Yield and Dry Weight of Dehydrator Onions after Uprooting at Maturity and Delaying Harvest

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Abstract. In dry climates, onions usually have the roots undercut at maturity before harvest. In a 2-year study, dehydrator onions were uprooted at maturity to simulate undercutting, and harvest was delayed for several time intervals. Treatment effects on fresh and dry yield, the number of bulbs per plot, bulb fresh and dry weights, and percent dry weight of bulbs were measured. Plots were considered mature when 80% of the tops had fallen. Delaying harvest 15 days after maturity without uprooting did not reduce yield significantly. Yield and both bulb weight and percent dry weight tended to decline when harvest was delayed >15 days after maturity, especially if plants were uprooted. This suggests that undercutting of onions should not be performed until just prior to harvest and that harvest should not be delayed >15 days past maturity. Yield losses in delayed harvest treatments were attributed primarily to *Fusarium* basal rot.

White-skinned onion cultivars with high dry-weight (solids) content are dehydrated and used as primary ingredients in food seasonings and spices (American Spice Trade Association, 1993; Fenwick and Hanley, 1990). The dry weight of commercial dehydrator onion cultivars is usually $\geq 18\%$. Most of this consists of fructans (Darbyshire and Henry, 1979; Sinclair et al., 1995; Wall et al., 1999), which are water-soluble polymers of fructose formed by the cumulative addition of 1 to 11 fructose subunits to a terminal sucrose molecule (Darbyshire and Steer, 1990).

Most of onion production for dehydration in the United States is in California (American Dehydrated Onion and Garlic Association, 1993), but southern New Mexico has an ideal climate for onion production. Development of regionally adapted, high-yielding cultivars is needed to enable dehydrator onion production and processing in the southwestern United States, as well as cropping systems research to provide information on how to optimize crop production.

Dehydrator onions are considered mature when 80% to 100% of the tops have fallen

(Oregon State Univ. Cooperative Extension Service, 1997). Irrigation is usually terminated as onions approach maturity to accelerate leaf senescence and dry-down. Mature onions are usually undercut and left in the field for 3 to 10 d before harvest to promote drying of the outer scales and necks (Maw and Smittle, 1986). Field-curing is thought to improve subsequent postharvest handling and storage in warm, dry climates, but is not recommended in cool, humid regions (Brewster, 1990). Dehydrator onion processors schedule crop production in different regions and use different maturity groups to provide a steady supply of onions throughout the processing season, but harvest is often delayed past maturity because of transportation, harvest, and processing limitations and backlogs (Corgan and Kedar, 1990). These delays may affect onion yield and quality. An experiment was conducted for 2 years to determine the effects of uprooting at maturity, and then delaying harvest for varying time intervals, on yields, average bulb fresh and dry weight, and percent dry weight of three dehydrator onion lines.

Materials and Methods

Two intermediate-day dehydrator onion lines adapted to California (GS02 and GS04) and an intermediate-day open-pollinated (OP) dehydrator onion breeding line adapted to southern New Mexico (NM9335) were chosen for this study. GS02 and GS04 are commercial lines from Gilroy Foods, Inc., with 18% to 20% dry weight. NM9335 is an F₇ OP line originating from the cross of 'Ben Shemen' x 'Southport White Globe' with 11% to 12% average dry weight.

Plots were 120 cm long, with four rows planted on a 56-cm bed, and with a 1-m center-to-center bed spacing. Onions were direct seeded in early January to prevent bolting

(seed-stalk formation), at the Fabian Garcia Agricultural Science Center in Las Cruces, N.M. Seedlings were thinned to 6 cm between plants in late January, and the crop was managed according to standard practices for southern New Mexico (Bailey and Corgan, 1986). Water and nitrogen were applied through drip irrigation.

Plots were arranged in a split-plot design with six replications, and the experiment was conducted for 2 years. Plots were considered mature when 80% of the tops had fallen. GS02 and NM9335 matured in mid-July in 1994 and early July in 1995; GS04 matured in early August in 1994 and in late July in 1995. Onions were uprooted by hand to simulate mechanical undercutting, and left uncovered in the bed. Uprooting is similar to undercutting, because onions are lifted from the ground and roots are broken in both practices. Onions remained rooted in the control plots (not-uprooted). In 1994, three delayed-harvest treatments (15, 30, and 45 d after maturity) were evaluated; the 45-d treatment was omitted in 1995.

Onions were hand harvested by taking bulbs from within the middle 90 cm of the plot (harvest area = 0.9 m²). Roots and tops were clipped, and bulbs were placed in paper bags. Bulbs were washed and dried to remove soil and dry scales, and tops and roots were removed prior to testing. Data were obtained on the day of harvest for number of plants per plot, percent dry weight, fresh- and dry-weight yields, and average bulb fresh and dry weight. Percent dry weight was determined as the proportion of dry to wet weight after drying a 10-bulb subsample at 70 to 75 °C for 48 h.

Data from each year were tested separately using analysis of variance for a split-plot design. Homogeneity of variance tests indicated that data could be combined; therefore, the data presented are means over 2 years.

Results and Discussion

NM9335 was well adapted to the experimental location and was tolerant to pink root [*Phoma terrestris* (Hansen)] and *Fusarium* basal rot [*Fusarium oxysporum* f. sp. *cepa* (Hans) Snyder and Hansen]. The commercial California lines, GS02 and GS04, were poorly adapted to the experimental environment in southern New Mexico, and had more symptoms of pink root and *Fusarium* basal rot.

Bulb characteristics. Onion line x treatment interactions were significant for average bulb fresh and dry weights, and for percent dry weight. Line NM9335 gained fresh and dry weight if bulbs were not uprooted and harvest was delayed 15 d (Fig. 1), indicating that 80% tops-down may have been premature for this line. Average bulb fresh and dry weight for lines GS02 and GS04 declined when harvest was delayed 30 d if bulbs were uprooted, but did not decline significantly if bulbs remained rooted after maturity (Fig. 1). Average bulb weight of GS04 declined sharply after maturity in uprooted plots. The reasons for this trend in GS04 were not evident. We did observe that a higher percentage of the larger

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Fig. 1. The effects of uprooting onions at maturity and delay of harvest on average bulb fresh and dry weights and percent dry weight of dehydrator onion breeding lines NM9335, and commercial cultivars GS02 and GS04, averaged over 1994 and 1995. (45-d postmaturity treatment data are from 1994 only, and mean standard errors for this treatment were estimated using SAS "Mixed ANOVA Procedure" for missing data prediction.)

bulbs of GS04 in uprooted treatments had more *Fusarium* basal rot than did the smaller bulbs, as harvest was delayed. This might partially explain the rapid decline of bulb weight as harvest was delayed past maturity in the uprooted treatments. Average bulb weights of GS02 and GS04 were relatively stable up to 15 d after maturity, and NM9335 bulb weight continued to increase after maturity. Wall and Corgan (1994) reported that bulb weight increased in fresh-market onions that remained rooted after 80% of the tops had fallen, and that delaying harvest past maturity reduced yield because of a higher incidence of bulb disease.

High percent dry weight is important to processors to reduce the marginal costs of production by decreasing transportation and drying costs. Also, high-solids cultivars may possess better processing characteristics, such as a whiter color after dehydration. Onion percent dry weight can increase because of bulb desiccation or solids accumulation, and can decrease because of respiration, higher bulb hydration, or bulb disease. Percent dry weight of NM9335 and GS02 was highest when bulbs were uprooted at maturity and then harvested 15 d later (Fig. 1), but tended to decline in all three lines when harvest was delayed >15 d after maturity (Fig. 1). These declines may have occurred because of respiration, increase in bulb hydration, or bulb disease. The loss in percent dry weight after

Fig. 2. The effects of uprooting onions at maturity and delay of harvest on the mean number of bulbs per plot, averaged over three dehydrator onion lines, and over 1994 and 1995. (Plot area was 0.9 m².) (45-d postmaturity treatment data are from 1994 only, and mean standard errors for this treatment were estimated using SAS "Mixed ANOVA Procedure" for missing data prediction.)

Fig. 3. The effects of uprooting onions at maturity and delay of harvest on fresh yields of three dehydrator onion lines, averaged over 1994 and 1995. (Plot area was 0.9 m².) (45-d postmaturity treatment data are from 1994 only, and mean standard errors for this treatment were estimated using SAS "Mixed ANOVA Procedure" for missing data prediction.)

Fig. 4. The effects of uprooting onions at maturity and delay of harvest on dry-weight yield, averaged over three dehydrator onion lines, and over 1994 and 1995. (Plot area was 0.9 m².) (45-d postmaturity treatment data are from 1994 only, and mean standard errors for this treatment were estimated using SAS "Mixed ANOVA Procedure" for missing data prediction.)

maturity was less in the high-solids lines, GS02 and GS04, than in line NM9335, perhaps because they are higher in storage carbohydrates, or declines in percent dry weight could have been offset by desiccation.

Yield. Both cultivar and treatment affected yield; interactions were significant for fresh yield, but not for number of bulbs per plot or dry-weight yield. Delaying harvest after uprooting at maturity reduced yield (Figs. 2–4). The data were variable, especially for the 45-d treatment, because of disease. Fresh yields tended to decline in all lines if uprooting was performed at maturity (Fig. 3), but the effects were significant only in line NM9335. Mean dry-weight yields at maturity for all three lines were estimated to be 36,600 kg·ha⁻¹ in 1994 and 67,750 kg·ha⁻¹ in 1995. Doubling of yield in 1995 may be attributed to better weather for crop growth, better soil conditions, and less disease. Line NM9335 had high fresh yield, relative to GS02 and GS04 (Fig. 3), but was relatively low in percent dry weight (Fig. 1), so that dry-weight yields did not differ among the lines.

Dry-weight yields declined as harvest was delayed, especially if plots were uprooted at maturity (Fig. 4). The reductions were nonsignificant if harvest was delayed only 15 d past maturity. All tops were down and dry ≈15 d after 80% of the tops had fallen.

Conclusions

Average bulb dry weight was relatively constant up to 15 d past maturity and then declined, especially if plots were uprooted. Dry-weight yields declined after maturity in uprooted plots when harvest was delayed 30 or 45 d, primarily because of *Fusarium* basal rot. Delaying harvest would not be advisable when bulb diseases are a problem or when rainy weather prevails. Evidence from this study suggests that for greatest yields, onions should not be undercut until just prior to harvest, and harvest should not be delayed >15 d after 80% of the tops are down.

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