Postharvest Losses from Delayed Harvest and during Common Storage of Short-day Onions

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Abstract. A 2-year field study was conducted to evaluate the effects of maturity and storage on fresh-market onion (*Allium cepa* L.) quality. Four short-day onion cultivars ('NuMex BR1', 'NuMex Sunlite', 'NuMex Starlite', and 'Buffalo') were seeded in early October each year. Bulbs were harvested at five times; the first and second harvests were when 20% and 80 %, respectively, of the bulbs in a plot had mature necks; the third, fourth, and fifth harvests were at 5, 10, and 15 days after the second harvest date, respectively. After curing for 3 days, bulb firmness, weight, and incidence of disease were evaluated for all harvests. Bulbs were re-evaluated after 10 and 20 days storage in a shed under ambient conditions. 'Buffalo' and 'NuMex Starlite' bulbs had the lowest incidence of disease before storage. For all cultivars, average bulb weight increased and firmness decreased with delayed harvest. Percent diseased bulbs increased for all cultivars as harvest was delayed in 1991 but not in 1992. The optimum harvest time was at 80% maturity. In storage, average bulb weight and firmness decreased, and the incidence of bulb diseases increased.

Short-day onions are harvested in early summer when temperatures are often high. In the southwestern United States, harvest temperatures may exceed 38C, and heat injury, fungal rots, and bacterial decay are potential problems. These onions are rarely held in environmentally controlled storage but are commonly held past maturity in the field or stored at ambient temperatures after harvest and grading. At peak harvest times in any area, onion supply sometimes exceeds market demand, requiring growers to delay harvest or to hold bulbs in the packing shed until they can be sold. Onion harvest may also be delayed past optimum maturity if labor, handling facilities, or transportation are limited (Corgan and Kedar, 1990). Under these circumstances, fresh-market onions are subjected to additional days or weeks at high temperatures, causing postharvest losses. Our objective was to evaluate the effects of bulb maturity and storage duration under ambient conditions on fresh-market onion quality.

Materials and Methods

Four short-day onion cultivars ('NuMex BR1' (BR1), 'NuMex Sunlite' (Sunlite), 'NuMex Starlite' (Starlite), and 'Buffalo') were

direct-seeded, four rows per bed, on 9 Oct. 1990 and 8 Oct. 1991 at the Fabian Garcia Research Center at Las Cruces, N.M. The first three cultivars are yellow grano types with good bolting resistance, suitable for early fall planting (Corgan, 1984, 1988; Corgan and Holland, 1990, 1993). Buffalo is a hybrid of Japanese origin. Seedlings were hand-thinned to 10-cm spacings in mid-Jan. 1991 and delayed until late Feb. 1992 because of wet soils and slower growth during winter.

Plots were arranged in a split-plot design with cultivars as main plots and five harvest dates as subplots. Each cultivar × harvest treatment had five replications. Main plots of each cultivar per replication were 18 m long and 1 m wide, with 0.75-m borders on each end. Subplots for each harvest date were 1.5 m long and 1 m wide. The first harvest was performed when 20% of the bulbs in a plot had mature necks (mature necks collapse easily when

squeezed gently). The second harvest was performed when 80% of the bulbs in a plot had matured (80% maturity). The third, fourth, and fifth harvests were 5, 10, and 15 days after the second harvest date, respectively. Harvesting started in the last week of May for both years.

At each hand harvest, the roots and tops of 60 bulbs per subplot were clipped, placed in mesh bags, cured in a greenhouse (32–38C day, 21 C night) for 3 days, and weighed. A subsample of 30 was visually inspected for number of diseased bulbs and type of disease and stored in a shed in ambient conditions. Diseases found at harvest were black mold (*Aspergillus niger* Van Tieghem), botrytis bulb rot (*Botrytis* spp.), fusarium basal rot (*Fusarium oxysporum* f.sp. *cepae* Snyder & Hansen), and bacterial infections (*Erwinia* and *Pseudomonas* spp.). Ten bulbs per subplot were tested for resistance to puncture, using a Wagner force gauge (100 N) (Wagner Instruments, Greenwich, Conn.) with a 6-mm plunger, and discarded. Two measurements were taken per bulb, at the equatorial axis and the shoulder. Twenty bulbs were marked and stored for later firmness evaluations. After 10 and 20 days of storage, bulbs were re-evaluated for incidence of bulb disease, and 10 bulbs were evaluated for firmness and discarded. In 1992, average bulb weight also was determined after 10 and 20 days of storage. Temperatures in the shed ranged from 15 to 34C, with a mean of 24.8C. The average minimum and maximum relative humidities (RH) were 10% and 76%, respectively, during the storage periods.

Data from each year were tested separately using analyses of variance for a split-plot design, including repeated measures overtime for the storage data (Gomez and Gomez, 1984). After assumptions for homogeneity of variance were met, data from both years were combined and reanalyzed, except for the incidence of bulb disease at harvest data, which differed significantly between years. Mean separations among cultivar and harvest dates were performed according to the Waller–Duncan k ratio t test. Significant linear trends were determined for disease, firmness, and weight among storage treatments.

Table 1. Onion cultivar and maturity effects on average bulb weight, firmness, and disease incidence at harvest.

Variable	Wt ^a (g)	Firmness (N)	Disease incidence (%)	
			1991	1992
Cultivar				
NuMex Starlite	263 a ^c	54.4 a	21.5 a	8.4 a
NuMex Sunlite	239 ab	53.7 a	4.5 bc	5.2 ab
NuMex BR1	235 ab	53.5 a	10.9 b	7.8 a
Buffalo	220 b	55.3 a	1.9c	2.0 b
Harvest ^{b,w}				
1	182 d	56.1 a	0.3 c	4.5 a
2	231 c	56.1 a	4.0 c	6.3 a
3	244 bc	54.2 b	10.5 b	4.5 a
4	265 ab	52.6 bc	13.7 b	7.8 a
5	274 a	52.2 c	20.0 a	6.3 a

^aAverage bulb weight and bulb firmness data combined for 1991 and 1992. Bulb evaluations were after curing but before storage.

^bMean separation within columns by Waller–Duncan k ratio t test at $P \leq 0.05$.

^cHarvests 1 and 2 were when 20% and 80% of the tops had matured, respectively. Harvests 3, 4, and 5 were 5, 10, or 15 days after harvest 2, respectively.

^wCultivar × harvest was nonsignificant at $P \leq 0.05$ for all criteria.

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Results and Discussion

Average bulb weights and firmness were similar among cultivars, although Starlite bulbs were significantly heavier than 'Buffalo' (Table 1). 'Buffalo' had the lowest percentage of diseased bulbs at harvest in both years; however, the levels were not significantly lower than those for Sunlite. In 1991, Starlite had the highest percentage of diseased bulbs. Starlite matures slightly later than 'Buffalo', Sunlite, and BR1 (Corgan and Holland, 1993), which may explain the higher bulb weight and disease incidence in Starlite. The first harvest for Starlite was 10 days later than that for the other cultivars in 1991 and 3 days later in 1992. The later harvest date allowed for increased bulb expansion and exposure to pathogens in the field.

For all cultivars, average bulb weight increased and firmness decreased as harvest was delayed (Table 1). The greatest increases in average bulb weight occurred between harvests 1 and 2 (21.5%) and 3 and 4 (7.8%). The time interval between harvests 1 and 2 was 6 to 8 days, depending on cultivar and year. Delaying harvest past 20% maturity allowed bulbs to increase in fresh weight; however, bulb firmness began to decrease when harvest was delayed past 80% maturity (harvest 3).

In 1991, but not in 1992, the incidence of diseased bulbs increased when harvest was delayed past 80% maturity (Table 1). For all bulbs evaluated at harvest, 7.9% had black mold, 1.1% botrytis, and 0.6% bacterial infections in 1991. In 1992, 5.3% had black mold, 0.2% botrytis bulb rot, and 0.4% bacterial infections.

When onions were stored for 10 or 20 days under ambient shed conditions (15–34°C, 76% to 10% RH, respectively), average bulb weight and firmness decreased linearly with time in storage (Table 2). Weight loss ranged from 0.4% to 0.6% per day. After 10 days in storage, disease incidence ranged from 13.1% to 47.7%, with an average daily increase of 2.1% in 1991 and 1.6% in 1992. Diseases found were black mold (27.7% and 18.5% of total bulbs), bacterial infections (1.1% and 2.3%), and botrytis bulb rot (2% and 0.9%) in 1991 and 1992, respectively. After 20 days in storage, the percentage of diseased bulbs ranged from ~50% to ~70%, depending on year and cultivar. Similar results have been reported for 'Texas Grano 1015Y' onions, in which the incidence of black mold was 52% and that of slippery skin 3% (*Pseudomonas* spp.) after 3 weeks of storage at 24°C (Pike et al., 1989). We stored onions primarily in June, when the average daily temperature was 24.8°C, and maximum temperatures in the shed reached 34°C in both years. The black mold pathogen, *Aspergillus niger*, is prolific at these temperatures (Yoo et al., 1989).

In 1991, the incidence of bulb diseases increased as harvest was delayed (Fig. 1), and this increase may have affected disease development in storage. Previous research with granex onions has shown a similar increase in storage losses with later maturity (Smittle and Maw, 1988). However in 1992, delaying har-

Table 2. Onion cultivar and storage duration effects on average bulb weight, firmness and disease incidence.

Cultivar	Storage (days)	Wt ^a (g)	Firmness (N)	Disease incidence (%)	
				1991	1992
Starlite	0	208	54.4	21.5	8.4
	10	195	52.3	47.7	25.0
	20	183	49.6	68.7	50.4
Sunlite	0	209	53.7	L ^{***}	L ^{***}
	10	200	52.8	4.5	5.2
	20	189	48.8	25.9	14.2
BR1	0	186	53.5	53.2	49.7
	10	177	L ^{***}	L ^{***}	L ^{***}
	20	171	52.1	10.9	7.8
Buffalo	0	186	55.3	36.9	25.8
	10	180	49.8	65.1	50.6
	20	171	L ^{***}	L ^{***}	L ^{***}

^aAverage bulb weights for 1992. Bulb firmness data combined for 1991 and 1992.

***Linear (L) response significant at $P \leq 0.001$.

Fig. 1. Percent diseased onion bulbs in (A) 1991 and (B) 1992 after 0, 10, or 20 days of storage. Harvests 1 and 2 were performed when 20% and 80% of the tops had matured, respectively. Harvests 3, 4, and 5 were 5, 10, or 15 days after harvest 2, respectively. Data were combined for all cultivars. Vertical bars indicate the SE of the means.

vest did not significantly affect the incidence of bulb diseases, and no clear relationship between storage diseases and maturity at harvest was evident. The percentage of diseased bulbs did increase during storage, suggesting that factors other than bulb maturity had a greater influence on disease development during storage.

Short-day onions are typically harvested when the field is 80% mature. This was the optimum harvest maturity in this study based on maximum bulb firmness, low incidence of disease, and acceptable average bulb weight. Harvesting bulbs earlier, at 20% maturity, resulted in smaller bulbs. Bulbs held in the field continued to gain weight but developed more disease in 1991. If onions are grown in fields with high levels of disease pressure, harvests should not be delayed past 80% ma-

turity. Stored bulbs dessicated and quickly developed black mold; the magnitude depended on cultivar, maturity at harvest, and time in storage. Our data indicate the importance of timely harvesting and rapid handling and marketing to minimize postharvest losses of short-day onions grown in warm environments when cold storage is not used.

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