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CONTENTS

From the Editors 1
Notes for Contributors 5

Research on onion in Bangladesh: M.A. Rahim and M.A. Siddique 5

Onion production practices and their improvement in Nigeria:  
'Laure Denton and I. M. Ojello 10

Yield, bolting and storage losses of selected onion cultivars in Nigeria:  
E. B. Amaro and A. M. Kadams 14

Note on correlation of traits in Nigerian onions: F. Bodnarz 17

Research for the improvement of shallot production in Indonesia:  
Q. P. van der Meer and Aangoro Hadi Permadi 18

Onion situation in Uganda: Charles Ssekyera 21

Effect of irrigation rate on nutrient accumulation and yield of “Yellow  
Granex” onions: Bernard A. Kraitky, John E. Bowe and I-Pai Wu 23

The Onion Development Programme in Barbados: Winstons Small and Frances Chandler 27

No-tillage for onion production: T. J. C. Amado 32

Evaluation of onion germplasm for resistance against Stemphylium blight:  
I. S. Bisht, Kamala Venkateswaran and T. A. Thomas 36

Critical period for weed competition in onions (Allium cepa L. cv. Bombay Red):  
T. A. Mutia and M. Lombadia 37

Ventilated bamboo structure for onion storage: K. Subburamu, M. Singaravelu,  
T. Thangaraj and L. Iralappan 38

Effect of bulb size, spacing, time of planting and insecticides and fungicides on the  
production of onion seed in south-western region of Punjab, India:  

LISTINGS

Short-day onions: seed suppliers and cultivars 41

Extension publications on onion growing and storage 43

Network members, April 1990 46

Recent papers by network members 53

Editors: Lesley Currah and Felicity J Proctor  
Natural Resources Institute  
Chatham Maritime, Chatham, Kent, ME4 4TB, UK.

Address for all Newsletter correspondence:  
L Currah, Institute of Horticultural Research,  
Wellesbourne, Warwick, CV35 9EF, UK.
EFFECT OF IRRIGATION RATE ON NUTRIENT ACCUMULATION AND YIELD OF 'YELLOW GRANEX' ONIONS

by

Bernard A. Kratky, John E. Bowen and I-Pai Wu

Departments of Horticulture, Plant Molecular Physiology and Agricultural Engineering, University of Hawaii, 461 West Lanikaula street, Hilo, Hawaii 96720, U.S.A.

Onions (Allium cepa L, cv Yellow Granex) grown at upper elevations in Hawaii command a premium price. The Volcano Experiment Station is located at an elevation of 1200 m and received 159 cm of rainfall between the date seedlings were transplanted in this experiment (November 6, 1987) and April 13, 1988 when they were harvested. The onions were grown in a plastic-covered rain shelter with 0.6-m high open sidewalls.

Two-month-old seedlings were transplanted into the Manu silt loam soil in 4-row bedded plots with a 15-cm spacing between plants and 23 cm between rows. Plants were watered daily from the transplanting date until 42 days before harvest via two lines of 'Drip-In 2L' irrigation tubing (30-cm emitter spacing) per plot. The total amounts of water applied during the crop were 8, 35, 67, 140 and 247 liters (L) per meter of row. In addition, sub-surface movement of water contributed to the supply of available moisture by unknown amounts. A pre-plant fertilizer application consisted of, in kg/ha, 16-16-16 (1150), dolomite (2800), treble super phosphate (300) and KMag (300). A side-dressing of calcium nitrate solution (100 kg/ha) was applied 10 days after transplanting.

Total saleable onion yield and yield of the largest bulbs (greater than 10 cm in diameter) were 2.3- and 4.6-fold greater, respectively, in plots that received 140 L of water per meter of row as compared to those receiving 8 L (Figs 1 and 2). When the amount of water applied was raised to 247 L/m of row, however, the total and largest-bulb yields decreased by 24 percent and 59 percent, respectively, compared to the yields in plots receiving 140 L of water/m of row.

The yield of smaller onions (less than 10 cm diameter) was much greater in those plots that received 8 L/m of row, compared to those receiving 140 L of water/m (Fig. 1). However, there was a tendency for these yields to increase again at the highest rate of water application; i.e., 247 L/m of row. Increased water application did increase the number of split bulbs, though. For example, the yield of split onions increased 16-fold, from 0.07 kg/m of row at 8 L of water to 1.23 kg/m at 247 L.
Tissue nutrient concentrations were also monitored as functions of the amount of water applied (Table 1). The most recently-matured leaf (leaf number 3 when the newly-emerging leaf is designated as number 1) was sampled for analysis 84 days after transplanting. The leaf nitrogen content decreased by 27 percent in plants receiving 247 L of water compared to those with 8 L but the greatest decrease (25 percent) occurred when the rate of water application was raised from 140 to 247 L. Tissue potassium levels showed a similar pattern with no significant effect when the water application rate was 140 L/m of row and below. However, the tissue K level did decrease by 9 percent at the highest rate of water application. Tissue concentrations of phosphorus and magnesium were unaffected by water availability over the range tested.

Plant tissue samples were also taken 115 days after transplanting. The responses described above for N, P, K and Mg were repeated. In addition, the tissue was analyzed for Fe, Zn, Cu and Mn (Table 1). Tissue Fe and Zn levels decreased by 29 and 22 percent, respectively, at 247 L of water compared to those at 140 L/m of row. There was no apparent effect of water availability on Cu uptake and accumulation in the plant tissues. The effects, if any, on Ca and Mn utilization were inconclusive.

Soil analyses for K, Ca and Mg were conducted after harvest to determine the effect of water application rate on nutrient retention (Table 2). The electrical conductivity of a saturated soil extract, and the soil K, Ca and Mg levels, decreased by 52, 54, 7 and 17 percent, respectively, in the 247-L plots compared to the 8-L ones.

In summary, the rate at which water is applied during an onion crop strongly affects both the total saleable yield and the size of the individual bulbs. Further, irrigation rates also influence availability, uptake and accumulation of nitrogen, and possibly of K, Ca, Mg, Fe, Zn and Mn. Thus, the rate of water application should be considered in planning fertilizer application rates and timing.

The technical assistance of George Terasawa, Gaillane Maehira, and Catherine Robbins is gratefully acknowledged.
Table 1. Nutrient concentrations in onion tissues as functions of irrigation rate. (Data for N, P, K, Ca and Mg obtained from plants 84 days after transplanting; Fe, Zn, Mn and Cu data obtained 115 days after transplanting.)

<table>
<thead>
<tr>
<th>Rate, L/m</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Fe</th>
<th>Zn</th>
<th>Mn</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>µg/g dry wt</td>
<td>µg/g dry wt</td>
<td>µg/g dry wt</td>
<td>µg/g dry wt</td>
</tr>
<tr>
<td>8</td>
<td>3.03</td>
<td>0.30</td>
<td>3.02</td>
<td>0.50</td>
<td>0.28</td>
<td>90</td>
<td>40</td>
<td>183</td>
<td>5.3</td>
</tr>
<tr>
<td>35</td>
<td>2.97</td>
<td>0.32</td>
<td>2.89</td>
<td>0.55</td>
<td>0.29</td>
<td>101</td>
<td>40</td>
<td>297</td>
<td>5.0</td>
</tr>
<tr>
<td>67</td>
<td>3.20</td>
<td>0.34</td>
<td>3.03</td>
<td>0.56</td>
<td>0.30</td>
<td>94</td>
<td>40</td>
<td>282</td>
<td>5.5</td>
</tr>
<tr>
<td>140</td>
<td>2.93</td>
<td>0.32</td>
<td>2.98</td>
<td>0.51</td>
<td>0.27</td>
<td>90</td>
<td>32</td>
<td>209</td>
<td>5.5</td>
</tr>
<tr>
<td>247</td>
<td>2.20</td>
<td>0.32</td>
<td>2.75</td>
<td>0.46</td>
<td>0.27</td>
<td>64</td>
<td>25</td>
<td>178</td>
<td>5.5</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>0.42</td>
<td>0.04</td>
<td>0.25</td>
<td>0.07</td>
<td>0.04</td>
<td>21</td>
<td>13</td>
<td>111</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Table 2. Potassium, calcium and magnesium contents of soil and its electrical conductivity as a function of irrigation rate.

<table>
<thead>
<tr>
<th>Rate, L/m</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>ECₑ, mmole/cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1313</td>
<td>3389</td>
<td>1109</td>
<td>2.3</td>
</tr>
<tr>
<td>35</td>
<td>1041</td>
<td>3331</td>
<td>1003</td>
<td>1.9</td>
</tr>
<tr>
<td>67</td>
<td>879</td>
<td>3193</td>
<td>934</td>
<td>1.3</td>
</tr>
<tr>
<td>140</td>
<td>722</td>
<td>3071</td>
<td>847</td>
<td>1.3</td>
</tr>
<tr>
<td>247</td>
<td>601</td>
<td>3150</td>
<td>810</td>
<td>1.1</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>414</td>
<td>201</td>
<td>136</td>
<td>1.2</td>
</tr>
</tbody>
</table>
FIGURE 1. Onion yield by grade as a function of water applied.

FIGURE 2. Grades of onions, as percent of total yield, as a function of water applied.