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# Influence of Irrigation and Nitrogen Levels on Bulb Yield, Water Use Efficiency and Moisture Extraction Pattern and ET/Epan Ratio in Onion *(Allium cepa)*

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**Abstract**

A field experiment was conducted during *rabi* season of 1993-94 to 1995-96 to study the influence of irrigation and nitrogen in onion (Allium cepa) cultivar Nasik Red on sandy loam soil. Pooled data of three years revealed a significant increase in bulb yield (106.6 q/ha) under frequently irrigated plots of 1.2 IW/CPE requiring nine irrigations of 5 cm depth each. Corresponding water requirement and evapotranspiration were 46.7 and 30.4 cm, respectively with crop water use efficiency of 350.47 kg/ha. Crop extracted maximum moisture from 0–20 cm (12.8 cm) accounting to 62.11% of the total moisture used by the crop. Mid-season ET/Epan ratio ranged between 0.89–0.91 in February-March. Bulb yield increased with increase in N levels upto 150 kg N/ha though the difference among the levels was statistically non-significant.
**Key words : Irrigation, Nitrogen, Bulb yield, Water use, Onion.**

Onion is an important commercially valuable crop. Its cultivation promises has increased to tail end areas of different canal commands owing to its ability to withstand under lesser water supply conditions. However, its shallow and fibrous root system requires precise application of water along with optimal use of nitrogen which is by far the most important nutrient influencing yield potential of the crop. Keeping this in view, present study was planned under the agro-climatic condition of Hirakud irrigation command in western Orissa.

## Methods

Field experiments were carried out during *rabi* season from 1993-94 to 1995-96 at Regional Research and Technology Transfer Station, Chiplima, Sambalpur. Soil of the experimental site was sandy loam in texture having 17.0 and 8.0% moisture at field capacity and permanent wilting point, respectively. Soil was low in nitrogen (212 kg N/ha), medium in phosphorus (16.0 kg $P_2O_5$/ha) and potash (312 kg $K_2O$/ha). Crop received 19.3 mm, 6.9 mm and 117.9 mm through rainfall and lost 394.9 mm, 461.5 mm and 456.6 mm moisture through evaporation during first, second and third year of study, respectively. About 45 days old seedlings of variety Nasik red were transplanted in third week of December with a crop geometry of 15 cm row to row and 10 cm plant to plant and fertilized with a common level of phosphorus (60 kg $P_2O_5$/ha) and potash (100 kg $K_2O$/ha). The experiment was laid out in split plot design where four irrigation levels (0.6, 0.8, 1.0 and 1.2 IW/CPE) in main plot and three nitrogen levels (90, 120 and 150 kg N/ha) in subplots were replicated three times. Phosphorus was applied as basal while nitrogen and potash were applied in two equal splits i.e. 50% as basal and 50% at the time of first intercultural operation. Irrigation treatments were imposed after the first top dressing and measured amount of water (IW = 5.0 cm) was applied through irrigation modules having a discharge capacity of three liters second. Soil moisture study was carried out by gravimetric method and data on yield and growth characters were analyzed statistically using standard method (1). Crop matured in 117, 126 and 124 days during first, second and third year, respectively.

## Results and Discussion

*Effect of Irrigation*

Bulb yield of onion variety Nasik red increased

**Table 1.** Bulb yield and growth of onion as influenced by levels of irrigation and nitrogen. $S_1$—Season 1993-94, $S_2$—season 1994-95, $S_3$—Season 1995-96.

| Particulars | Bulb yield (q/ha) $S_1$ | $S_2$ | $S_3$ | Pooled | Plant height (cm) | Stem girth (cm) | Fresh weight/ bulb (g) | Bulb diameter (cm) | Percent moisture loss 40 days after harvest | Percent rotting 40 days after harvest |
|---|---|---|---|---|---|---|---|---|---|---|
| **Irrigation Levels (IW : CPE)** | | | | | | | | | | |
| 0.6 | 92.4 | 72.9 | 80.2 | 81.8 | 35.2 | 2.6 | 20.7 | 10.9 | 17.7 | 2.5 |
| 0.9 | 98.1 | 84.8 | 84.4 | 89.1 | 35.7 | 2.8 | 22.1 | 11.0 | 19.0 | 7.4 |
| 1.0 | 99.0 | 87.7 | 96.8 | 91.2 | 36.8 | 3.1 | 23.7 | 11.5 | 19.1 | 7.5 |
| 1.2 | 121.1 | 104.0 | 94.7 | 106.6 | 36.9 | 3.1 | 25.0 | 11.8 | 19.3 | 10.3 |
| CD (0.05) | 7.69 | 4.48 | 9.08 | 3.71 | NS | 0.20 | 0.72 | NS | | |
| **N Level (kg/ha)** | | | | | | | | | | |
| 90 | 100.1 | 84.9 | 82.4 | 89.1 | 32.4 | 2.7 | 20.4 | 10.6 | 17.2 | 4.2 |
| 120 | 103.5 | 87.9 | 87.0 | 92.8 | 37.2 | 2.9 | 22.7 | 11.4 | 19.5 | 6.6 |
| 150 | 104.3 | 90.5 | 90.2 | 95.0 | 88.9 | 3.1 | 25.5 | 11.8 | 19.5 | 10.1 |
| CD (0.05) | NS | 5.32 | 3.40 | NS | 1.45 | 0.14 | 1.45 | 0.52 | | |

with increasing IW : CPE ratios and was significantly the highest (121.1 q/ha) under most frequently irrigated plots of 1.2 IW/CPE in the first year of study. Similar trend was also observed during second and third year with declined trend over the years. Yield reduction was the minimum (12.3%) under 1.0 IW/CPE and was the maximum (21.8%) under 1.2 IW/CPE. Data pooled for three seasons revealed a significantly higher bulb yield (1,06.6 q/ha) under 1.2 IW/CPE ratio which reduced by 14.5, 16.4 and 23.3% under 1.0, 0.8 and 0.6 IW/CPE, respectively. Similar higher bulb yield at 1.2 IW/CPE has also been reported from Memari, West Bengal (2). In the present study the increase in bulb yield due to increased levels of irrigation was associated with significant increase in single fresh bulb weight (Table 1).

*Effect of Nitrogen*

No significant difference in yield of bulb was observed during first year though yield increased marginally with increase in nitrogen levels. However, during second and third year, significantly the highest yield was observed at 150 kg N/ha with a bulb yield of 90.5 and 90.2 q/ha, respectively. The superiority was however, only over the lowest level of nitrogen (90 kg/ha). Pooled data also did not show any significant difference is bulb yield due to levels of nitrogen (Table 1). Response of onion to applied nitrogen was not consistent and the response to a wide range of N-levels was reported by various workers. Its response to a lowest N level of 40 kg N/ha (3), to a moderate level of 90 kg N/ha (4) and to a higher level of 150 kg N/ha (5) are also under report. Economically, 120 kg N/ha gave more profit than the 150 kg N/ha (Table 2).

*Keeping Quality of Onion*

Onion bulbs are subjected to losses due to des-

**Table 2.** Economics of nitrogen use in onion (mean of three seasons). Coat of urea = Rs 450/q, Cost of onion = Rs 400/q.

| Nitrogen levels (kg/ha) | Bulb yield (q/ha) | Cost per kg N applied (Rs/ha) | Total cost of nitrogen (Rs/ha) | Cost of produce (Rs/ha) | Return from N (Rs/ha) | Profit over 90 kg N/ha level (Rs/ha) | Profit over each N level (Rs/ha) |
|---|---|---|---|---|---|---|---|
| 90 | 89.1 | 9.78 | 888.20 | 35,640 | 34,759.8 | - | - |
| 120 | 92.8 | 9.78 | 1,173.60 | 37,120 | 35,946.4 | 1,186.6 | 1,186.6 |
| 150 | 95.00 | 9.78 | 1,467.00 | 38,000 | 36,533.0 | 1,773.2 | 586.6 |

**Table 3.** Bulb yield and water use efficiency of onion under levels of irrigation (mean of three seasons).

| IW : CPE | Bulb yield (q/ha) | Irrigation requirement (cm) | Water requirement (cm) | Consumptive use (cm) | Water use efficiency Field (kg/ha-cm) | Water use efficiency Crop (kg/ha-cm) | Crop susceptibility factor (cf) |
|---|---|---|---|---|---|---|---|
| 0.6 | 81.8 | 30 (6) | 37.8 | 21.5 | 216.40 | 380.47 | 0.23 |
| 0.8 | 89.1 | 35 (7) | 41.9 | 24.4 | 212.65 | 365.16 | 0.16 |
| 1.0 | 91.2 | 40 (8) | 42.0 | 26.1 | 217.14 | 349.43 | 0.14 |
| 1.2 | 106.6 | 45 (9) | 46.7 | 30.4 | 228.27 | 330.66 | - |

iccation, sprouting, rotting, respiration and shrinkage during storage which is due to presence of high moisture content in scales and physiologically active growing points (6). In the present investigation the per cent moisture in onion stabilized after 40 days of storage and, the loss of moisture was comparatively less under stress regime of 0.6 IW : CPE and at a lower N levels of 90 kg/ha (17 to 17.2%). Per cent rotting increased markedly with increase in irrigation and N levels. A minimum of 2.5% rotting, observed at 0.6 IW/CPE, increased by 3 and 4 times at moderate level of 0.8 and 1.0, and frequent level of 1.2 IW/CPE, respectively. Similarly, lowest rotting percentage of 4.2 was observed at 90 kg N/HA which increased by 57 and 140% at 120 and 150 kg N/ha, respectively (Table 1). Singh and Singh (7) has also reported a minimum loss in onion at moderate dose of nitrogen.

*Water Requirement and Water Use Efficiency*

Pooled study over 3 years indicated that water requirement of onion varied from 37.8 cm (ET 21.5 cm) at 0.6 IW : CPE to 46.7 cm (ET 30.4 cm) at 1.2 IW/CPE ratio requiring 6 and 9 irrigations, respectively. An increase in irrigation by 3 numbers and in WR by 10 cm resulted in an increase of 30.3% in bulb yield. However, the efficiency of water use by the crop was the maximum at lowest irrigation level (380.47 kg/ha-cm) which declined with increase in IW : CPE with a lowest of about 350 kg/ha-cm at 1.0 and 1.2 IW/CPE ratio (Table 3).

*Moisture Extraction Pattern*

Crop utilized more water from 0–10 cm profile accounting to 34.4% of the total water used. Moisture utilization increased from stress regime of 0.6 IW/CPE (17.2 cm) to 24.5 cm at 1.2 IW/CPE upto 50 cm profile. It decreased with increasing profile depth in all the irrigation treatments (Table 4). An average reduction in utilization by 83% from surface (0—10 cm) to lowest depth of 40–50 cm indicated more root configuration at the surface in onion.

*ET/Epan Ratio*

Crop coefficient (ET/Epan ratio) increased with increasing levels of IW/CPE ratio (Table 5). Monthly crop coefficient under frequently irrigated plots (1.2 IW/CPE) increased from 0.43 in December (early stage) to 0.89—0.91 in February-March (mid-season) and declined to 0.29 at maturity in April. Mid-season crop coefficient values varying from 0.85—0.96 has also been reported by Doorenbos and Pruitt (8).

**Table 4.** Moisture extraction pattern (cm) in onion under levels of irrigation (mean of three seasons).

| Profile depth (cm) | Irrigation levels IW/CPE 0.6 | 0.8 | 1.0 | 1.2 | Mean |
|---|---|---|---|---|---|
| 0–10 | 5.60 (32.6) | 7.00 (36.5) | 7.60 (25.5) | 8.10 (33.1) | 7.08 (34.4) |
| 10–20 | 4.80 (27.9) | 5.20 (27.1) | 5.90 (27.6) | 6.90 (28.2) | 5.70 (27.7) |
| 20–30 | 3.50 (20.3) | 3.90 (20.3) | 4.20 (19.6) | 5.00 (20.4) | 4.15 (20.2) |
| 30–40 | 2.00 (11.6) | 2.30 (12.0) | 2.40 (11.2) | 3.00 (12.3) | 2.43 (11.8) |
| 40–50 | 1.39 (7.6) | 0.80 (4.1) | 1.30 (6.1) | 1.50 (6.0) | 1.23 (5.90) |
| Total | 17.20 | 19.20 | 21.40 | 24.50 | 20.60 |

**Table 5.** Monthly ET/Epan ratio onion under different levels of irrigation (mean of three seasons).

| | Months | | | | |
|---|---|---|---|---|---|
| IW : CPE | Dec | Jan | Feb | Mar | Apr |
| 0.6 | 0.43 | 0.51 | 0.61 | 0.50 | 0.31 |
| 0.8 | 0.43 | 0.51 | 0.71 | 0.66 | 0.31 |
| 1.0 | 0.43 | 0.51 | 0.77 | 0.71 | 0.24 |
| 1.2 | 0.43 | 0.51 | 0.91 | 0.89 | 0.29 |

## References


1. Panse V. G. and P. V. Sukhatme. 1985. Statistical methods for agriculture workers. Indian Coun. Agric. Res., New Delhi, India.
2. Anonymous. 1995. Annual report of Directorate of Water Management Research, Patna, 1994-95, WMR, Patna, Bihar, India, pp. 30—31.
3. Shukla V., K. P. G. K. Rao and B. S. Prabhar. 1992. Effect of nitrogen on bulb yield and keeping quality of onion cultivars. Prog. Hort. 21 : 244—245.
4. Patel J. J. and A. T. Patel. 1990. Effect of nitrogen and phosphorus levels on growth and yield of onion (*Allium cepa* L.) cultivar, Pusa Red. Res. J., Gujarat Agric. Univ. 15 : 1—5.
5. Vachhani M. V. and Z. G. Patel. 1993. Effect of nitrogen, phosphorus and potash on bulb yield and quality of onion *(Allium cepa).*Indian J. Agron. 38 : 333—334.
6. Stow J. R. 1975. Effect of humidity on losses of bulb stand at high temperature. Experim. Agric. 11 : 85—87.
7. Singh S. and T. Singh. 2000. Quality and post harvest response of rainy season onion to nitrogen, sulfur and zinc application. Nat. Symp. on onion and garlic production and post harvest technology : Challenges and strategies, 19-21, Nov, Nasik, India, pp. 222.
8. Doorenbos J. and W. D. Pruitt. 1997. Guidelines for predicting crop water requirements. Food and Agric. Organ., Rome, Italy.