

# ONION PRODUCTION FROM TRANSPLANTS GROWN IN A LOW TUNNEL COLD FRAME AND IN A GREENHOUSE

Clinton Shock, Erik Feibert, and Lamont Saunders  
Malheur Experiment Station  
Oregon State University  
Ontario, OR, 2008

Bob Simerly  
McCain Foods  
Fruitland, ID

## Introduction

Increased interest in an earlier start for the onion harvest season has led to interest in transplanting. Our earlier research showed that onions can be harvested in July when grown from transplants started in the winter in a greenhouse (Shock et al. 2004). Transplants must be grown locally as required by the local onion white rot quarantine that prohibits importation of onion transplants from areas outside the Treasure Valley. Onion transplant production in the Treasure Valley is expensive due to the need for heated greenhouse production during the winter. Transplants produced from field-grown, over-wintering varieties have performed inconsistently and the available over-wintering varieties do not have adequate bulb quality and appearance (Shock et al. 2007). Another alternative would be to plant seed in the winter and grow transplants in unheated "low tunnel" cold frames. This trial evaluated the performance of onion transplants produced in low tunnels and in a heated greenhouse.

## Materials and Methods

A 44-inch bed was made in a field of Nyssa silt loam and fumigated with Telone<sup>®</sup> C-17 at 20 gal/acre on October 8, 2007. Two drip tapes were laid 11 inches to each side of the bed center at 3-inch depth on November 8. A soil sample taken on November 8 indicated the need for 136 lb phosphate/acre, 4 lb zinc/acre, 2 lb manganese/acre, 1 lb copper/acre, and 200 lb sulfur/acre, which were broadcast on the bed surface. Onion seed of 10 varieties was broadcast on the bed surface at an approximate rate of 1 seed/inch<sup>2</sup> on December 17. The onion seed was covered with 0.25 to 0.5 inch of shredded bark mulch. Low tunnel cold frames were assembled over each bed. The 6-ft-wide plastic sheet was laid over wire hoops leaving about 6 inches of plastic on the outside of each bed side. The excess plastic was covered with soil to secure the plastic. The 76-inch-long hoops were made of number 10-gauge smooth galvanized steel wire. The hoops were inserted about 6 inches into the ground at the bed edges. The low tunnel was about 20 inches high at the center.

The beds were irrigated after planting as required to wet the bed surface. Emergence in both low tunnels started on February 18, 2008. Thereafter, the beds were irrigated when the soil water tension at 4-inch depth in the bed center reached 20 cb (1 cb = 1 kPa). Soil water tension in each low tunnel was monitored by 6 granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrrometer Co. Inc., Riverside, CA) centered at 4-inch depth below the bed center. The sensors were automatically read three times a day with two AM-400 meters (Mike Hansen Co., East Wenatchee, WA).

In addition to the low tunnel cold frames, transplants of variety 'Ranchero' were also grown in a heated greenhouse (65°F day, 45°F night air temperatures). Onion seed of Ranchero was planted in flats with a vacuum seeder at 72 seeds/flat on January 25, 2008. The seed was sowed on a 1-inch layer of Sunshine general purpose potting mix. The seed was then covered with 1 inch of potting mix. The flats were watered immediately after planting and were kept moist. Onion seedlings emerged on February 10.

On April 8, the one- to two-leaf onions from each low tunnel and the three-leaf onions from the greenhouse were transplanted to a field of Owyhee silt loam. The seedlings were planted in double rows spaced 3 inches apart on 22-inch beds. The spacing between plants in each single row was 6 inches (every 3 inches in the double row), equivalent to 95,000 plants per acre. Plots of each treatment were 20 ft long by 4 double rows wide arranged in a randomized complete block design with 5 replicates.

The onions were managed to avoid yield reductions from weeds, pests, diseases, water stress, and nutrient deficiencies. Weeds were controlled with an application of Prowl<sup>®</sup> at 1 lb ai/acre and Select<sup>®</sup> at 0.125 lb ai/acre on April 28. On May 13, Goal<sup>®</sup> at 0.16 lb ai/acre, Buctril<sup>®</sup> at 0.19 lb ai/acre, and Volunteer<sup>®</sup> at 0.25 lb ai/acre were applied. On May 16, Goal at 0.16 lb ai/acre, Buctril at 0.19 lb ai/acre were applied. On June 12, Aza-Direct<sup>®</sup> at 0.0062 lb ai/acre and Success<sup>®</sup> at 0.25 lb ai/acre were applied for thrips control and Select at 0.25 lb ai/acre was applied for weed control. On June 18, Goal at 0.22 lb ai/acre and Buctril at 0.19 lb ai/acre were applied. On June 19 and June 24, Aza-Direct at 0.0062 lb ai/acre and Success at 0.25 lb ai/acre were applied for thrips control. Subsequent insecticide applications for thrips control were done aerially: July 12, Lannate<sup>®</sup> at 0.9 lb ai/acre; July 19, Carzol<sup>®</sup> at 1.25 lb ai/acre; July 28, Lannate at 0.9 lb ai/acre; August 11, Lannate at 0.9 lb ai/acre. Not all of these late treatments were necessary for these onions, but they were planted in a field to be harvested in September and received all treatments appropriate for these full-season trials.

The field was fertilized with a total of 200 lb nitrogen(N)/acre divided in two sidedressings of urea at 100 lb N/acre on June 4 and on June 25.

On July 23, August 1, and August 11, 6.7 ft of the middle 2 rows in each plot were topped and bagged. Decomposed bulbs were not bagged. Following each harvest the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), bulbs infected with neck rot (*Botrytis allii*) in the

neck or side, plate rot (*Fusarium oxysporum*), or black mold (*Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (<2.25 inches), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and supercolossal (>4¼ inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

Onion bulbs from all harvests were rated for single centers. Twenty-five onions ranging in diameter from 3.5 to 4.25 inches from each plot were rated. The onions were cut equatorially through the bulb middle and, if multiple centered, the long axis of the inside diameter of the first single ring was measured. These multiple-centered onions were ranked according to the diameter of the first single ring: "small" had diameters under 1.5 inch, "medium" had diameters from 1.5 to 2.25 inches, and "large" had diameters over 2.25 inches. Onions were considered "functionally single centered" for processing if they were single centered or had a small multiple center.

Treatment differences were compared using ANOVA and protected least significant differences at the 5 percent probability level, LSD (0.05).

## **Results and Discussion**

### ***Emergence***

Onion seed in the greenhouse emerged on February 10 (16 days to emergence) and onion seed in the low tunnels emerged on February 18 (63 days to emergence). After planting, air temperature in the low tunnels reached 40 to 60°F during the day, but starting in early January the air temperature never went above 40°F until late January to early February (Fig. 1). Air temperature increased during February. At the time of transplanting, the greenhouse transplants had two to three true leaves while the low tunnel transplants had only one to two true leaves. The greenhouse transplants were substantially larger than the low tunnel transplants.

### ***July 23 Harvest***

Bulbs from the greenhouse-grown Ranchoero transplants had the higher total, marketable, and colossal bulb yield than bulbs from the low-tunnel-grown transplants on all three harvest dates (Table 1). On July 23, the only varieties with a marketable yield greater than 400 cwt/acre were Ranchoero from the greenhouse transplants (533 cwt/acre), 'Caballero' (455 cwt/acre), and 'Exacta' (431 cwt/acre). Colossal bulb yields were less than 20 cwt/acre for all varieties on July 23.

### ***August 1 Harvest***

On August 1, bulbs from the greenhouse-grown transplants of Ranchoero (680 cwt/acre), Exacta (535 cwt/acre), low tunnel Ranchoero (516 cwt/acre), and Caballero (514 cwt/acre) were the only varieties yielding more than 500 cwt/acre marketable yield. The Ranchoero grown from greenhouse transplants had 102 cwt/acre of colossal yield. All the other varieties yielded less than 40 cwt/acre of colossal yield.

### **August 11 Harvest**

On August 11, the only varieties with marketable yield greater than 500 cwt/acre were the Ranchero grown from greenhouse transplants (757 cwt/acre), Ranchero grown from low tunnel transplants (577 cwt/acre), 'Golden Spike' (561 cwt/acre), Exacta (539 cwt/acre), and Caballero (522 cwt/acre). On August 11, the only varieties with colossal yield greater than 100 cwt/acre were the Ranchero grown from greenhouse transplants (267 cwt/acre), Golden Spike (141 cwt/acre), Exacta (138 cwt/acre), and 'Joaquin' (138 cwt/acre).

### **Single Centers**

Averaged over varieties, the percentage of bullet single-centered bulbs decreased from 70 percent on July 23 to 60 percent on August 1, and 31 percent on August 11 (Table 2). On July 23, all varieties had more than 80 percent functionally single-centered bulbs except 'Sequoia', 'Kalahari', and Caballero (Table 2). On August 1, all varieties had more than 80 percent functionally single centered bulbs except Sequoia, Kalahari, Caballero, Golden Spike, and Exacta (Table 2). On August 11, only Joaquin had more than 80 percent functionally single-centered bulbs.

### **References**

Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2004. Onion production from transplants in the Treasure Valley. Oregon State University Agricultural Experiment Station Special Report 1055:47-52.

Shock, C.C., E. B. G. Feibert, and L.D. Saunders. 2007. Onion production from transplants. Oregon State University Agricultural Experiment Station Special Report 1075:45-50.

Table 1. Performance data for three harvest dates for onion varieties grown from transplants. Transplants of all varieties were produced in unheated low tunnel cold frames and transplants of Ranchoero only in a heated greenhouse, Malheur Experiment Station, Oregon State University, Ontario, OR (continued on next page).

| Harvest date                 | Total yield | Marketable yield by grade |         |        |         |      | Small | No. 2 | Rot  | Maturity |
|------------------------------|-------------|---------------------------|---------|--------|---------|------|-------|-------|------|----------|
|                              |             | Total                     | 4-4¼ in | 3-4 in | 2¼-3 in |      |       |       |      |          |
| ----- cwt/acre ----- % ----- |             |                           |         |        |         |      |       |       |      |          |
| 23 Jul                       |             |                           |         |        |         |      |       |       |      |          |
| Ranchoero greenhouse         | 546.3       | 533.3                     | 16.5    | 445.7  | 71.1    | 13.0 | 0.0   | 0.0   | 3.0  |          |
| Ranchoero low tunnel         | 374.9       | 362.3                     | 0.0     | 264.1  | 98.3    | 12.6 | 1.2   | 0.0   | 8.0  |          |
| Montero                      | 363.5       | 352.1                     | 0.0     | 274.7  | 77.4    | 11.4 | 0.0   | 0.0   | 9.5  |          |
| Joaquin                      | 294.3       | 285.4                     | 0.0     | 213.7  | 71.7    | 8.8  | 0.0   | 0.0   | 4.4  |          |
| Sequoia                      | 404.8       | 393.5                     | 2.9     | 309.0  | 81.5    | 11.3 | 0.0   | 0.0   | 14.4 |          |
| Kalahari                     | 298.3       | 248.4                     | 0.0     | 79.4   | 169.0   | 49.9 | 0.0   | 0.0   | 32.0 |          |
| Talon                        | 349.8       | 328.2                     | 0.0     | 118.7  | 209.5   | 21.6 | 0.0   | 0.0   | 11.0 |          |
| Caballero                    | 467.7       | 454.7                     | 0.0     | 328.2  | 126.5   | 13.0 | 0.0   | 0.0   | 19.5 |          |
| Golden Spike                 | 411.1       | 396.9                     | 0.0     | 314.4  | 82.5    | 14.1 | 3.1   | 0.0   | 8.5  |          |
| Exacta                       | 441.7       | 431.1                     | 3.1     | 346.2  | 81.7    | 10.6 | 0.0   | 0.0   | 12.5 |          |
| Gunnison                     | 308.5       | 287.4                     | 0.0     | 74.7   | 212.7   | 21.1 | 0.0   | 0.0   | 11.9 |          |
| Average                      | 387.3       | 370.3                     | 2.1     | 251.7  | 116.6   | 17.0 | 0.4   | 0.0   | 12.2 |          |
| 1 Aug                        |             |                           |         |        |         |      |       |       |      |          |
| Ranchoero greenhouse         | 682.6       | 680.3                     | 102.2   | 550.2  | 27.9    | 2.4  | 0.0   | 0.0   | 8.0  |          |
| Ranchoero low tunnel         | 523.5       | 515.6                     | 13.4    | 464.5  | 37.7    | 7.9  | 0.0   | 2.4   | 14.0 |          |
| Montero                      | 470.8       | 467.3                     | 5.5     | 417.0  | 44.8    | 3.5  | 0.0   | 0.0   | 20.0 |          |
| Joaquin                      | 339.0       | 333.6                     | 37.3    | 281.0  | 15.2    | 5.4  | 0.0   | 0.0   | 10.0 |          |
| Sequoia                      | 492.7       | 486.3                     | 0.0     | 424.4  | 61.9    | 6.4  | 0.0   | 0.0   | 30.0 |          |
| Kalahari                     | 309.3       | 263.7                     | 0.0     | 112.8  | 150.9   | 45.6 | 0.0   | 0.0   | 66.0 |          |
| Talon                        | 409.1       | 387.9                     | 0.0     | 243.3  | 144.6   | 21.2 | 0.0   | 0.0   | 23.0 |          |
| Caballero                    | 529.0       | 514.0                     | 6.3     | 433.1  | 74.7    | 14.9 | 0.0   | 0.0   | 38.0 |          |
| Golden Spike                 | 502.7       | 489.7                     | 10.2    | 435.4  | 44.0    | 13.0 | 0.0   | 0.0   | 16.0 |          |
| Exacta                       | 536.8       | 534.5                     | 36.2    | 459.0  | 39.3    | 2.4  | 1.6   | 4.7   | 24.0 |          |
| Gunnison                     | 363.1       | 353.7                     | 0.0     | 171.9  | 181.8   | 9.4  | 0.0   | 0.0   | 22.5 |          |
| Average                      | 469.0       | 457.0                     | 19.2    | 363.0  | 74.8    | 12.0 | 0.1   | 0.6   | 24.7 |          |

| Harvest date                     | Total yield | Marketable yield by grade |         |        |         |      | Small         | No. 2 | Rot  | Maturity |
|----------------------------------|-------------|---------------------------|---------|--------|---------|------|---------------|-------|------|----------|
|                                  |             | Total                     | 4-4¼ in | 3-4 in | 2¼-3 in |      |               |       |      |          |
|                                  |             | ----- cwt/acre -----      |         |        |         |      | ----- % ----- |       |      |          |
| 11 Aug                           |             |                           |         |        |         |      |               |       |      |          |
| Ranchero greenhouse              | 759.0       | 757.3                     | 266.8   | 471.6  | 18.9    | 1.7  | 0.0           | 0.0   | 17.0 |          |
| Ranchero low tunnel              | 579.8       | 577.2                     | 62.4    | 482.9  | 31.9    | 2.6  | 0.0           | 1.6   | 22.0 |          |
| Montero                          | 423.3       | 423.3                     | 16.9    | 381.2  | 25.2    | 0.1  | 0.0           | 3.9   | 26.0 |          |
| Joaquin                          | 445.1       | 315.0                     | 138.5   | 297.7  | 5.9     | 2.9  | 0.0           | 4.0   | 18.1 |          |
| Sequoia                          | 439.2       | 437.7                     | 17.2    | 395.0  | 25.5    | 1.5  | 0.0           | 3.1   | 57.5 |          |
| Kalahari                         | 240.9       | 196.5                     | 0.0     | 68.8   | 127.7   | 44.4 | 0.0           | 0.0   | 78.0 |          |
| Talon                            | 388.3       | 365.9                     | 0.0     | 247.2  | 118.7   | 22.4 | 18.9          | 0.9   | 39.0 |          |
| Caballero                        | 527.0       | 521.9                     | 44.4    | 421.7  | 55.8    | 5.1  | 0.0           | 0.0   | 56.0 |          |
| Golden Spike                     | 566.4       | 561.2                     | 140.7   | 400.1  | 20.4    | 5.2  | 0.0           | 2.0   | 34.0 |          |
| Exacta                           | 539.4       | 538.8                     | 138.7   | 384.7  | 15.3    | 0.6  | 11.8          | 3.5   | 42.0 |          |
| Gunnison                         | 317.3       | 305.1                     | 0.0     | 180.8  | 124.3   | 12.3 | 0.0           | 2.2   | 42.5 |          |
| Average                          | 475.1       | 454.5                     | 75.1    | 339.2  | 51.8    | 9.0  | 2.8           | 1.9   | 39.3 |          |
| Average over three harvest dates |             |                           |         |        |         |      |               |       |      |          |
| Ranchero greenhouse              | 662.6       | 657.0                     | 128.5   | 489.2  | 39.3    | 5.7  | 0.0           | 0.0   | 9.3  |          |
| Ranchero low tunnel              | 486.5       | 478.5                     | 22.6    | 398.2  | 57.7    | 8.0  | 0.0           | 0.4   | 13.2 |          |
| Montero                          | 419.2       | 414.2                     | 7.5     | 357.6  | 49.1    | 5.0  | 0.0           | 3.9   | 18.5 |          |
| Joaquin                          | 316.6       | 311.3                     | 35.5    | 243.8  | 32.0    | 5.2  | 0.0           | 4.0   | 8.5  |          |
| Sequoia                          | 445.6       | 439.2                     | 6.7     | 376.1  | 56.3    | 6.4  | 0.0           | 3.1   | 32.0 |          |
| Kalahari                         | 282.8       | 236.2                     | 0.0     | 87.0   | 149.2   | 46.6 | 0.0           | 0.0   | 58.7 |          |
| Talon                            | 382.4       | 360.6                     | 0.0     | 203.1  | 157.6   | 21.7 | 18.9          | 0.9   | 24.3 |          |
| Caballero                        | 507.9       | 496.9                     | 16.9    | 394.3  | 85.7    | 11.0 | 0.0           | 0.0   | 37.8 |          |
| Golden Spike                     | 493.4       | 482.6                     | 50.3    | 383.3  | 49.0    | 10.8 | 0.0           | 2.0   | 19.5 |          |
| Exacta                           | 506.0       | 501.5                     | 59.3    | 396.7  | 45.5    | 4.5  | 11.8          | 3.5   | 26.2 |          |
| Gunnison                         | 329.7       | 315.4                     | 0.0     | 142.5  | 172.9   | 14.3 | 0.0           | 2.2   | 25.6 |          |
| Overall average                  | 443.8       | 427.3                     | 32.1    | 318.0  | 81.0    | 12.7 | 1.1           | 0.9   | 25.4 |          |
| LSD (0.05) variety               | 71.6        | 73.8                      | 31.5    | 67.9   | 20.3    | 8.9  | 3.9           | NS    | 5.5  |          |
| LSD (0.05) date                  | 17.8        | 18.3                      | 15.9    | 24.0   | 9.7     | 3.1  | 2.2           | 0.6   | 1.5  |          |
| LSD (0.05) variety X date        | 59.0        | 60.9                      | 52.7    | NS     | NS      | NS   | NS            | NS    | 4.8  |          |

Table 2. Bulb single centeredness for three harvest dates for onion varieties grown from transplants. Transplants of all varieties were produced in unheated low tunnel cold frames and transplants of Ranchero only in a heated greenhouse, Malheur Experiment Station, Oregon State University, Ontario, OR (continued on next page).

| Harvest date        | Multiple center                  |                           |                   | Single center           |        |
|---------------------|----------------------------------|---------------------------|-------------------|-------------------------|--------|
|                     | Large<br>>2¼ inches <sup>a</sup> | Medium<br>1½ to 2¼ inches | Small<br><1½ inch | Functional <sup>b</sup> | Bullet |
| ----- % -----       |                                  |                           |                   |                         |        |
| 23 Jul              |                                  |                           |                   |                         |        |
| Ranchero greenhouse | 0.8                              | 0.0                       | 0.0               | 99.2                    | 99.2   |
| Ranchero low tunnel | 6.4                              | 8.6                       | 1.0               | 85.0                    | 84.0   |
| Montero             | 0.0                              | 0.0                       | 0.0               | 100.0                   | 100.0  |
| Joaquin             | 1.0                              | 0.0                       | 1.0               | 99.0                    | 98.0   |
| Sequoia             | 9.0                              | 21.0                      | 32.0              | 70.0                    | 38.0   |
| Kalahari            | 11.6                             | 28.9                      | 41.2              | 59.5                    | 18.3   |
| Talon               | 1.6                              | 0.0                       | 2.4               | 98.4                    | 96.0   |
| Caballero           | 3.2                              | 35.2                      | 28.8              | 61.6                    | 32.8   |
| Golden Spike        | 4.0                              | 12.8                      | 22.4              | 83.2                    | 60.8   |
| Exacta              | 3.2                              | 16.0                      | 26.4              | 80.8                    | 54.4   |
| Gunnison            | 2.0                              | 3.0                       | 4.0               | 95.0                    | 91.0   |
| Average             | 3.9                              | 11.4                      | 14.5              | 84.7                    | 70.2   |
| 1 Aug               |                                  |                           |                   |                         |        |
| Ranchero greenhouse | 1.6                              | 3.2                       | 2.4               | 95.2                    | 92.8   |
| Ranchero low tunnel | 4.0                              | 5.6                       | 14.4              | 90.4                    | 76.0   |
| Montero             | 0.8                              | 1.6                       | 2.4               | 97.6                    | 95.2   |
| Joaquin             | 0.0                              | 2.0                       | 0.0               | 98.0                    | 98.0   |
| Sequoia             | 10.0                             | 31.0                      | 41.0              | 59.0                    | 18.0   |
| Kalahari            | 12.8                             | 48.0                      | 28.8              | 39.2                    | 10.4   |
| Talon               | 0.0                              | 4.8                       | 10.4              | 95.2                    | 84.8   |
| Caballero           | 16.0                             | 44.8                      | 23.2              | 39.2                    | 16.0   |
| Golden Spike        | 4.8                              | 17.6                      | 31.2              | 77.6                    | 46.4   |
| Exacta              | 5.6                              | 26.4                      | 32.8              | 68.0                    | 35.2   |
| Gunnison            | 2.0                              | 4.0                       | 9.0               | 94.0                    | 85.0   |
| Average             | 5.2                              | 17.2                      | 17.8              | 77.6                    | 59.8   |

| Harvest date                     | Multiple center                  |                           |                   | Single center           |        |
|----------------------------------|----------------------------------|---------------------------|-------------------|-------------------------|--------|
|                                  | Large<br>>2¼ inches <sup>a</sup> | Medium<br>1½ to 2¼ inches | Small<br><1½ inch | Functional <sup>b</sup> | Bullet |
| ----- % -----                    |                                  |                           |                   |                         |        |
| 11 Aug                           |                                  |                           |                   |                         |        |
| Ranchero greenhouse              | 12.0                             | 19.2                      | 20.8              | 68.8                    | 48.0   |
| Ranchero low tunnel              | 25.0                             | 25.0                      | 10.0              | 50.0                    | 40.0   |
| Montero                          | 15.2                             | 16.0                      | 13.6              | 68.8                    | 55.2   |
| Joaquin                          | 6.0                              | 12.0                      | 4.0               | 82.0                    | 78.0   |
| Sequoia                          | 49.3                             | 42.7                      | 5.3               | 8.0                     | 2.7    |
| Kalahari                         | 53.6                             | 37.6                      | 8.8               | 8.8                     | 0.0    |
| Talon                            | 8.0                              | 24.8                      | 29.6              | 67.2                    | 37.6   |
| Caballero                        | 52.0                             | 36.0                      | 8.8               | 12.0                    | 3.2    |
| Golden Spike                     | 42.4                             | 29.6                      | 13.6              | 28.0                    | 14.4   |
| Exacta                           | 49.6                             | 38.4                      | 8.0               | 12.0                    | 4.0    |
| Gunnison                         | 4.0                              | 17.0                      | 19.0              | 79.0                    | 60.0   |
| Average                          | 28.8                             | 27.1                      | 12.9              | 44.1                    | 31.2   |
| Average over three harvest dates |                                  |                           |                   |                         |        |
| Ranchero greenhouse              | 4.8                              | 7.5                       | 7.7               | 87.7                    | 80.0   |
| Ranchero low tunnel              | 10.9                             | 12.2                      | 8.3               | 76.9                    | 68.6   |
| Montero                          | 5.3                              | 5.9                       | 5.3               | 88.8                    | 83.5   |
| Joaquin                          | 1.6                              | 3.2                       | 1.2               | 95.2                    | 94.0   |
| Sequoia                          | 20.4                             | 30.5                      | 28.0              | 49.1                    | 21.1   |
| Kalahari                         | 26.0                             | 38.2                      | 26.3              | 35.8                    | 9.6    |
| Talon                            | 3.2                              | 9.9                       | 14.1              | 86.9                    | 72.8   |
| Caballero                        | 23.7                             | 38.7                      | 20.3              | 37.6                    | 17.3   |
| Golden Spike                     | 17.1                             | 20.0                      | 22.4              | 62.9                    | 40.5   |
| Exacta                           | 19.5                             | 26.9                      | 22.4              | 53.6                    | 31.2   |
| Gunnison                         | 2.7                              | 8.0                       | 10.7              | 89.3                    | 78.7   |
| Overall average                  | 12.7                             | 18.6                      | 15.0              | 68.8                    | 53.7   |
| LSD (0.05) variety               | 6.4                              | 6.3                       | 5.2               | 6.7                     | 6.9    |
| LSD (0.05) date                  | 3.4                              | 3.9                       | 3.5               | 4.2                     | 3.8    |
| LSD (0.05) variety X date        | 11.1                             | NS                        | 11.6              | 13.9                    | 12.6   |

<sup>a</sup> diameter of the first continuous ring.

<sup>b</sup> bullet single center plus small multiple center.



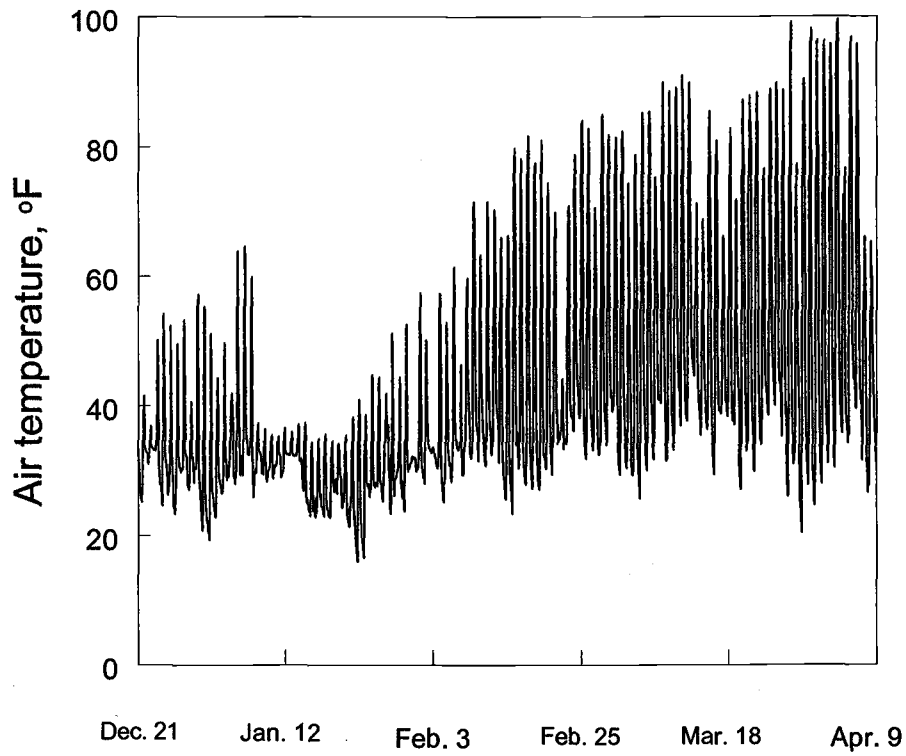


Figure 1. Low tunnel air temperature from seeding onions in December 2007 to transplanting on April 9, 2008, Malheur Experiment Station, Oregon State University, Ontario, OR.