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# Effect of Fertigation on Yield, Water Use, Economics and Storability of Onion (*Allium cepa*) Cultivated in Inceptisols

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**Abstract:** A field experiment (2014-17) was conducted to study the effect of fertigation on yield, water use, economics and storability of onion (*var*. N-2-4-1) during the *rabi* season in silty clay loam soils of Western Maharashtra. The experiment comprised of i) 100, 80 and 60 per cent recommended dose of fertilizer through fertigation, ii) N and K through drip fertigation and P application in soil, iii) drip irrigation with conventional fertilizers application in soil, iv) micro-sprinkler irrigation with 100% RDF through fertigation, and v) surface irrigation with conventional fertilizers as control. The drip irrigation was beneficial than the surface irrigation in increasing the yield (78.8%) and saving the fertilizer. The total seasonal water requirement in drip irrigation was 480.3 mm compared to 807.2 mm in the surface irrigation. The drip irrigation with 100% RDF through fertigation was profitable with higher net seasonal income of Rs. 2, 74,445 per ha, compared to control (Rs.1, 32,450 per ha) with a B:C ratio of 4.62 and water productivity of Rs. 566 per mm of water used. The micro-sprinkler irrigation with 100% RDF through fertigation had significantly higher total storage losses of 21.10 per cent followed by surface irrigation with 100% RD of conventional fertilizer (19.86%) and drip irrigation with 100% RDF through fertigation. The results revealed that drip fertigation with 100% RDF through fertigation in 13 weekly splits are the best treatment to improve the yield, economical returns and storability of onion.

**Keywords:** *Drip fertigation, yield, water use, economics and storability of onion*

## Introduction

India is the second largest producer of onion in the world after China. In India, the area under cultivation of onion is 1.16 million ha with the total production of 20.2 million tonnes and productivity of 17.32 tonnes $ha^{-1}$ (Anonymous 2017). It is grown in Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Bihar and Haryana. Maharashtra is the leading state in onion production with the total area of 0.44 million ha and production of 5.40 million tonnes with a productivity of 12.13 tonnes $ha^{-1}$ (Anonymous 2017).

The productivity of onion in our country is lower than many other onion producing countries (Pandey *et al.* 2004). The yield of onion is influenced by many factors *viz.,* variety, spacing, nutrition and irrigation; amongst these, nutrition and irrigation play a pivotal role. Onion is a shallow rooted bulb crop. The judicious and frequent irrigation and fertigation will

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improve plant growth. Therefore, the adoption of fertigation strategies holds the key in enhancing the productivity as well as quality of produce. In Maharashtra, only 18 per cent of total cultivable area is under irrigation with ultimate potential of 50 per cent. To bridge this vast gap, it is necessary to manage the available water efficiently for maximum crop production. Maximizing the yield of onion is possible through improved pressurized irrigation systems, like drip, sprinkler and micro-sprinkler. Water saving in pressurized irrigation systems is achieved mainly due to irrigation of smaller portion of soil volume, decreased surface evaporation and reduced run-off and deep percolation losses (Suresh Kumar and Palanisami 2010). Mane and Khade (1987) reported a 24.6% increase in yield and 33.3% water saving by sprinkler methods over surface method. The sprinkler irrigation method gave water use efficiency of 1.46 q $ha^{-1}$ cm, which was two times more than the surface method. Both water and nutrient management for onion production have a significant effect on post-harvest behavior of the produce. These pre-harvest inputs influence the storage behaviour of onion bulbs directly or indirectly.

In Indian agriculture, low fertilizer use efficiency and prices of the fertilizers is the major hurdle in agriculture development. It is essential to suggest the most efficient method of fertilizer application. Fertigation increases the fertilizer use efficiency by increasing the nutrient uptake. Hansen and Peterson (1974) reported higher yield of onion and sweet corn and fertilizer use efficiency under drip and sprinkler irrigation than furrow and sub-surface irrigation on a sandy loam soil at Sian Diego, California, USA. Despite the fact that amount and frequency of irrigation influences yield and quality of onions, Indian farmers apply water to the crop without a thought whether the plant actually needs it or not (Patil and Karale 1985). Tripathi *et al.* (2010) reported that the total storage losses after three months of storage were lowest in drip irrigation (13.38%) and surface irrigation (13.59%) while higher losses were found in micro-sprinkler irrigation (22.58%) and big sprinkler irrigation (32.25%) systems. Virtually information is available on the simultaneous application of water and fertilizers through drip and micro-sprinkler irrigation on post-harvest attributes of crop. Thus, present investigation was undertaken to study the effect of water soluble fertilizers on yield, water use, economics and storability of onion over conventional method of irrigation and fertigation.

## Materials and Methods

The field experiment was conducted during 2014-2017 at research farm of Inter Faculty Department of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri. Agro-climatically, the area falls under semi-arid and sub-tropical zone of Maharashtra with annual rainfall of 520 mm. The experimental plot was uniformly leveled with well drained medium deep (silty clay loam), slightly alkaline (pH 7.9) soil. The soil bulk density was 1.30 Mg $m^{-3}$, electrical conductivity 0.23dS $m^{-1}$. The soil was low in available N (200.00 kg $ha^{-1}$), medium in available P (17.00 kg $ha^{-1}$) and available K (224.00 kg $ha^{-1}$). The field experiment was laid out in randomized block design (RBD) with eight treatments replicated thrice. The treatments were $T_1$- Drip irrigation (DI) with 100% RDF through fertigation; $T_2$ - DI with 80% RDF through fertigation; $T_3$ – DI with 60% RDF through fertigation; $T_4$ – DI with 100% RD of conventional fertilizer (CF), N and K-(fertigation) and P as soil application; $T_5$ – DI with 100% RD of CF; $T_6$ - DI with no fertilizer; $T_7$ - Surface irrigation (SI) with 100% RD of CF applied in soil and $T_8$ -Micro sprinkler irrigation (MSI) with 100% RDF through fertigation.

The recommended dose of fertilizer for onion was 100:50:50; N: $P_2O_5$:$K_2O$ kg $ha^{-1}$. In fertigation treatments ($T_1$ to $T_3$ and $T_8$), the fertilizers were applied in 13 splits apportioned as per crop growth stages (Table 2). In N and K fertigation treatment ($T_4$), the entire N and K was applied through urea and muriate of potash (MOP) in 13 weekly splits as per schedule and P was applied as a basal dose (Table 1). In conventional practice of fertilizer application ($T_5$ and $T_7$), 50% nitrogen and 100% recommended dose of phosphorus and potassium was applied as a basal dose and remaining 50% nitrogen was applied in 2 splits at 30 DAT (days after transplanting) and 45 DAT. The fertigation was done using water soluble fertilizers *viz.* urea (46:0:0), urea phosphate (17:44:00) and SOP (0:0:50) through automized fertijet system (Galicol make, Israel) at weekly interval.

**Table 1.** Fertigation schedules for onion applied in 13 weekly splits

| Days after planting | Nitrogen(N) | | Phosphorus(P) | | Potassium(K) | |
|---|---|---|---|---|---|---|
| | % | kg ha$^{-1}$ | % | kg ha$^{-1}$ | % | kg ha$^{-1}$ |
| 1-21 (3 weeks) | 25 | 25 | 20 | 10 | 10 | 5 |
| 22-42 (3weeks) | 35 | 35 | 40 | 20 | 20 | 10 |
| 43-70 (4 weeks) | 25 | 25 | 30 | 15 | 40 | 20 |
| 71-91 (3 weeks) | 15 | 15 | 10 | 5 | 30 | 15 |
| Total | 100 | 100 | 100 | 50 | 100 | 50 |

Thirty days old seedlings (*var.* N-2-4-1) were transplanted in the second week of December, 2014 and in the fourth week of December during 2015 and 2016 with spacing of 15 x 7.5 cm. Adequate plant protection measures were adopted as and when required. In the drip irrigation system, single lateral of 16 mm per six rows of onion with 4 lph inline drippers at 0.45 m was provided. In conventional method of irrigation, 63 mm depth of irrigation was applied at 50 mm cumulative pan evaporation. In drip method, the net quantity of water requirement per emitter at every alternate day was calculated by the following formula (Allen *et al.* 1998).

$$V = ET_c \times S_1 \times S_2 \times Wa$$

Where, V-Volume of water per two days in liters;

$S_1$-spacing between dripper (m);

$S_2$,-spacing between laterals (m); Wa-Wetted area

The yield contributing characters of onion *viz.,* average bulb weight, bulb yield and yield of dry leaves were recorded at harvest. The total cost of cultivation includes cost of cultivation and fixed cost on irrigation systems which was more in drip and micro sprinkler irrigated treatments due to more cost of water soluble fertilizers and drip and micro sprinkler system installation. Net seasonal income was the returns from bulb yield. Benefit: cost ratio was calculated for each treatment by following equation.

$$\text{Benefit: cost ratio} = \frac{\text{Gross income (Rs. ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs. ha}^{-1}\text{)}}$$

The net extra income over control as influenced by different treatments was calculated by subtracting the (Rs. ha$^{-1}$) corresponding value of the net seasonal income from the value of net seasonal income of control treatment. The water productivity (Rs. ha$^{-1}$ mm) as influenced by different treatments was calculated by division of corresponding values of the net seasonal income with water used (Pawar *et al*. 2013). For storage studies, 10 kg of healthy onion bulbs from each treatment were stored in gunny bags up to 180 days for periodical observation. The observation on physiological, rotting and weight loss was recorded at 120, 150 and 180 days after harvest. The statistical analysis was performed by using analysis of variance (ANOVA) for randomized block design (Panse and Sukhatme 1967).

## Results and Discussion

*Yield and yield contributing characters*

The pooled data for 2014-2017 on yield and yield contributing parameters of onion was significantly influenced by fertigation treatments (Table 2). The significantly higher average weight of onion bulb (83.30 g) was obtained in the treatment of DI with 100% RDF through fertigation ($T_1$) than other treatments, however, it was at par with $T_8$ (79.14 g) and $T_2$ (77.12 g). The maximum yield of dry leaves (7.34 t $ha^{-1}$) was recorded in $T_1$ which was significantly higher than other treatments. It was at par with MSI with 100% RDF through fertigation ($T_8$) followed by DI with 80% RDF through fertigation ($T_2$) and DI with 100% RD of CF, N&K-fertigation ($T_4$). The minimum dry leaves yield of onion was recorded in DI with no fertilizer treatment *i.e.* $T_6$ (3.91 t$ha^{-1}$).

DI with 100% RDF through fertigation ($T_1$) produced significantly higher bulb yield (48.95 t $ha^{-1}$) than other treatments and it was at par with MSI with 100% RDF through fertigation *i.e.* $T_8$ (44.48 t $ha^{-1}$) and $T_2$ (43.85 t $ha^{-1}$). This might be due to higher availability of nutrients under drip and micro sprinkler than that of straight fertilizer application to soil in surface irrigation. It indicates that fertigation using WSF can save fertilizer dose up to 20%. These results are similar to the findings of Pawar *et al*. (2014).

*Water use efficiency*

The conventional method of irrigation used maximum amount of water (807.2 mm) as compared to drip and micro-sprinkler irrigation (480.3 and 549.0 mm). Thus saving of water to the extent of 40.5% and 32.00 % was possible due to drip and micro sprinkler irrigation method, respectively. Drip irrigation with 100% RDF through fertigation ($T_1$) recorded 78.8% increase in yield over surface irrigation (40.5% water saving) followed by micro sprinkler irrigation with 100% RDF through fertigation with 62.5% increase in yield and 32.00% water saving over $T_7$. The maximum water use efficiency of 103.1 kg $ha^{-1}$ mm was recorded in DI with 100% RDF through fertigation ($T_1$) followed by $T_2$ (87.7 kg $ha^{-1}$ mm) and $T_8$ (82.7 kg $ha^{-1}$ mm) and the lowest WUE of 33.7 kg $ha^{-1}$ mm in SI with 100 % RD of CF.

*Cost economics*

The total seasonal cost of cultivation was computed by adding the seasonal cost of drip and micro sprinkler irrigation and operating cost. The seasonal cost of drip system for 1.20 m lateral spacing for planting of onion was considered for 6 months crop period. It revealed that the cost of cultivation was more in $T_1$ (Rs. 83,758 $ha^{-1}$) followed by $T_2$ (Rs. 81,717 $ha^{-1}$) and $T_8$ (Rs. 81,548 $ha^{-1}$) and the lowest seasonal cost of cultivation was recorded in surface irrigation treatment (Rs. 67599 $ha^{-1}$).

The maximum net seasonal income Rs. 2,74,445 $ha^{-1}$ was obtained in DI with 100% RDF through fertigation treatment ($T_1$) owing to higher yield followed by micro sprinkler irrigation with 100% RDF through fertigation ($T_{8,}$ Rs. 2,43,665 $ha^{-1}$) and DI with 80% RDF through fertigation (Rs. 2, 38,679 $ha^{-1}$). Treatment $T_6$ gave the lowest bulb yield hence the net seasonal income was also lowest as Rs. 74,809 $ha^{-1}$. The maximum B:C ratio (4.62) was recorded in treatment $T_1$ followed by $T_8$ due to high onion yield. The lowest B:C ratio was observed in no fertilizer treatments (2.37). Pawar *et al.* (2013) reported highest net seasonal income of Rs. 2, 38,402 $ha^{-1}$, total net income of Rs. 5, 68,958 and net extra income over control of Rs. 86,656 under 100% RD of fertigation treatment.

The net extra income over control ($T_7$) was highest in DI with 100% RDF through fertigation treatment (Rs. 1,41,995) followed by MSI with 100% RDF through fertigation (Rs. 1,11,195) and (Rs. 1,06,228 in $T_2$). The lowest net extra income over control was recorded in treatment $T_5$ (Rs. 47,793).

**Table 2.** Yield and water use of onion as influenced by different treatments

| Treatments | Average bulb weight (g) | Bulb yield (t ha$^{-1}$) | Weight of leaves (t ha$^{-1}$) | Total water applied (mm) | WUE kg ha$^{-1}$ mm | Water saving (%) | % increase over $T_7$ |
|---|---|---|---|---|---|---|---|
| $T_1$ | 83.30 | 48.95 | 7.34 | 480.3 | 103.1 | 40.50 | 78.8 |
| $T_2$ | 77.12 | 43.85 | 6.65 | 480.3 | 87.7 | 40.50 | 60.1 |
| $T_3$ | 69.32 | 34.01 | 4.92 | 480.3 | 71.6 | 40.50 | 24.1 |
| $T_4$ | 74.55 | 39.22 | 5.89 | 480.3 | 81.8 | 40.50 | 43.2 |
| $T_5$ | 68.05 | 35.47 | 5.03 | 480.3 | 74.5 | 40.50 | 29.5 |
| $T_6$ | 60.13 | 20.20 | 3.91 | 480.3 | 41.9 | 40.50 | -26.4 |
| $T_7$ | 63.95 | 27.38 | 4.64 | 807.2 | 33.7 | ---- | 0.0 |
| $T_8$ | 79.14 | 44.48 | 6.90 | 549.0 | 82.7 | 32.00 | 62.5 |
| SEm(+) | 2.17 | 2.65 | 0.50 | | | | |
| CD @ 5% | 6.50 | 7.95 | 1.49 | | | | |

**Table 3.** Economics of onion as influenced by different treatments

| Treatments | Cost of cultivation (Rs. ha$^{-1}$) | Net seasonal income (Rs. ha$^{-1}$) | B:C ratio | Net extra income over control ($T_7$) (Rs. ha$^{-1}$) | Water productivity (Rs. ha$^{-1}$-mm$^{-1}$) |
|---|---|---|---|---|---|
| $T_1$ | 83758 | 274445 | 4.62 | 141995 | 566 |
| $T_2$ | 81717 | 238679 | 4.26 | 106228 | 490 |
| $T_3$ | 79676 | 169093 | 4.46 | 36643 | 351 |
| $T_4$ | 78090 | 207503 | 3.98 | 75053 | 421 |
| $T_5$ | 78090 | 180243 | 3.64 | 47793 | 366 |
| $T_6$ | 72804 | 74809 | 2.37 | -57641 | 156 |
| $T_7$ | 67599 | 132450 | 3.30 | 0 | 157 |
| $T_8$ | 81548 | 243645 | 4.32 | 111195 | 430 |

*Storability*

The pooled data for 2014-2017 indicated that the total losses in stored bulb were significantly influenced due to different levels of fertigation (Table 4). The MSI with 100% RDF through fertigation ($T_8$) recorded maximum total storage losses (21.10%) followed by $T_7$ (19.86%) and $T_1$ (18.10%). The higher storage losses in micro sprinkler irrigation systems may be due to the application of irrigation over canopy of crop that caused disease infestation at later stage of crop maturity resulting in rotting of bulbs in storage. Similar results were reported by Tripathi *et al.* (2010). The higher storage losses were also recorded in higher fertigation levels and maximum water application treatments might be due to higher availability of nitrogen to the crop during production phase which accelerated the sprouting during storage. Minimum losses during storage were observed in $T_2$ (15.20%). These results are in close conformity with the results of Kumar *et al.* (2007).

**Table 4.** Total storage losses in onion as influenced by different treatments

| Treatments | Total weight losses (%) | | |
|---|---|---|---|
| | 120 DAH | 150 DAH | 180 DAH |
| DI with 100% RD of fertigation | 10.2 | 14.94 | 18.10 |
| DI with 80% RD of fertigation | 8.80 | 12.90 | 15.20 |
| DI with 60% RD of fertigation | 7.82 | 11.38 | 17.32 |
| DI with 100% RD of CF, N and K- fertigation, P- soil | 9.07 | 13.15 | 17.41 |
| DI with 100% RD of CF | 9.17 | 13.37 | 17.58 |
| DI with no fertilizer | 8.68 | 13.53 | 17.30 |
| SI with 100% RD of CF | 9.32 | 13.83 | 19.86 |
| 100% RD of fertigation under MS | 9.67 | 14.10 | 21.10 |
| SEm (+) | 0.30 | 0.40 | 0.52 |
| CD @ 5 % | 0.90 | 1.20 | 0.76 |

## Conclusions

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It can be concluded that drip irrigation with 100% RDF through fertigation in 13 splits at weekly intervals resulted in higher yield, water productivity and storability of onion (*var.* N-2-4-1) under silty clay loam soils of western Maharashtra.

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