categories, surface water and ground water resources. India has major rivers whose total catchment area is 252.80 M.ha (ICAR, 2016). The geographical area of Maharashtra is about 30.77 M.ha, which is third largest in the country in terms of land area. Out of this 30.77 M.ha, 21.04 M.ha (68 %) is cultivable land and 6.20 M.ha (20%) is under forest. World micro irrigation land area covers 14.41 M.ha out of which India is having 1.8 M.ha (ICID, 2016). The highest micro irrigation coverage is in the state of Maharashtra (0.48 M.ha) followed by Andhra Pradesh, Karnataka, Gujarat and Tamil Nadu (NCPAH, 2016).

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, 1993). 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). Splitting of irrigation depth in to six pulses with interval of fifty minutes increased the yield by 5.78 per cent with 25 per cent of water saving in lettuce crop under sandy soils (Willian *et al*., 2015). Under pulse irrigation (drip) productivity of potato increased from 10.44 $t.ha^{-1}$ in continuous drip irrigation to 15.60 $t.ha^{-1}$ in four pulse irrigation (drip) recording an increase of 49 per cent yield (Abdeleaouf *et al*., 2012). Average maximum green bean yield was obtained under four pulse irrigation (drip) 4.78 $t.ha^{-1}$ (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 rate 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 (Abdeleaouf *et al*., 2012).

METHODOLOGY

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

Table A : Physical and chemical properties of soil

Physical /chemical properties	
Textural class (% 54.76 Sand, 18.62 % silt and 26.62 % clay), Bouyoucos (1962)	Sandy clay loam
Bulk density, Black (1965)	1.68 $g.cm^{-3}$
Field capacity, Michael (1978)	26.00 %
Wilting point, Michael (1978)	12.50 %
Basic infiltration rate , Michael (1978)	6.0 $cm.hr^{-1}$
pH, Jackson (1973)	6.5
EC, Jackson (1973)	0.45 $dS.m^{-1}$
Available N (kg ha^{-1}), Subhiah and Asija (1956)	175
Available P (kg ha^{-1}), Olsen *et al.* (1954)	15.50
Available K (kg ha^{-1}), Hanway and Heidal (1952)	270.50

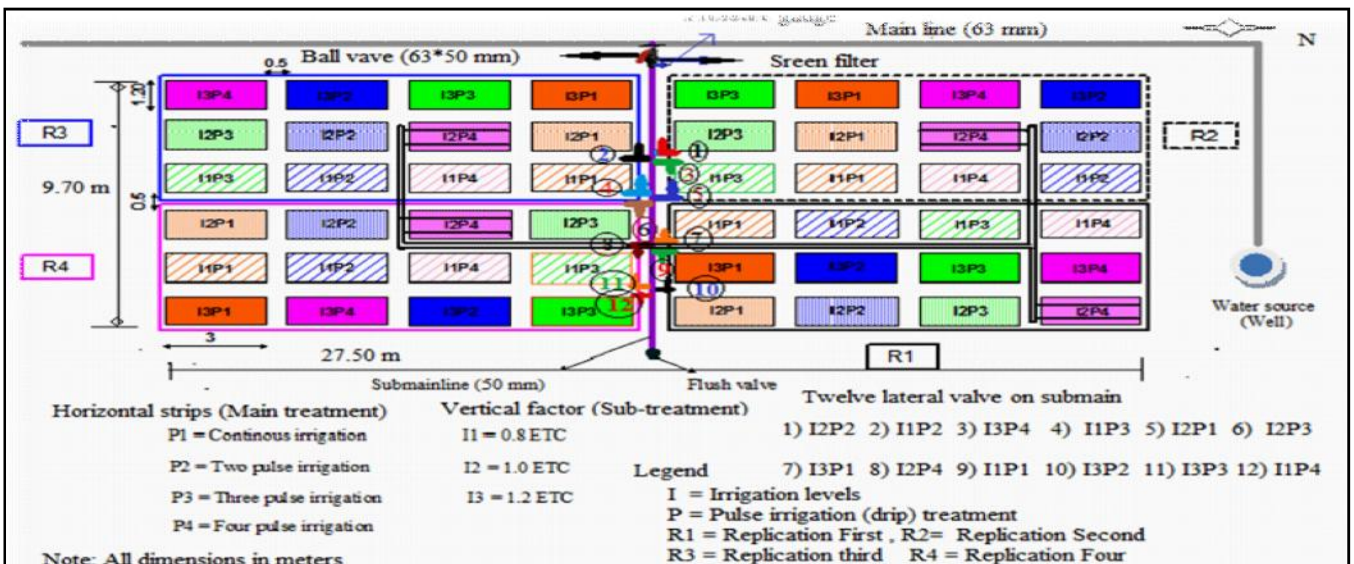

Fig. A: Experimental layout

Drainage Engineering, College of Agricultural Engineering and Technology, Dr. BSKKV, Dapoli. 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 ^{0}C to 31.0 ^{0}C, respectively. The relative humidity ranges from 55 per cent to 99 per cent (Gaikwad, 2013). 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). 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 kgha^{-1} N, P_2O_5 and K_2O, respectively (Anonymous, 2012). Nine and twelve millimetre of irrigation water 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 after irrigation at fortnight interval starting from 30 DAT to 75 DAT for all treatment combinations sequentially in all replications. 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 97.06 for year 2015 and 3.96 l.ha^{-1} and 94.50 for 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 per cent level of significance were worked out.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Gross depth of water applied:

The reference evapotranspiration, crop evapotranspiration (net depth) and total seasonal gross depth of water applied during the year 2014-15 and 2015-16 are presented in Table 1.

Table 1: Month wise gross depth of water applied and seasonal irrigation applied (mm) of white onion under three 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

It was evident 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 varied from 327.7 mm to 340.5 mm during the year 2014-15 and 2015-16. From Table 1 total water applied under treatment I_1 (0.8 ET_C) ranged from 276.8 mm to 289.8 mm in the year 2014-15 and 2015-16, while it was 340.5 mm to 359.8 mm and 406.1 mm to 359.8 mm for irrigation treatments I_2 (1.0 ET_C) and I_3 (1.2 ET_C), respectively.

Yield and quality attributing parameters of white onion:

The data contemplated in the Table 2 revealed that influencing different irrigation levels through different pulse treatments P_2 (two pulse), P_3 (three pulse) and P_4 (four pulse) and continuous irrigation (P_1) increased significant the yield parameters like bulb diameter, average bulb weight and yield of white onion. The highest mean 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 white onion was found in P_4 (four pulse treatment), respectively.

Similar trend of irrigation level on size of onion bulb was also 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

Table 2 : Individual and interaction effect of yield parameters of white onion (Pooled)

Pulse/ irrigation treatments	Mean polar diameter (mm)	Geometric mean diameter (mm)	Equatorial diameter (mm)	Average bulb weight (g)	Yield ton per (hectare)	TSS (^{o}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. (P=0.05)	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.±	0.93	0.67	0.33	0.78	0.25	0.15
C.D. (P=0.05)	2.86	2.05	1.03	2.39	0.78	0.46
Interactions						
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.±	0.71	0.71	0.74	2.19	0.81	0.10
C.D. (P=0.05)	2.04	NS	NS	NS	NS	0.28

NS= Non-signifincat

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 trend for bulb yield was reported by Quadir *et al*. (2005) and Kumar *et al*. (2007).

It was contemplated from the Table 2 that among the different treatment combinations I_2P_4 (irrigation level I_2 (1.0 ET_C) with four pulse treatment P_4) treatment combination was found significant superior over I_1P_1 (irrigation level I_1 (0.8 ET_C) with continuous irrigation P_1) and at par with I_3P_4 (irrigation level I_3 (1.2 ET_C) with four pulse drip irrigation P_1). The interaction effect endowed superior 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

Table 3 : Cost estimation of white onion different treatment combinations of (pooled data)

Treatment combinations	Variable cost (Rs./ha)	Cost of production (Rs./ha)	Yield (t/ha)	Selling prices (Rs./ton)	Gross monetary returns (Rs./ha)	Net income (Rs./ha)	B : C ratio
I_1P_1	2,25,220	3,91,232	25.25	25000	6,31,125	2,39,893	1.61
I_1P_2	2,25,220	3,95,460	26.26	25000	6,56,500	2,61,041	1.66
I_1P_3	2,25,220	4,19,346	32.00	25000	7,99,875	3,80,529	1.91
I_1P_4	2,25,220	4,26,489	37.71	25000	8,42,750	4,16,261	1.98
I_2P_1	2,26,039	4,00,427	27.25	25000	6,81,250	2,80,824	1.70
I_2P_2	2,26,039	4,08,569	29.21	25000	7,30,125	3,21,556	1.78
I_2P_3	2,26,039	4,27,145	33.67	25000	8,41,625	4,14,480	1.79
I_2P_4	2,26,039	4,47,366	38.52	25000	9,63,000	5,15,634	2.15
I_3P_1	2,26,859	4,11,558	29.72	25000	7,43,000	3,31,442	1.81
I_3P_2	2,26,859	4,29,462	34.12	25000	8,53,000	4,23,538	1.98
I_3P_3	2,26,859	4,34,695	35.28	25000	8,81,875	4,47,180	2.03
I_3P_4	2,26,859	4,42,962	37.26	25000	9,31,500	4,88,538	2.10

Table 4 : Average water use efficiency of white onion crop under pulse irrigation (drip)

Treatment combinations	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	27.6	29.06	28.25	8.94
I_1P_2	300.78	224.53	262.66	27.6	29.06	28.25	9.30
I_1P_3	348.32	291.58	319.95	27.6	29.06	28.25	11.33
I_1P_4	355.08	319.16	337.12	27.6	29.06	28.25	11.93
I_2P_1	307.50	237.51	272.51	34.1	35.96	35.04	7.78
I_2P_2	327.94	256.24	292.09	34.1	35.96	35.04	8.34
I_2P_3	371.58	301.75	336.67	34.1	35.96	35.04	9.61
I_2P_4	394.06	376.39	385.23	34.1	35.96	35.04	10.99
I_3P_1	329.52	246.92	288.22	40.6	42.96	41.92	6.88
I_3P_2	337.70	277.41	307.56	40.6	42.96	41.92	7.34
I_3P_3	362.56	343.05	352.81	40.6	42.96	41.92	8.42
I_3P_4	384	361.21	372.61	40.6	42.96	41.92	8.89

treatment) followed by I_3P_4 (irrigation level 1.2 ET_C and four pulse treatment), respectively. This may be attributed to better performance of growth and yield parameters and in turn this was because of balanced availability of moisture, air and nutrients throughout the crop growth period. These results corroborate with findings of Zin El-Abedin (2006); Feng- Xin *et al*. (2006) and Beeson (1992).

It was observed from the Table 2 that the quality attributes of white onion like total soluble solid increases with increased from continuous drip irrigation P_1 (7.11 °Brix) to four pulse drip irrigation P_4 (9.81 °Brix). The highest TSS of 9.03 °Brix at 1.2 ET_C irrigation level probably due to fulfilment of optimum demand of crop for moisture and their proper utilization. This corresponds to earlier finding of Vagen and Slimestad (2008). From pooled data of effect of interaction, maximum T.S.S was 10.56 °Brix found in treatment combination I_3P_4, which was significantly superior than other treatment combinations.

Cost analysis of white onion:

It was evident from the Table 3 that interaction effect of treatment combinations I_2P_4 (irrigation level 1.0 ET_C and four pulse treatment) and I_3P_4 (irrigation level 1.2 ET_C and four pulse treatment) were significantly superior and at par. The cost of production of Rs. 4,47,366 and Rs. 4,42,962 ha^{-1}, gross returns of Rs. 9,63,000 and Rs. 9,31,500 ha^{-1}, net returns of Rs. 5,15,634 and Rs. 4,88,538 ha^{-1} and B:C ratio of 2.15 and 2.10, were observed for I_2P_4 and I_3P_4 treatment combination, respectively.

It was observed from the data reported in the Table 4 that maximum average water use efficiency was found in 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 combinations, respectively. The trend of water use efficiency with depth of water applied was varied as the yield of white onion. The reason is that amount of water applied was not same for all treatments.

Conclusion:

The present study indicated that among the different treatment combinations I_2P_4 (irrigation level I_2 (1.0 ET_C) with four pulse treatment P_4) was found significantly superior over I_1P_1 (irrigation level I_1 (0.8 ET_C) with continuous irrigation P_1) irrigation levels and at par with treatment combination I_3P_4 (irrigation level 1.2 ET_C and four pulse treatment). The average seasonal water applied to white onion under pulse irrigation (drip) through different irrigation levels varied from 276.8 mm for I_1 (0.8 ET_C) to 429.0 mm for I_3 (1.2 ET_C) irrigation level. The cost of production of Rs. 4,47,366 and Rs. 4,42,962 ha^{-1}, gross returns of Rs. 9,63,000 and Rs. 9,31,500 ha^{-1}, net returns of Rs. 5,15,634 and Rs. 4,88,538 ha^{-1} and B: C ratio of 2.15 and 2.10, were observed for I_2P_4 and I_3P_4 treatment combination, 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, respectively.

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REFERENCES

Abdeleaouf, R. E., Aboou-Hussein, S.D., Abd-Alla, A.M. 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. *J. Appl. Sci. Res.*, **8** (7) : 3823-3833.

Allen, R.G., Pereira, L.S., Dirk, R. and Martien, S. (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, Rajagurunagar, Maharashtra, India. [site: *www.dogr.org.in/database*].

Bakeer, G.A., El-Ebabi, F.G., El- Sadi, M. and Abdelghany, A.E. (2009). Effect of pulse drip irrigation on yield and water use efficiency o potato crop under organic Agricultural in sandy soil. *J. Agric. Engg. Irrig. & Drainage*, **26** : 736-765.

Beeson, R.C. (1992). Restricting overhead irrigation to dawn limits growth container ornamentals. *Hort. Sci.,* **27**: 996-999.

Black, C. A. (1965). *Method of soil analysis* Part-II. American Society Agronomy Including Madism Wisconsin, USA., **1040-41** : 1374 -1375.

Bouyoucos, G. J. (1962). Hydrometer method for making particle size analysis of soil. *Agron. J.,* **54**: 464-465.

Dole, J.M. (1993). Water and fertilizer rate reduction. *Greenhouse Grower,* **11**(13) : 24-28.

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

Eric, S., David, S. and Robert, H. (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) .

Feng-Xin Wang, Yaohu Kang and Shi-Ping Liu (2006). Effects of drip irrigation frequency on soil wetting pattern and potato growth in North China plain. *J. Agric. Water Mgmt.,* **79** : 248-264.

Freeman, B. M., Blackwell, J. and Garzoli, K. V. (1976). Irrigation frequency and total water application with trickle and furrow systems. *J. Agric. Water Mgmt.,* **1** : 21-31.

Gaikwad, M.A. (2013). Estimation of crop water requirement under varying climatic conditions for Dapoli Tahsil. College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, M.S. (India)

Hanway J. J. and Heidal, H. (1952). Soil analysis method as used in Iowa State College, soil testing laboratory. *Bull. Iowa State College,* **57**: 1-13.

ICAR (2016). *Handbook of agriculture*. Indian Council of Agricultural Research.

ICID (2016). Micro and sprinkler irrigated area. Data provided by National committees. International Commission on Irrigation and Drainage.

Jackson M. L. (1973). *Soil chemical analysis*. Prentice Hall of Indian Pvt. Ltd., New Delhi, India.

Keller, J. and Karmeli, D. (1974). Trickle irrigation design parameters. *Transaction, ASAE,* **17** (4) : 678.

Kumar, Satyendra, Imtiyaz, M., Kumar, Ashwani and Singh, Rajbir (2007). Response of onion (*Allium cepa* L.) to different levels irrigation water. *J. Agric. Water Mgmt.,* **89** : 161-166.

Mandale, V. (2016). Trend analysis of rainfall in Konkan region of Maharashtra. College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, M.S. (India)

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

Mane, M.S., Kadam, G. G. and Patil, S.T. (2014). Effect of irrigation levels on vegetative growth and yield characteristics in white onion (*Allium Cepa* L.) in konkan region. Internat. J. Agric. Engg., **7** (2) : 422-226.

Michael, A.M. (1978). *Irrigation theory and practices*. Vikas Publication House, New Delhi, India, pp. 515-526.

Mohamed, M.E., Mohamed, E.A. and Amal, L.A. (2012). Response of green bean to pulse surface drip irrigation. *J. Hort. Sci. & Ornamental Plants,* **4**(3): 329-334.

Olsen, S., Cole, F., Walanable, S. and Dean, L. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *USDA: Circular,* **939** : 19-23.

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

Segal, E., Ben-Gal, A. and Shani, U. (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, 22-27October. E-mail *alonben-gal@rd.ardom.co.in*.

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

Willian, F. DE., Almeida, Luiza A. Lima and Geraldo M.P. (2015). Drip pulses and soil mulching effect on American cripshead lettuce yield. *J. Brazilian Association of Agric. Engg.,* **35n6p** (5): 1009-1018.

Zin El-Abedin T. K. (2006). Effect of pulse drip on soil moisture distribution and maize production in clay soil. *J. Irrig. & Drainage Engineering* 'new trends in agricultural engineering': 1032-1035.

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