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## Original Research Article

# Impact of Water Stress Regimes on Growth, Yield and Quality Parameters of Onions using Drip System

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**A B S T R A C T**

The experiment was carried out to study the growth stage specific water stress in onion (Cv. N-2-4-1) using drip irrigation system. Conducted at research farm of ICAR – National Institute of Abiotic Stress Management (NIASM), Malegaon (kh) Baramati in Pune district of Maharashtra during 2018-19 in *rabi* season. The experiment was laid out in spilt plot design with three replications consisting of four water levels. ($I_1$ – 1.00 IW: CPE, $I_2$ – 0.75 IW: CPE, $I_3$ – 0.50 IW: CPE, and $I_4$ – 0.25 IW: CPE) and three growth stages ($G_1$- 30 DAT, $G_2$ – 60 DAT, $G_3$ – 90 DAT) with 12 treatment combinations. Results revealed that treatments comprised of four water levels (1.0, 0.75, 0.50, 0.25 IW: CPE ratio) and three water stress stages (30, 60, 90 DAT). The irrigation level $I_1$ (IW:CPE=1.0) was found better for all growth attributes like plant height, number of leaves, stem girth, canopy temperature geometric mean diameter, average weight of bulb and total yield of bulb, were maximum in $I_1$ (IW:CPE=1.0). And T.S.S. of bulb was measured in case of irrigation level $I_1$ (IW: CPE=1.00). Highest water use efficiency was found with irrigation level $I_1$ which decreased with increase in irrigation interval (decreasing IW: CPE ratio). Water stress imposed at 30, 60 and 90 DAT adversely affected growth and physiological processes of plants which resulted in decreased commercial yield.

## Introduction

In India, onion is being grown in an area of 1.29 Mha with production of 23.2 million ton (2019-20) and the average productivity is 21.2 tons per hectare.

Though India`s share in global market is only about 1%. However, to meet the dietician demand and to enhance our export, we have to harmonize the productivity and quality of vegetable crops. Maharashtra State ranks first in onion production with share of 27.72%. There is a lot of demand of Indian onion to export in the world. Onion is one of the major vegetable crops grown in arid and semi–arid regions across the world. India is second largest onion producer contributes one-fifth of the world production. Though cultivated both during and post monsoon seasons later is preferred by farmers for its superior quality, larger and uniform bulb size, better storage and fewer incidences of diseases. However, this crop is vulnerable to midseason drought as a consequence of erratic rainfall and low storage of moisture due to shallowness of soils which are insufficient to meet crop water demands (Pelter *et al.,* 2004 and EI Balla *et al.,* 2013). Therefore, supplemental irrigation continues to be the key strategy to achieve its yield potential and stabilized production (Zheng *et al.,* 2012 and Pejic *et al.,* 2011). The scarcity of water being a main constraint for its production, the priority should be on the adoption of appropriate irrigation strategies those help in saving irrigation water. Among the various techniques proposed, deficit irrigation provides a means of reducing water consumption while minimizing adverse effects on yield (Zhang *et al.,* 2012 and Mermoud *et al.,* 2005). The crop is exposed to a certain level of water stress either during a particular period or throughout the growing season. However, the deficit irrigation has been tested in most of agricultural crops which are able to sustain via extracting water from comparatively lower soil depth during irrigation limiting situations (Aliet *et al.,* 2007).

Being shallow–rooted crop, onion is more sensitive to water stress (Rao, 2016) and therefore requires frequent and light irrigations (Koriem *et al.,* 1994). Abiotic stresses can directly or indirectly affect the physiological status of an organism by altering its metabolism, growth and development and adversely affect the agricultural productivity (Bartles and Sunkar 2005, Vibhuti *et al.,* 2015 and Shahi *et al.,* 2015). Water is the main limiting factor for production of many crops including onion in the arid and semiarid regions. Fresh and dry mass production of crop may reduce due to the adverse effect of water stress (Shahi *et al.,* 2015). When water resources are scarce, deficit irrigation is one way of maximizing water use efficiency (Bekele and Tilahun, 2007). Deficit irrigation is the practice of irrigating crops deliberately below their water requirements. Such practice is aimed at minimizing water applied to the crop so as to maximize crop yield per unit of water applied. This may however lower the yield per unit area. Many research works have been carried out to study the consequences of deficit irrigation on onion crop (Olalla *et al.,* 1994; Gorantiwar and Smout, 2003; Pelter *et al.,* 2004; Mermoud *et al.,* 2005; Bekele and Tilahum, 2007; Ouda *et al.,* 2010 and *Pejiae et al.,* 2011). A research gap in the region where onion is produced in India is the knowledge of water requirement of the onion crop under deficit irrigation. Moreover, the consequences of deficit irrigation regimes are yet to be fully understood. Two key parameters commonly required in determining crop water requirement and predictions of yield-water response to deficit irrigation are crop coefficient (Kc) and yield response factor (Ky). The yield response factor (Ky) is ratio of relative yield reduction to relative evapotranspiration deficit. It is the factor that integrates the weather, crop and soil conditions that make crop yield less than its potential yield in the case of deficit evapotranspiration. The yield response factor Ky is commonly required as input data in some empirical water production functions (Jensen, 1968).

In order to determine the yield response factor of onion crop for Maharashtra the present study was carried out by raising the onion crop under different regimes of deficit irrigation approach. It is anticipated that the information generated in this study will be useful for developing crop water requirements for irrigated onion under deficit irrigation regimes and for the overall improvement of irrigation water management for onion in the study area.

Therefore, the present investigation on "Studies on growth stage specific water stress in onion (Cv.N-2-4-1)" using drip system was undertaken to develop the suitable method of good quality and yield of onion. By keeping this in view, the present study was conducted.

## Materials and Methods

Experimental site and treatments A field experiment was carried at the research farm of ICAR–National Institute of Abiotic Stress Management (NIASM), Baramati in Pune district of Maharashra, India (18◦09N, 74◦30 E and 560 MAMSL), during the post monsoon season consecutive years (2018–2019). The black soil (≤40 cm depth) of the experimental site was sandy clay in texture (sand, silt, clay, 56.1, 8.0, 35.9%, respectively), its pH (1: 2.5 soil: water suspension) was 8.2; EC 0.26 dS m−1; organic matter 6.6 g kg−1; available N, P, K 176, 25 and 148 kg ha−1, respectively. The site characterized by low and erratic rainfall and is highly susceptible to drought. The long term average annual rainfall is 588 mm mainly restricted to south–west monsoon (71%) and retreating monsoon (22%) of which, post monsoon onion growing season receives less than 20 mm rainfall (Saha *et al.*, 2015). Annual USWB open pan evaporation averages 1965 mm (Minhas *et al.*, 2015) and that of the two growing seasons is 769.4 mm. The meteorological parameters during onion growth in two years were recorded using automated weather station (AWS) located at the Research Farm of NIASM. The daily mean temperature ranged between 17.5–32.2 ◦C while the corresponding minimum and maximum temperatures were 6.5 and 39.8 ◦C, respectively. For same growth period, average wind speed values were 5.3 and 4.7 km h−1 in the year 2015–16 and 2016–17, respectively. The corresponding average relative humidity values were 47.6 and 45.1% for the respective years. Only 5.5 mm and 0.8 mm rainfall was received during the entire onion growth season in the year 2015–16 and 2016–2017, respectively. Experimental field was initially ploughed and this was followed by rotovator for preparation of beds. Onion (cv. N-2-4-1) seedlings of 45 days old were transplanted in rows 15 cm apart keeping plant to plant distance as 10 cm. After initial two post–plant irrigations to facilitate the seedling establishment, the treatments consisted of the combinations of; four Irrigation levels ($I_1$ – 1.00 IW: CPE, $I_2$ – 0.75 IW: CPE, $I_3$ – 0.50 IW: CPE, and $I_4$ – 0.25 IW: CPE) and three growth stages ($G_1$- 30 DAT, $G_2$ – 60 DAT, $G_3$ – 90 DAT) with 12 treatment combinations.. These were arranged in split plot design with three replications. The irrigation water applied using line source Drip irrigation system.. Thus the levels of irrigation created in terms of IW: CPE were 1.00, 0.75, 0.50, 0.25. The recommended doses of N, P2O5 and K2O i.e. 40 kg ha−1 each were applied as basal dose while remaining 70 kg ha−1 of N was top dressed in two splits at 35 and 55 days after transplanting (DAT). The crop was harvested manually at physiological maturity at 120 day after transplanting respectively.

## Results and Discussion

Growth and bulb yield Periodic changes in growth as indicated by growth and canopy parameters like plant height, stem girth and number of leaves. The overall improvements in these parameters was quite rapid until 70 days after transplanting (DAT) and thereafter stem girth and plant height remained almost constant while the number of leaves decreased with drying. The growth rate was limited by water stress under deficit irrigation e.g. the plant height at 120 DAT averaged

45.62, 43.38, 40.99 and 34.30 when irrigated at IW:CPE of 1.0, 0.75, 0.50, and 0.25, where as their respective stem girth was 11.89, 10.85, 10.36, 9.70 Similarly the number of leaves 8.82, 8.03, 7.90 and 7.38 at 120 DAT respectively. The other physiological parameter like relative water content (RWC) indicated that the impact of water stress was the maximum at 60−90 DAT. The highest CATD was obtained 43.36 ◦C followed by 42.97 ◦C, 41.90 ◦C, and 40.67 ◦C at 120 DAT. Further, the limited water uptake after 60–90 DAT at IW: CPE 0.25–0.50 indicates that their transpiration was reflected in terms of rise in CATD. This is supported by lower RWC which is the main factor accountable for lowering of transpiration rate resulted into higher canopy temperature at severe water deficits (Bandyopadhyay *et al.*, 2014). Onion bulb yield decreased with increase in water deficits. The deficit irrigation levels adversely affects on bulb weight per plant. The treatment 1.00 IW:CPE was recorded maximum bulb weight per plant 53.04 g followed by 44.13 g and 39.28g in 0.75 IW:CPE and 0.50 IW:CPE, respectively. The minimum bulb weight per plant 28.02 g was recorded in 0.25 IW:CPE. This results strongly coincide with Nisha Nandle *et al.*, (2018) found that the treatments comprised of three levels of irrigation (1.0, 0.75 and 0.50 IW: CPE ratio) and three different varieties (NHRDF Red-1, NHRDF Red-3, Agrifound Light Red),The deficit irrigation levels adversely affects on geometric mean diameter. The treatment 1.00 IW:CPE recorded maximum geometric mean diameter 50.05 mm followed by 48.51 and 46.97 mm in 0.75 IW:CPE and 0.50 IW:CPE, respectively. The minimum geometric mean diameter 45.26 mm was recorded in 0.25 IW:CPE. Neeraja *et al.*, (1999), Sharda *et al.*, (2006) and Metwally (2011) in onion have also found similar effect of irrigation levels on equatorial diameter of bulb. The deficit irrigation levels adversely affects on total bulb yield. The treatment 1.00 IW: CPE recorded maximum total bulb yield 22.52 t $ha^{-1}$followed by 16.08 and 13.12 t $ha^{-1}$in 0.75 IW:CPE and 0.50 IW:CPE, respectively. The minimum total bulb yield 7.70 t $ha^{-1}$ was recorded in 0.25 IW: CPE. The results obtained in present investigation strongly coincide with Wakchaure *et al.,* (2018), they found that crop could sustain little water deficits and its bulb yield declined to 0.84, 0.66, 0.48, 0.35, 0.24 and 0.16 when irrigation water (IW) applied equalled 0.85, 0.70, 0.55, 0.40, 0.25 and 0.10 times the pan evaporation (CPE) against maximum yield at full irrigation (IW: CPE 1.00). The deficit irrigation levels adversely affects the total biomass. The treatment 1.00 IW:CPE was recorded maximum total biomass 2.76 t $ha^{-1}$followed by 2.51 and 2.29 t $ha^{-1}$ in 0.75 IW:CPE and 0.50 IW:CPE, respectively. The minimum total biomass 1.92 t $ha^{-1}$ was recorded in 0.25 IW:CPE. More biomass production requires more transpiration because when stomata open, carbon dioxide flows into the leaves for photosynthesis and water flows out. Water outflow is essential for cooling and for creating liquid movement in the plant for transporting nutrients. Stomata close during drought, limiting transpiration, photosynthesis, and production. Different kinds of plants are more water efficient in terms of the ratio between biomass and transpiration (Steduto *et al.*, 2007). Above results are supported by Agbemabiese *et al.*, (2017) in onion and Singh and Bilas (2009) who established that varying water stress regimes affected both biomass and yield production in *Dalbergia sissoo.* The deficit irrigation levels adversely affects on harvesting index. The treatment 1.00 IW:CPE was recorded maximum harvesting Index 88.00% followed by 81.33 and 73.11% in 0.75 IW:CPE and 0.50 IW:CPE, respectively. The minimum harvesting index58.00% was recorded in 0.25 IW:CPE. In the present study, irrigation levels treatments were reported statistically significant results, while growth stages and interaction was reported non-significant results. The deficit irrigation levels adversely affects on Total soluble solids. The treatment 1.00 IW: CPE was recorded maximum Total soluble solid12.82% followed by 12.36 and 11.23% in 0.75 IW: CPE and 0.50 IW: CPE, respectively. The minimum Total soluble solid 10.64% was recorded in 0.25 IW: CPE. The characteristic initial upward and constant trend of TSS is usually attributed to the influence of water stress on carbohydrates synthesis mechanism in the leaves and subsequent translocation to the bulb during senescence Hamilton *et al.,* (1998).

While summarizing the present investigation it may be concluded that, water saving with deficit irrigation for vegetable crops has become a major concern to sustain their yields, while maintaining the quality to produce. On the basis of present experiment, it may be concluded that among the different irrigation levels, application of I1 (IW:CPE = 1.00) proved best treatment compared with rest of the treatments. Economic evaluation also revealed highest monetary returns with irrigation level I1. However, these results are on the basis of one year experimentation, which needs further testing and confirmation.

However, water stress for the growth period from 30 DAT i.e. G1 (Bulb initiation stage) was found to be the moderate critical to initiate the bulb formation with overall reduction in crop growth and quality. In contrast, the water stress during the bulb formation stage i.e. $G_2$ (60 DAT) most sensitive stage and towards the bulb maturity stage i.e. G3 (90 DAT) was found to be less sensitive as the plants were able to survive with better performance and able to produce marketable size bulbs. The study thus, identified $G_2$ (60 DAT) bulb formation stage was the most sensitive growth stage in onion crop for water stress.

## References

Abd El-Kader A.A., Shaaban, S.M. and Abd El-Fattah, M.S. (2010). Effect of irrigation levels and organic compost on okra plants (*Abelmoschus esculentus* L.) grown in sandy calcareous soil. *Agric. Biol. J. N. Am.* 1(3): 225-231.

Ali, M.H., Hoque, M.R., Hassan, A.A., Khair, A., (2007). Effects of deficit irrigation on yield, water productivity, and economic returns of wheat. *Agric. Water Manag.* 92, 151–161.

Bagali A. N., Patil, H. B., Chimmad, V. P., Patiland, P. L., Patil R.V., (2012). Effect of in organics and organics on growth and yield of onion (*Allium cepa L.*) Department of Horticulture University of Agricultural Sciences, Dharwad -580 005, India (Received: May, 2011; Accepted: March, 2012) *Karnataka J. Agric. Sci.,* 25(1): (112-115).

Bagali, A.N., Patil, H.B. and Pati, R.V. (2012). Effect of scheduling of drip irrigation on growth, yield and water use efficiency of onion. *Karnataka J. Agric. Sci.* 25(1): 116-119.

Bandyopadhyay, K.K., Pradhan, S., Sahoo, R.N., Singh, R. and Gupta, V.K. (2014). Characterization of water stress and prediction of yield of wheat using spectral indices under varied water and irrigation management practices. *Agric. Water Manag*, 146, 115–123.

Bekele, S and Tilahun K. (2007). Regulated deficit irrigation scheduling of onion in a semiarid region of Ethiopia. *Agricultural Water Management*, 89: 148-152.

El Balla, M.M.A, Hamid, A.A., Abdelmageed, A.H.A. (2013). Effects of time of water stress on flowering: seed yield and seed quality of common onion (*Allium cepa* L.) under the arid tropical conditions of Sudan. *Agric. Water Manag*. 121, 149–157.

El-Oksh, I.I., A.M. El-Gizawy, M.M.F. Abdallah, A.R.A.G. Mohamed and Abdalla, A.A.G. (1993). Effect of soil mosture and nitrogen fertilizer levels on onion grown in mixture of talfa and sand. Bull. Fac. Agric. Uni. 44 (1): 145-156.

Ghodke P. H., D. V. Shirsat, A. Thangasamy, V. Mahajan, V. N. Salunkhe, Y. Khade and M. Singh (2018). Effect of water logging stress at specific growth stages in onion crop. *Interl. J. Current Microbiological Applied Sci*, 7 (01): 3438-3448.

Ghodke.P.H, P.S. Andhale, U.M. Gijare, A. Thangasamy, Y.P. Khade, V. Mahajan and M. Singh (2018). Physiological and Biochemical Responses in Onion Crop to Drought Stress *Int.J.Curr.Microbiol.App.Sci*, *7*(1) : 2054-2062.

Gobu, R., Babu, B. N., Chandra, K., Shankar, M., and Prakash, O. (2017).Effect of Moisture stress on Key Physiological traits in Brinjal (*Solanum melongena* L.)Cultivars. *Vegetos-An International Journal of Plant Research*, 30(special), Pp. 403-408.

Gorantiwar, S. and Smout, I. (2005). Performance assessment of irrigation water management of heterogeneous irrigation schemes: 2. Case study. Irrigation and Drainage systems, March 2005, Volume 19,Issue 1,pp37-60.

Hegde, D.M. (1988). Effect of irrigation and nitrogen fertilization on yield, quality, nutrient uptake and water use of onion (*Allum cepa L.).*Singapore Journal of Primary Industries 16: 111-123.

Henson, B.; May, D.; Voss, R.; Cantwell, M. and Rice, R. (2003). Response of garlic to irrigation water. *Agric. Water Manage.* 58:29-43.

Hsiao, T. C., Acevedo, E., Fereres, E., and Henderson, D. W. (1976). Water stress, growth and osmotic adjustment. Philosophical Transactions of the Royal Society of London. *B, Biological Sciences*, 273(927), 479-500.

Jackson, R. D., Idso, S. B., Reginato, R. J., and Pinter Jr, P. J. (1981).Canopy temperature as a crop water stress indicator. *Water resources research*, 17(4), 1133-1138.