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Research Article

# WATER USE EFFICIENCY AND COST ECONOMICS OF ONION UNDER DIFFERENT FERTILIZER LEVELS IN SURFACE AND DRIP IRRIGATION

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**Abstract:** Investigation on the effect of different fertigation levels and soil application of fertilizers was carried out at Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *rabi* season of 2018-19. Akola Safed cultivar (white onion) with spacing of 15 x 10 cm, was used for the study. The treatments comprised of one treatment of application of recommended dose fertilizers (RDF) to the onion crop planted as per traditional system and irrigated by surface irrigation system and three treatments of fertigation with 100%, 80% and 60% of RDF respectively (drip irrigation) with five replications in randomised block design. Fertigation with 100 % RDF recorded highest values of average weight of bulb (148.5 g), total bulb yield (32.28 t/ha), marketable bulb yield (27.85 t/ha), per cent marketable bulb yield (83.17%) followed by fertigation with 80 % and 60% of RDF. The lowest values were recorded in soil application of fertilizers with RDF. 71.7%, 54.87% and 21.58% more yield of onion over conventional method of irrigation and fertilization was obtained by fertigation of 100%, 80% and 60% RDF, respectively. The total water requirement of onion under surface irrigation was found to be 1000 mm, whereas it was found 623.19 mm when drip irrigation was used for fertigation. Thus, by using drip irrigation, 37.68% irrigation water was saved over surface method of irrigation. The crop water use efficiency in surface irrigation was 0.191 t/ha$^{-cm}$ whereas in fertigation with 100% RDF it was 0.518 t/ha$^{-cm}$ followed by 0.467 t/ha$^{-cm}$ and 0.381 t/ha$^{-cm}$ in fertigation of 80% RDF and 60% RDF, respectively. Highest benefit cost ratio 2.77 was recorded in fertigation of 100%, RDF. It is concluded that fertgation with 100 % recommended dose of fertilizers (N:P:K:S) with 11 given splits, is most suitable in order to get maximum yield, water use efficiency and benefit cost ratio for onion crop.

**Keywords:** *Fertigation, Onion, Akola Safed, Drip irrigation, Soil application of fertilizers*

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## Introduction

Onion (*Allium cepa* L.) is indispensable item in every kitchen as condiment and vegetable. Onion is liked for its flavour and pungency which is due to the presence of a volatile oil 'allyl propyl disulphide'- rich in sulphur. Onion is being used in several ways such as fresh, frozen, dehydrated bulbs and green bunching types. Onion has got good medicinal value. Recently onion is being used by processing industry to greater extent for preparing dehydrated forms like powder and flakes. India is second largest producer of onions in the world next to China. In India, onion is being grown in an area of 1.27 million hectares with production of 21.56 million tons. Productivity of onion in India is 16.97 t ha$^{-1}$. The leading onion producing states in India are Maharashtra, Madhya Pradesh and Karnataka, etc. Maharashtra is having onion cultivation on 0.47 million hectares and production is 6.77 million tons with productivity of 14.36 t ha$^{-1}$. Onion is one of the important vegetables in terms of export. India exported 2.41 million tons of onion in 2016-17 with value of 3,10,650 Lakh Rupees [1].

Onion is most sensitive to irrigation. As the roots of onion are concentrated in upper layer of soil, irrigation is required with short intervals. Traditionally onion is irrigated by check basin system in which considerable wastage of water is involved which results in reduced water use efficiency. As the water is scarce, it is essential to use it more efficiently by the way of adopting proper scheduling and adopting water saving methods. In recent years, it has been observed that the traditional surface irrigation methods are being replaced by modern irrigation techniques like sprinkler, micro sprinkler and drip irrigation systems. Still there is need to expand the area under micro irrigation.

Fertilizers can also be saved to a great extent if applied with irrigation water *i.e.* by fertigation. Therefore, present investigation was carried out to decide correct dose of fertigation for onion by comparing with the traditional system of irrigation and fertilization. Water use efficiency and benefit cost ratio were also studied as these are important parameters are important for adopting the results.

## Materials and Methods

A field experiment on "Comparative performance of onion under different fertilizers levels in surface and drip irrigation" was conducted at Chilli and Vegetable Research Unit, Dr. PDKV, Akola, Maharashtra, India during *rabi* season of 2018-19. Akola is located at an altitude of 307.415 m above mean sea level (MSL) at the intersection of 20o 40' North latitude and 77o02' East longitudes. The climate of Akola is subtropical and semi-arid. The average annual rainfall at Akola is 760 mm. Most of the rains are received during June to September months. The soil of experimental plot was sandy clay loam having pH 7.76, EC 0.44 dS/m, bulk density 1.1 g/cm3, field capacity 28.24% and permanent wilting point 17.20%. The irrigation water used had pH 7.24 and EC 0.73 dS/m. Smooth and nearly levelled field was obtained by ploughing followed by harrowing and rotavator. Broad bed furrows of height 15 cm and width 120 cm with the help of broad bed furrow marker were prepared as shown in [Fig-1]. Healthy seedlings of Akola Safed cultivar of onion (white onion) were transplanted on the beds with the spacing of 15 cm x 10 cm. The experiment was laid out in RBD with five treatments and four replications as per details given in [Table-1].

Inline drip irrigation system having 4 lph drippers spaced at 50 cm distance on 16 mm diameter lateral was installed. Two laterals with valves per bed were provided. Provision of separate water delivery was made for surface irrigation treatment. All other agronomic and plant protection practices were kept uniform for all treatments.

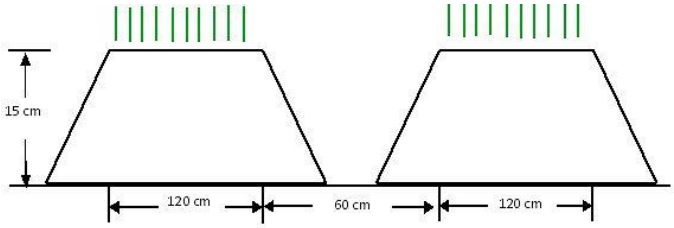


Fig-1 Broad bed furrows for onion plantation under drip irrigation system

Five plants from each plot were selected randomly and tagged for recording growth parameters *viz*., plant height, number of leaves, and neck girth and yield contributing parameters *viz*., polar diameter, equatorial diameter, bulb weight etc. Before transplanting, common irrigation was applied to bring the soil at the field capacity in each plot. The first irrigation was given immediately after transplanting to all treatments and afterwards irrigations and fertilizers were applied according to treatment and split schedule.

Table-1 *Experimental details*

| SN | Treatment/Particulars | Details |
|---|---|---|
| 1 | $T_1$ | 100% RDF (soil application) with surface irrigation at 50 mm CPE |
| 2 | $T_2$ | 100% RDF with drip irrigation at 100% PE |
| 3 | $T_3$ | 80% RDF with drip irrigation at 100% PE |
| 4 | $T_4$ | 60% RDF with drip irrigation at 100% PE |
| 5 | Design | RBD |
| 6 | Replications | 5 |
| 7 | Plot size | 1.20 m × 4 m |
| 8 | Number of plots | 20 |
| 9 | RDF | 110:40:60:30 N:P:K:S kg/ha |
| 10 | Date of transplanting | 21 January, 2019 |
| 11 | Date of harvesting | 20th May, 2019 |
| 12 | Sources of fertilizers | Urea, 19:19:19, White MOP and Elemental S |
| 13 | Splits of fertigation | 11 (6 days interval) |
| 14 | Fertigation method | Fertilizer Injection Pump |

**Surface irrigation method ($T_1$)**

The requirement of irrigation water for surface irrigation was satisfied by IW/CPE ratio method [2] with IW/CPE ratio 1. Irrigation was applied when cumulative pan evaporation reached to 50 mm. Daily pan evaporation data was obtained from meteorological observatory of Dr PDKV, Akola.

*Volume of water (lit) = (CPE, mm x Area of beds, m2) / field efficiency* (1)

**Drip irrigation method ($T_2$, $T_3$ and $T_4$)**

Water requirement (Crop evapotranspiration) of crop under drip irrigation at 100% pan evaporation at alternate day (two days)

$ET_c = E_p \times K_c \times K_p$ (2)

Where,

$Et_c$ - Crop evapotranspiration for two days, mm

$E_p$ - Pan evaporation for two days, mm

$K_c$ - Crop coefficient [3]

$K_p$ - Pan coefficient (0.8)

Volume of water to be applied was calculated using following equation,

$V = ET_c \times A \times N$ (3)

Where,

V - Volume of water per treatment, lit

$ET_c$ - Crop evapotranspiration for two days, mm

A - Area of one plot, $m^2$

N - Number of plots.

**Application of fertilizers**

For treatment $T_1$ (100% RDF), the recommended fertilizer dose of 110:40:60:30 N:P:K:S kg/ha was given in 3 splits. Before transplanting, 30% N and 100% of PKS were applied as a basal dose. Remaining 70% N was applied in two equal splits at 30 and 45 days after transplanting (DAT) as a top dressing. In fertigation treatments ($T_2$, $T_3$ and $T_4$), dose of 100%, 80% and 60% of RDF was applied through drip fertigation system using injection pump, in 11 different splits of N:P:K:S at an interval of 6 days starting after 15 days after transplanting. The distribution of fertilizers in the splits as per requirement is given in [Table-2]. For fertilization in all treatments water soluble fertilizers, Urea, 19:19:19, White MOP and Elemental S were used.

Table-2 *Schedule (Splits) of fertigation applied for onion*

| Split Number | Date | N:P:K:S (Ratio) |
|---|---|---|
| I | 4-Feb-19 | 1:1:1:1 |
| II | 10-Feb-19 | 1.5:1.2:1.3:1.2 |
| III | 16-Feb-19 | 1.5:1.2:1.3:1.2 |
| IV | 22-Feb-19 | 1.5:1.2:1.3:1.2 |
| V | 28-Feb-19 | 1.5:1.2:1.3:1.2 |
| VI | 6-Mar-19 | 1:1.1:0.8:1.2 |
| VII | 12-Mar-19 | 0.7:1.1:0.8:1 |
| VIII | 18-Mar-19 | 0.7:1:0.8:1 |
| IX | 24-Mar-19 | 0.6:1:0.8:1 |
| X | 30-Mar-19 | 0:0:0.3:0 |
| XI | 5-Apr-19 | 0:0:0.3:0 |

**Yield Parameters**

The observations of onion bulb yield were taken after harvest and then after curing period of ten days.

**Cost economics**

The cost of cultivation of each treatment was calculated per hectare on the basis of prevailing rates of labours, fertilizers, organic manures, irrigation and other expenditure. The total monetary income per hectare was calculated as per the average wholesale price of onion in the local market (Rs 7000 /- per tonne). The net profit per hectare was calculated by deducting the cost of cultivation from the total income. The benefit cost ratio was calculated accordingly

**Results and Discussion**

**Yield parameters**

The yield contributing characters were recorded and the results are depicted in [Table-3]. It is prominently observed that, treatment $T_2$ (fertigation with 100% RDF) showed superior results in terms of average weight of bulb (148.5 g), total bulb yield (32.28 t/ha), marketable bulb yield (27.85 t/ha), per cent marketable bulb yield (83.17%) followed by treatments $T_3$ (fertigation with 80% RDF) and $T_4$ (fertigation with 60% RDF). The lowest values were recorded in treatment $T_1$ (soil application with 100% RDF). This indicates superiority of treatment $T_2$ (fertigation with 100% RDF) over all other treatments. The increase in yield of onion over conventional method of irrigation and fertilization ($T_1$) obtained in fertigation treatments $T_2$ (fertigation with 100% RDF), $T_3$ (fertigation with 80% RDF) and $T_4$ (fertigation with 60% RDF) was found to be 71.7%, 54.87% and 21.58% respectively. This indicates the effectively of fertigation using drip irrigation system for onion crop. Similar findings have been reported by Yadav *et al.* (2010) [4], Prabhakar *et al.* (2011[5]) and Kamble and Kathmale (2015) [6].

**Stage wise Water Requirements**

For determining crop growth stage wise water requirement, the crop evapotranspiration and rainfall values were recorded and accordingly water was applied for 100% replenishment considering field efficiency of 90%. The stage wise water requirements of onion obtained in surface irrigation and drip irrigation are depicted in [Table-4]. It was observed that, in surface irrigation, the water required in every stage of the crop was more than that in drip irrigation. The total water requirement of onion under surface irrigation was found to be 1000 mm, whereas it was found 623.19 mm in drip irrigation. Thus, by using drip irrigation, 37.68% irrigation water can be saved. These results are similar with findings of Bhaskare *et al.* (2018) [7].

Table-3 *Yield contributing characters of onion under different levels of fertilizers*

| Treatments | Average Bulb Wt. (g) | Total Bulb Yield (t/ha) | Marketable Bulb Yield (t/ha) | Marketable Bulb Yield (%) |
|---|---|---|---|---|
| $T_1$ | 78.10 | 19.18 | 16.22 | 79.69 |
| $T_2$ | 148.5 | 32.28 | 27.85 | 83.17 |
| $T_3$ | 126.4 | 29.10 | 25.12 | 82.96 |
| $T_4$ | 124.5 | 23.72 | 19.72 | 80.01 |
| F- test | Sig. | Sig. | Sig. | NS |
| SE(m) ± | 8.85 | 1.23 | 1.11 | 1.40 |
| CD (5%) | 27.26 | 3.79 | 3.42 | 4.31 |

Table-4 *Crop growth stage wise water requirement of onion in surface and drip irrigation*

| SN | Crop growth stage | Water applied, Mm (Surface irrigation) | Water applied, Mm (Drip irrigation) |
|---|---|---|---|
| 1 | Irrigation before transplanting | 55.55 | 50 |
| 2 | Initial stage | 166.67 | 70.94 |
| 3 | Crop development stage | 222.22 | 141.09 |
| 4 | Mid-season stage | 333.33 | 182.25 |
| 5 | Late season stage | 222.22 | 178.91 |
| Total | | 1000 | 623.19 |

Table-5 *Cost analysis of different treatments of fertilizer levels*

| Treatment | Marketable Yield (t/ha) | Gross monetary return (Rs/ha) | Total cost (Rs/ha) | Net monetary return (Rs/ha) | B:C Ratio |
|---|---|---|---|---|---|
| $T_1$ | 16.22 | 145980 | 78794 | 67186 | 1.85 |
| $T_2$ | 27.85 | 250650 | 90349 | 160301 | 2.77 |
| $T_3$ | 25.12 | 226080 | 86072 | 140008 | 2.62 |
| $T_4$ | 19.72 | 177480 | 81786 | 95694 | 2.17 |

It was observed that, in surface irrigation, the water required in every stage of the crop was more than that in drip irrigation. The total water requirement of onion under surface irrigation was found to be 1000 mm, whereas it was found 623.19 mm in drip irrigation. Thus, by using drip irrigation, 37.68% irrigation water can be saved. These results are similar with findings of Bhaskare *et al.* (2018) [7].

**Crop water use efficiency (water productivity)**

The crop water use efficiency with respect to soil application of fertilizers with 100% RDF using surface irrigation in treatment $T_1$ and fertigation through drip irrigation in treatments $T_2$, $T_3$ and $T_4$ was estimated from the data of total bulb yield and total water applied. It was found that the crop water use efficiency in surface irrigation ($T_1$) was 0.191 t/ha$^{-cm}$ only. Whereas in fertigation treatment $T_2$ (fertigation with 100% RDF), it was found 0.518 t/ha$^{-cm}$ followed by $T_3$ (0.467 t/ha$^{-cm}$) and T4 (0.381 t/ha$^{-cm}$). It was clear that, the crop water use efficiency of all drip irrigation treatments was superior over surface irrigation. Amongst the fertigation treatments, treatment $T_2$ (fertigation with 100% RDF) was found superior over all other treatments. This proves the fact of more crop per drop in case of drip irrigation and fertigation. These results are similar to findings of Gebremedhin (2015)[8] and Kahlon (2016)[9].

**Cost economics**

The various parameters regarding to economics *i.e.* cost of cultivation, gross monetary return (Rs/ha) and B:C ratio was studied for the different treatments considering the costs prevailing at the time of harvest and is shown in [Table-5]. The data revealed that, highest gross monetary return (Rs.250650/-) was recorded under treatment $T_2$ (fertigation with100% RDF) with highest net monetary return (Rs. 160301 /-) as well as cost benefit ratio (2.77). It was followed by $T_3$ (fertigation with 80% RDF) and $T_4$ (fertigation with 60% RDF). Lowest gross monetary return (Rs. 145980/-), net monetary return (Rs. 67186/-) as well as cost benefit ratio (1.85) was found with $T_1$ (soil application with 100% RDF). These findings were in accordance with Bhakare [10]); Kamble and Kathmale (2015)[6] and Zanjad, (2019) [11].

**Conclusion**

After comparison of conventional method of surface irrigation and soil application of fertilizers with three levels of fertilizer application through drip irrigation (fertigation) for onion crop, it was found that, 37.68% irrigation water over surface irrigation was saved using drip irrigation with higher water use efficiency confirming more crop per drop. Application of fertilizers with drip irrigation *i.e.,* fertigation proved to be more effective. All fertigation treatments showed higher values of yield and benefit cost ratio over conventional method of soil application of fertilizers. The fertigation with 100 % recommended dose of fertilizers recorded highest yield and other parameters. Therefore, it is concluded that for higher water use efficiency, higher yield and superior quality of onion and more economic returns from onion cultivation, drip irrigation system and fertigation with 100% recommended dose of fertilizers *i.e.,* 110:40:60:30 NPKS kg/ha with 11 splits should be adopted

**Application of research:** The results clearly indicate the superiority of drip irrigation over surface irrigation in case of onion.

**Research Category:** Fertigation

**Abbreviations:** RDF- Recommended dose of fertilizers, IW- Irrigation Water, CPE- Cumulative pan evaporation

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**Study area / Sample Collection:** Chilli and Vegetable Research Unit, Dr PDKV Akola

**Cultivar / Variety / Breed name:** Akola safed (White onion)

**Conflict of Interest:** None declared

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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