

# **Varietal Evaluation of Garlic in New Mexico**



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# Varietal Evaluation of Garlic in New Mexico

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The majority of the U.S. garlic crop is grown in California (Peirce, 1987). In New Mexico, garlic is grown as a high-value specialty crop and used in traditional cuisine and in ristras sold to tourists. Most production requirements have been established (Dickerson, 1994), but little is known about varietal adaptation to the various growing areas of the state and the effects of these growing conditions on pungency.

Garlic varieties often vary in a number of characteristics including bulb color (off-white to purplish), number of cloves per bulb, maturity, shape, and storage-life. Hardneck types (Asiatic, Rocambole) normally will produce seedstalks. Softneck types (Silverskin, Artichoke) form seedstalks only when bulbs are stressed for water or damaged by cold weather.

Generally, it is recommended that garlic cloves be planted 3 to 4 inches apart in the row and that smaller cloves be discarded (Peirce, 1987; Sims and Little, 1970). It also is recommended that cloves be planted base down. Dickerson (1994) recommends that cloves be planted 3 to 6 inches apart in New Mexico. Given the cost of seed stock, smaller cloves are rarely discarded. As transplanters are often used on large acreages, planting the cloves with the base down cannot be guaranteed. In this study, optimum clove size and the performance of several garlic varieties were evaluated at sites in southern, central, and northern New Mexico.

## MATERIALS AND METHODS

Nine varieties of softneck and hardneck garlic were obtained from Filaree Farm, Okanogan, Washington in fall 1993. Samples of each variety were weighed, and the mean bulb weight, mean number of cloves per bulb, and mean number of cloves per pound were determined before planting (table 1).

Varieties were planted in replicated trials at three locations (Mesilla, Edgewood, and Mora, New Mexico)

**Table 1. Garlic varieties, types, mean bulb weight, mean number of cloves per bulb, and mean number of cloves per pound, 1993.**

| *Variety         | Type                 | Mean bulb wt (lb) | Mean number cloves/bulb | Mean number cloves/lb |
|------------------|----------------------|-------------------|-------------------------|-----------------------|
| Asian Tempest    | Asiatic; hardneck    | 0.224             | 5.5                     | 27.0                  |
| Spanish Roja     | Rocambole; hardneck  | 0.210             | 11.8                    | 58.8                  |
| German Red       | Rocambole; hardneck  | 0.163             | 9.0                     | 58.8                  |
| Mild French      | Silverskin; softneck | 0.135             | 14.2                    | 111.1                 |
| Inchelium Red    | Artichoke; softneck  | 0.125             | 8.9                     | 76.9                  |
| Skuri #1         | Artichoke; softneck  | 0.122             | 11.7                    | 100.0                 |
| California Early | Artichoke; softneck  | 0.105             | 8.3                     | 83.3                  |
| Carpathian       | Rocambole; hardneck  | 0.103             | 7.8                     | 76.9                  |
| Locati           | Silverskin; softneck | 0.090             | 15.9                    | 200.0                 |

\*Source: Filaree Farm, Okanogan, Washington, 1993.

during fall 1993. Plots were harvested in summer 1994. In Mesilla, eight garlic varieties were planted on October 12 at the Dan Lowry Farm, using a randomized complete block (RCB) design with three blocks. The same varieties were planted on September 30 at the Ricky Parker Farm in Edgewood, using a RCB with two blocks. Varieties included in these trials were 'Inchelium Red', 'Spanish Roja', 'Carpathian', 'Skuri #1', 'California Early', 'Locati', 'Mild French', and 'German Red'. At Mora, nine garlic varieties were planted on the Salman Farm on September 24, using a RCB with three blocks. 'Asian Tempest' was the additional variety evaluated at Mora. Cloves were planted 3 inches deep and 6 inches apart in 3-foot plots with one row per plot (6 cloves per plot). Rows were on 40-inch centers and were furrow irrigated at Mesilla. At Edgewood, flat beds on 30-inch centers and sprinkler irrigation were used. At Mora, flat beds on 36-inch centers with drip irrigation were used. Superphosphate (0-46-0) fertilizer was banded 6 inches below the cloves before planting at a rate of 100 lb/acre of P<sub>2</sub>O<sub>5</sub>. Urea (46-0-0) was applied on top of the planted

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bed and hoed in at a rate of 25 lb/acre of nitrogen. Another 50 lb/acre of nitrogen (46-0-0) was banded into the side of the bed below developing plants on March 5 at Mesilla, March 22 at Edgewood, and April 9 at Mora.

Before planting, cloves of each variety were graded by size into two groups (small and large). Clove size varied according to variety, therefore, cloves for each variety were divided into large and small cloves based on visual observations of relative size differences. Small and large cloves were planted alternately in the plots (3 large and 3 small cloves per plot). The sequence of planting was changed for each block. Border plots of garlic (3 feet) were planted at the end of rows and between blocks. At Mora, 'Asian Tempest', 'Locati', and 'Mild French' were not graded by size, and all plots were covered with a 1–2 inch layer of shredded raspberry canes as a mulch.

Data were collected on emergence, plant populations, plant height, and leaf width on March 5 (Mesilla), March 22 (Edgewood), and April 9 (Mora). Yield, plant stands, bulb diameter, bulb weight, and bolting percentages were collected at harvest. Early maturing plants were harvested on June 23 (Mesilla), July 20 (Edgewood), and July 14 (Mora), while later maturing varieties were harvested on June 30 (Mesilla), July 25 (Edgewood), and July 23 (Mora). Two bulbs were collected from each plot and analyzed in the laboratory for pungency using the pyruvic acid method (Wall and Corgan, 1992).

## RESULTS AND DISCUSSION

Garlic varieties planted in this trial were either hardneck or softneck types (table 1). Hardneck varieties ('Asian Tempest', 'Spanish Roja', and 'German Red') had the largest bulbs and tended to have larger cloves than softneck varieties. The "silverskin" softneck varieties, 'Mild French' and 'Locati', had the greatest number of cloves per bulb. The cloves of silverskin types are generally smaller than other softneck types.

### Mesilla

In spring 1994, plant populations were assessed for emergence and vigor. 'Inchelium Red', 'California Early', and 'Skuri #1' exhibited excellent vigor (plant height), with 100% of the plants emerged by March 5, 1994 (table 2). As percent emergence and plant populations decreased, plant height also seemed to decrease. The hardneck varieties, 'German Red', 'Carpathian', and 'Spanish Roja', had the poorest spring emergence.

At harvest, most varieties (large clove treatments) had complete stands (100%), with the exception of 'German Red' (table 3). Smaller clove treatments for

**Table 2. Plant characteristics for eight garlic varieties at Mesilla, NM on March 5, 1994.**

| Variety          | Plant populations (per acre) | Percent emergence | Plant height (in) | Relative leaf width |
|------------------|------------------------------|-------------------|-------------------|---------------------|
| Inchelium Red    | 26,136                       | 100.0             | 9.6               | Wide                |
| California Early | 26,136                       | 100.0             | 8.0               | Medium to wide      |
| Skuri #1         | 26,136                       | 100.0             | 8.1               | Medium              |
| Mild French      | 24,684                       | 94.4              | 6.4               | Thin to medium      |
| Locati           | 24,684                       | 94.4              | 6.0               | Thin to medium      |
| Spanish Roja     | 23,232                       | 88.9              | 5.9               | Medium              |
| Carpathian       | 18,876                       | 72.2              | 2.5               | Medium              |
| German Red       | 15,972                       | 61.1              | 6.2               | Medium to wide      |

'Inchelium Red' (88.9%) and 'Spanish Roja' (65.9%) also resulted in lower plant stands.

'California Early' produced the greatest yields of both bulbs and plants and also produced the heaviest bulbs (tables 3 and 4). Although 'Spanish Roja' produced large top growth, its total bulb yield was among the lowest. 'German Red' had the poorest yields at Mesilla.

Large clove treatments resulted in greater yields (bulbs and plants) than small clove treatments ( $P \leq 0.001$ ). The mean bulb yield (averaged over seven varieties; 'German Red' not included) was 6,074 and 4,231 lb/acre, and the mean plant yields were 8,849 and 6,120 lb/acre for large and small clove treatments, respectively. Small clove treatments decreased bulb yields by as much as 41.4% ('Spanish Roja'), with an average decrease of 30.7% for all varieties. Large clove treatments produced heavier bulbs ( $P \leq 0.001$ ) than small clove treatments. Mean bulb weights were 0.23 and 0.17 lb for large and small clove treatments, respectively. Bulb diameter was largest (2.9–3.0 inches) for large clove treatments of the "Artichoke" softneck types, 'California Early', 'Inchelium Red', and 'Skuri #1' (table 5). When large cloves were planted, larger diameter bulbs were produced for all varieties. With only a few exceptions, both leaf length and neck diameter were increased by planting large cloves as compared to small cloves. 'Spanish Roja', 'Carpathian', and 'German Red' bolted, a characteristic of hardneck varieties (table 5). In general, 'California Early' was of excellent quality followed by 'Locati' and 'Mild French'.

### Edgewood

At Edgewood, 'Mild French', 'California Early', and 'Locati' produced the greatest number of plants with 100% emergence by March 22, 1994 (table 6), whereas 'German Red' had the poorest emergence (66.7%). 'Inchelium Red' had excellent vigor (plant height) followed closely by 'German Red' (of those plants that emerged), 'Mild French', 'California Early', and 'Spanish Roja'.

**Table 3. Plant characteristics for eight garlic varieties harvested at Mesilla, NM in 1994.**

| Variety                           | Harvest date | Plants/acre   | Plant stand  | Yield (lbs fresh wt/acre) |              | Mean bulb wt. (lb) |
|-----------------------------------|--------------|---------------|--------------|---------------------------|--------------|--------------------|
|                                   |              |               |              | plants                    | bulbs        |                    |
| California Early - <sup>1</sup> L | 6/23         | 26,136        | 100.0        | 10,873                    | 8,620        | 0.33               |
| California Early - <sup>1</sup> S | 6/23         | 26,136        | 100.0        | 8,442                     | 6,684        | 0.26               |
| <b>Mean<sup>2</sup></b>           | <b>6/23</b>  | <b>26,136</b> | <b>100.0</b> | <b>9,657</b>              | <b>7,652</b> | <b>0.29</b>        |
| Inchelium Red - L                 | 6/23         | 26,136        | 100.0        | 8,625                     | 6,962        | 0.27               |
| Inchelium Red - S                 | 6/23         | 23,232        | 88.9         | 5,884                     | 4,758        | 0.20               |
| <b>Mean</b>                       | <b>6/23</b>  | <b>24,684</b> | <b>94.4</b>  | <b>7,254</b>              | <b>5,860</b> | <b>0.24</b>        |
| Skuri #1 - L                      | 6/23         | 26,136        | 100.0        | 7,277                     | 6,500        | 0.25               |
| Skuri #1 - S                      | 6/23         | 26,126        | 100.0        | 5,201                     | 4,650        | 0.18               |
| <b>Mean</b>                       | <b>6/23</b>  | <b>26,136</b> | <b>100.0</b> | <b>6,239</b>              | <b>5,575</b> | <b>0.21</b>        |
| Locati - L                        | 6/30         | 26,136        | 100.0        | 9,011                     | 5,485        | 0.21               |
| Locati - S                        | 6/30         | 26,136        | 100.0        | 6,165                     | 3,841        | 0.15               |
| <b>Mean</b>                       | <b>6/30</b>  | <b>26,136</b> | <b>100.0</b> | <b>7,588</b>              | <b>4,663</b> | <b>0.18</b>        |
| Mild French - L                   | 6/23         | 26,136        | 100.0        | 9,139                     | 5,767        | 0.22               |
| Mild French - S                   | 6/23         | 26,136        | 100.0        | 5,442                     | 3,444        | 0.13               |
| <b>Mean</b>                       | <b>6/23</b>  | <b>26,136</b> | <b>100.0</b> | <b>7,290</b>              | <b>4,605</b> | <b>0.18</b>        |
| Spanish Roja - L                  | 6/30         | 26,136        | 100.0        | 8,686                     | 4,811        | 0.18               |
| Spanish Roja - S                  | 6/30         | 17,424        | 65.9         | 5,061                     | 2,819        | 0.16               |
| <b>Mean</b>                       | <b>6/30</b>  | <b>23,232</b> | <b>88.9</b>  | <b>7,957</b>              | <b>3,815</b> | <b>0.17</b>        |
| Carpathian - L                    | 6/30         | 26,136        | 100.0        | 8,224                     | 4,281        | 0.16               |
| Carpathian - S                    | 6/30         | 26,136        | 100.0        | 6,534                     | 3,423        | 0.13               |
| <b>Mean</b>                       | <b>6/30</b>  | <b>26,136</b> | <b>100.0</b> | <b>7,379</b>              | <b>3,852</b> | <b>0.15</b>        |
| German Red- L <sup>3</sup>        | 6/30         | 11,616        | 44.4         | 3,075                     | 1,993        | 0.17               |

<sup>1</sup>L = Large cloves, S = Small cloves. <sup>2</sup>Means based on 3 replications, except for Spanish Roja where the means are based on 2 replications. <sup>3</sup>Only large cloves were planted.

**Table 4. Bulb and plant weights for eight garlic varieties at Mesilla, NM, 1994.**

| Variety          | Bulb wt. (lb/acre)   | Mean bulb wt. (lb) | Plant wt. (lb/acre) |
|------------------|----------------------|--------------------|---------------------|
| California Early | 7,652 a <sup>1</sup> | 0.29 a             | 9,657 a             |
| Inchelium Red    | 5,860 b              | 0.24 b             | 7,254 b             |
| Skuri #1         | 5,575 b              | 0.21 bc            | 6,239 b             |
| Locati           | 4,663 bc             | 0.18 cd            | 7,588 b             |
| Mild French      | 4,605 bc             | 0.18 cd            | 7,290 b             |
| Carpathian       | 3,852 c              | 0.15 d             | 7,379 b             |
| Spanish Roja     | 3,815 c              | 0.17 cd            | 7,957 ab            |
| German Red       | 1,993 d              | 0.17 cd            | 3,075 c             |

<sup>1</sup>Means followed by the same letter are not significantly different ( $P \leq 0.05$ ).

**Table 5. Plant dimensions, percent bolting, and quality characteristics for eight garlic varieties at Mesilla, NM , 1994.**

| Variety                           | Leaf length (in.) | Neck diameter (in.) | Bulb diameter (in.) | Percent bolting | Comments  |
|-----------------------------------|-------------------|---------------------|---------------------|-----------------|---|
| California Early - L <sup>1</sup> | 21.6              | 0.68                | 3.0                 | 0               | excellent quality, semi-early, leaves still green |
| California Early - S <sup>1</sup> | 21.0              | 0.54                | 2.7                 | 0               |   |
| Inchelium Red - L                 | 22.7              | 0.62                | 2.9                 | 0               | early, soft, starting to rot                      |
| Inchelium Red - S                 | 21.3              | 0.46                | 2.6                 | 0               |   |
| Skuri #1 - L                      | 17.0              | 0.59                | 2.9                 | 0               | early, dry leaves, cloves fell apart              |
| Skuri #1 - S                      | 15.2              | 0.51                | 2.3                 | 0               |   |
| Locati - L                        | 18.5              | 0.68                | 2.3                 | 0               | good quality                                      |
| Locati - S                        | 18.2              | 0.50                | 2.0                 | 0               |   |
| Mild French - L                   | 20.7              | 0.66                | 2.3                 | 0               | good quality                                      |
| Mild French - S                   | 20.4              | 0.52                | 1.9                 | 0               |   |
| Spanish Roja - L                  | 16.6              | 0.61                | 2.2                 | 33.3            | soft, poor quality                                |
| Spanish Roja - S                  | 17.1              | 0.63                | 2.0                 | 50.0            |   |
| Carpathian - L                    | 16.2              | 0.59                | 2.0                 | 33.3            | late, soft, had not segmented                     |
| Carpathian - S                    | 15.1              | 0.47                | 1.9                 | 44.4            |   |
| <sup>2</sup> German Red - L       | 15.3              | 0.50                | 2.0                 | 25.0            | quality fair to poor                              |

<sup>1</sup> L = Large cloves, S = Small cloves. Means based on 3 replications, except for Spanish Roja where the means are based on 2 replications. <sup>2</sup> Only large cloves were planted.

**Table 6. Plant characteristics for eight garlic varieties at Edgewood, NM on March 22, 1994.**

| Variety          | Plant populations (per acre) | Percent emergence | Plant height (in) | Relative leaf width |
|------------------|------------------------------|-------------------|-------------------|---------------------|
| California Early | 34,848                       | 100.0             | 3.9               | Medium to wide      |
| Mild French      | 34,848                       | 100.0             | 4.1               | Medium to wide      |
| Locati           | 34,848                       | 100.0             | 2.2               | Thin to medium      |
| Inchelium Red    | 31,944                       | 91.7              | 5.1               | Medium to wide      |
| Carpathian       | 31,944                       | 91.7              | 2.0               | Medium to wide      |
| Skuri # 1        | 29,040                       | 83.3              | 3.2               | Medium to wide      |
| Spanish Roja     | 29,040                       | 83.3              | 3.9               | Wide                |
| German Red       | 23,232                       | 66.7              | 4.7               | Wide                |

Bulbs were harvested based on perceived maturity (drying leaves and bulb segmentation) on July 20 and July 25, 1994. Most varieties exhibited excellent plant stands (table 7), except 'German Red' with 33.3% for the small clove treatment.

'California Early', 'Spanish Roja', 'German Red', and 'Skuri #1' produced the greatest bulb yields, while 'Spanish Roja' and 'California Early' produced the greatest plant yields (tables 7 and 8). 'German Red', 'Spanish Roja', and 'California Early' produced the heaviest bulbs (table 8). 'Spanish Roja', 'Carpathian', and 'German Red' (small cloves) were the only varieties that bolted at Edgewood, and bulb quality was excellent to good for most varieties (table 9).

Greater yields (bulbs and plants) were obtained when large cloves were planted compared to small cloves ( $P \leq 0.001$ ). The mean bulb yield (averaged over eight varieties) was 7,954 and 4,808 lb/acre, and the mean plant yields were 13,547 and 8,284 lb/acre for large and small clove treatments, respectively. Planting small cloves decreased bulb yields by as much as 78.2% ('German Red'), with an average decrease of 36.8%. Large clove treatments produced heavier bulbs ( $P \leq 0.001$ ) than small clove treatments for each variety. Mean bulb weights were 0.24 and 0.16 lb for large and small clove treatments, respectively. Bulb diameter was largest (3.1 inches) for large clove treatments of 'German Red' (table 9). When large cloves were planted, larger diameter bulbs were produced for all varieties.

## Mora

Spring emergence was highest (100%) for 'Mild French' at Mora by April 9, 1994 (table 10), whereas 'German Red' had the poorest emergence (72.2%). Excellent vigor (plant height) was observed for 'Inchelium Red', followed closely by 'Spanish Roja' and 'California Early'.

Bulbs were harvested on July 14 and 23, by which time plant stands had increased for the smaller clove treatments for most varieties (table 11). 'California Early', 'Carpathian', and 'Locati' had 100% plant stands,

**Table 7. Plant characteristics for eight garlic varieties harvested at Edgewood, NM in 1994.**

| Variety                           | Harvest date | Plants/acre   | Plant stand  | Yield (lbs fresh wt/acre) |              | Mean bulb wt. (lb) |
|-----------------------------------|--------------|---------------|--------------|---------------------------|--------------|--------------------|
|                                   |              |               |              | plants                    | bulbs        |                    |
| California Early - <sup>1</sup> L | 7/20         | 34,848        | 100.0        | 15,977                    | 10,199       | 0.29               |
| California Early - S <sup>1</sup> | 7/20         | 34,848        | 100.0        | 9,031                     | 5,804        | 0.17               |
| <b>Mean</b>                       | <b>7/20</b>  | <b>34,848</b> | <b>100.0</b> | <b>12,504</b>             | <b>8,002</b> | <b>0.23</b>        |
| Spanish Roja - L                  | 7/25         | 29,040        | 83.3         | 17,668                    | 8,489        | 0.29               |
| Spanish Roja - S                  | 7/25         | 34,848        | 100.0        | 14,479                    | 7,035        | 0.20               |
| <b>Mean</b>                       | <b>7/25</b>  | <b>31,944</b> | <b>91.7</b>  | <b>16,074</b>             | <b>7,762</b> | <b>0.24</b>        |
| German Red - L                    | 7/25         | 34,848        | 100.0        | 17,691                    | 11,004       | 0.32               |
| German Red - S                    | 7/25         | 11,616        | 33.3         | 3,868                     | 2,402        | 0.21               |
| <b>Mean</b>                       | <b>7/25</b>  | <b>23,232</b> | <b>44.4</b>  | <b>10,780</b>             | <b>6,703</b> | <b>0.27</b>        |
| Skuri # 1 - L                     | 7/20         | 29,040        | 83.3         | 10,076                    | 7,254        | 0.25               |
| Skuri # 1 - S                     | 7/20         | 34,848        | 100.0        | 7,173                     | 5,168        | 0.15               |
| <b>Mean</b>                       | <b>7/20</b>  | <b>31,944</b> | <b>91.7</b>  | <b>8,625</b>              | <b>6,211</b> | <b>0.20</b>        |
| Mild French - L                   | 7/20         | 34,848        | 100.0        | 13,492                    | 7,743        | 0.22               |
| Mild French - S                   | 7/20         | 34,848        | 100.0        | 7,567                     | 4,346        | 0.12               |
| <b>Mean</b>                       | <b>7/20</b>  | <b>34,848</b> | <b>100.0</b> | <b>10,530</b>             | <b>6,045</b> | <b>0.17</b>        |
| Locati - L                        | 7/25         | 34,848        | 100.0        | 11,395                    | 6,777        | 0.23               |
| Locati - S                        | 7/25         | 34,848        | 100.0        | 8,142                     | 4,840        | 0.15               |
| <b>Mean</b>                       | <b>7/25</b>  | <b>34,848</b> | <b>100.0</b> | <b>9,769</b>              | <b>5,809</b> | <b>0.19</b>        |
| Inchelium Red - L                 | 7/20         | 34,848        | 100.0        | 9,867                     | 6,562        | 0.19               |
| Inchelium Red - S                 | 7/20         | 29,040        | 83.3         | 7,376                     | 4,902        | 0.17               |
| <b>Mean</b>                       | <b>7/20</b>  | <b>31,944</b> | <b>91.7</b>  | <b>8,622</b>              | <b>5,732</b> | <b>0.18</b>        |
| Carpathian - L                    | 7/25         | 34,848        | 100.0        | 12,208                    | 5,607        | 0.16               |
| Carpathian - S                    | 7/25         | 34,848        | 100.0        | 8,636                     | 3,965        | 0.11               |
| <b>Mean</b>                       | <b>7/25</b>  | <b>34,848</b> | <b>100.0</b> | <b>10,422</b>             | <b>4,786</b> | <b>0.14</b>        |

<sup>1</sup> L = Large cloves, S = Small cloves. Means are based on 2 replications.

**Table 8. Bulb and plant weights for eight garlic varieties at Edgewood, NM, 1994.**

| Variety          | Bulb wt. (lb/acre)   | Mean bulb wt. (lb) | Plant wt. (lb/acre) |
|------------------|----------------------|--------------------|---------------------|
| California Early | 8,002 a <sup>1</sup> | 0.23 abc           | 12,505 ab           |
| Spanish Roja     | 7,762 ab             | 0.24 ab            | 16,074 a            |
| German Red       | 6,703 abc            | 0.27 a             | 10,780 bc           |
| Skuri #1         | 6,211 abc            | 0.20 bcd           | 8,625 c             |
| Mild French      | 6,045 bc             | 0.17 de            | 10,530 bc           |
| Locati           | 5,809 c              | 0.19 bcd           | 9,769 bc            |
| Inchelium Red    | 5,732 c              | 0.18 cde           | 8,622 c             |
| Carpathian       | 4,786 c              | 0.14 e             | 10,422 bc           |

<sup>1</sup>Means followed by the same letter are not significantly different ( $P \leq 0.05$ ).

**Table 9. Plant dimensions, percent bolting, and quality characteristics for eight garlic varieties at Edgewood, NM, 1994.**

| Variety                           | Leaf length (in.) | Neck diameter (in.) | Bulb diameter (in.) | Percent bolting | Comments                            |
|-----------------------------------|-------------------|---------------------|---------------------|-----------------|-------------------------------------|
| California Early - L <sup>1</sup> | 23.1              | 0.57                | 2.8                 | 0               | excellent quality                   |
| California Early - S <sup>1</sup> | 22.2              | 0.47                | 2.3                 | 0               |                                     |
| Spanish Roja - L                  | 24.0              | 0.63                | 2.6                 | 100.0           | good to excellent quality           |
| Spanish Roja - S                  | 22.5              | 0.49                | 2.2                 | 100.0           | quality                             |
| German Red - L                    | 20.4              | 0.65                | 3.1                 | 0               | fair to good quality                |
| German Red - S                    | 20.7              | 0.43                | 2.2                 | 100.0           |                                     |
| Skuri #1 - L                      | 18.3              | 0.59                | 2.7                 | 0               | good quality, some mold, overmature |
| Skuri #1 - S                      | 18.5              | 0.49                | 2.2                 | 0               |                                     |
| Mild French - L                   | 22.3              | 0.55                | 2.3                 | 0               | excellent quality                   |
| Mild French - S                   | 22.8              | 0.45                | 2.0                 | 0               |                                     |
| Locati - L                        | 21.0              | 0.49                | 2.1                 | 0               | excellent quality                   |
| Locati - S                        | 19.9              | 0.41                | 2.0                 | 0               |                                     |
| Inchelum Red- L                   | 22.6              | 0.45                | 2.4                 | 0               | good quality, some mold, overmature |
| Inchelum Red - S                  | 22.3              | 0.47                | 2.3                 | 0               |                                     |
| Carpathian - L                    | 20.2              | 0.49                | 2.2                 | 100.0           | good quality                        |
| Carpathian - S                    | 19.9              | 0.39                | 1.8                 | 100.0           |                                     |

<sup>1</sup>L = Large cloves, S = Small cloves. Means based on 2 replications.

**Table 10. Plant characteristics for nine garlic varieties at Mora, NM on April 9, 1994.**

| Variety          | Plant populations (per acre) | Percent emergence | Plant height (in) | Relative leaf width |
|------------------|------------------------------|-------------------|-------------------|---------------------|
| Mild French      | 29,040                       | 100.0             | 6.3               | Thin                |
| California Early | 27,427                       | 94.4              | 7.1               | Medium to wide      |
| Locati           | 27,427                       | 94.4              | 4.8               | Thin to medium      |
| Spanish Roja     | 27,427                       | 94.4              | 7.2               | Wide                |
| Carpathian       | 27,427                       | 94.4              | 6.0               | Thin to medium      |
| Inchelum Red     | 24,200                       | 83.3              | 7.8               | Wide                |
| Skuri #1         | 24,200                       | 83.3              | 6.2               | Medium              |
| Asian Tempest    | 22,587                       | 77.8              | 5.5               | Wide                |
| German Red       | 20,973                       | 72.2              | 5.5               | Wide                |



**Table 11. Plant characteristics for nine garlic varieties harvested at Mora, NM, 1994.**

| Variety                           | Harvest date | Plants/acre   | Plant stand  | Yield (lbs fresh wt/acre) |              | Mean bulb wt. (lb) |
|-----------------------------------|--------------|---------------|--------------|---------------------------|--------------|--------------------|
|                                   |              |               |              | plants                    | bulbs        |                    |
| California Early - <sup>1</sup> L | 7/14         | 29,040        | 100.0        | 13,658                    | 9,056        | 0.31               |
| California Early - S <sup>1</sup> | 7/14         | 29,040        | 100.0        | 5,900                     | 3,913        | 0.13               |
| <b>Mean<sup>2</sup></b>           | <b>7/14</b>  | <b>29,040</b> | <b>100.0</b> | <b>9,779</b>              | <b>6,485</b> | <b>0.22</b>        |
| Asian Tempest - L <sup>3</sup>    | 7/14         | 24,200        | 83.3         | 13,182                    | 6,222        | 0.26               |
| Spanish Roja - L                  | 7/23         | 24,200        | 83.3         | 14,055                    | 6,792        | 0.28               |
| Spanish Roja - S                  | 7/23         | 29,040        | 100.0        | 10,241                    | 4,937        | 0.17               |
| <b>Mean</b>                       | <b>7/23</b>  | <b>26,620</b> | <b>91.7</b>  | <b>12,148</b>             | <b>5,865</b> | <b>0.23</b>        |
| Inchelium Red - L                 | 7/14         | 19,360        | 66.7         | 8,039                     | 5,360        | 0.28               |
| Inchelium Red - S                 | 7/14         | 29,040        | 100.0        | 5,662                     | 3,710        | 0.13               |
| <b>Mean</b>                       | <b>7/14</b>  | <b>24,200</b> | <b>83.3</b>  | <b>6,851</b>              | <b>4,535</b> | <b>0.21</b>        |
| Mild French <sup>4</sup>          | 7/14         | 27,427        | 94.4         | 7,429                     | 4,500        | 0.17               |
| Carpathian - L                    | 7/23         | 29,040        | 100.0        | 11,684                    | 5,860        | 0.20               |
| Carpathian - S                    | 7/23         | 29,040        | 100.0        | 6,679                     | 3,351        | 0.12               |
| <b>Mean</b>                       | <b>7/23</b>  | <b>29,040</b> | <b>100.0</b> | <b>9,182</b>              | <b>4,606</b> | <b>0.16</b>        |
| Locati <sup>4</sup>               | 7/23         | 29,040        | 100.0        | 5,126                     | 3,376        | 0.12               |
| Skuri #1 - L                      | 7/14         | 14,520        | 50.0         | 4,990                     | 3,124        | 0.22               |
| Skuri #1 - S                      | 7/14         | 24,200        | 83.3         | 3,499                     | 2,220        | 0.09               |
| <b>Mean</b>                       | <b>7/14</b>  | <b>19,360</b> | <b>66.7</b>  | <b>4,245</b>              | <b>2,672</b> | <b>0.16</b>        |
| German Red - L                    | 7/23         | 9,680         | 33.3         | 4,670                     | 2,239        | 0.23               |
| German Red - S                    | 7/23         | 24,200        | 83.3         | 6,965                     | 3,397        | 0.14               |
| <b>Mean</b>                       | <b>7/23</b>  | <b>16,940</b> | <b>58.3</b>  | <b>5,818</b>              | <b>2,818</b> | <b>0.19</b>        |

<sup>1</sup> L = Large cloves, S = Small cloves. <sup>2</sup>Means are based on 2 replications. <sup>3</sup>Only large cloves were planted, and means are based on 3 replications. <sup>4</sup>Only medium cloves were planted, and means are based on 3 replications.

while 'German Red' and 'Skuri #1' had the poorest plant stands.

Plant yields were similar for all varieties planted at Mora, whereas bulb yields varied significantly ( $P \leq 0.05$ , table 12). 'California Early' and 'Spanish Roja' produced the highest bulb yields with the greatest mean bulb weights, followed by 'Inchelium Red' and 'Mild French' (table 12). 'Asian Tempest', 'Spanish Roja', 'Carpathian', and 'German Red' bolted at Mora (table 13). 'Inchelium Red' bulbs were of excellent quality.

Large clove treatments resulted in greater bulb yields ( $P \leq 0.006$ ) and plant yields ( $P \leq 0.003$ ) than small clove treatments, with the exception of 'German Red'. The mean bulb yields (averaged over six varieties) were 5,435 and 3,641 lb/acre, and the mean plant yields were 9,442 and 6,471 lb/acre for large and small clove treatments, respectively. When small cloves were planted, bulb yields were decreased by as much as 56.8% ('California Early'), with an average decrease of 37.3%. Large clove treatments produced heavier bulbs ( $P \leq 0.001$ )

**Table 12. Bulb and plant weights for eight garlic varieties at Mora, NM, 1994.**

| Variety          | Bulb wt. (lb/acre)   | Mean bulb wt. (lb) | Plant wt. (lb/acre) |
|------------------|----------------------|--------------------|---------------------|
| California Early | 6,322 a <sup>1</sup> | 0.23 a             | 9,567 a             |
| Spanish Roja     | 5,819 ab             | 0.23 a             | 8,507 a             |
| Inchelium Red    | 4,522 bc             | 0.19 b             | 7,011 a             |
| Mild French      | 4,500 bc             | 0.17 bc            | 7,429 a             |
| Carpathian       | 4,309 cd             | 0.15 c             | 8,760 a             |
| Locati           | 3,376 cd             | 0.12 d             | 5,126 a             |
| Skuri #1         | 3,174 cd             | 0.15 c             | 5,127 a             |
| German Red       | 3,041 d              | 0.19 b             | 6,485 a             |

<sup>1</sup>Means followed by the same letter are not significantly different ( $P \leq 0.05$ ). Means are based on 3 replications.

than small clove treatments for each variety. Mean bulb weights were 0.25 and 0.13 lb for large and small clove treatments, respectively. 'California Early' and 'Spanish Roja' produced the heaviest bulbs (table 12). Bulb diameter was largest (2.8–3.0 inches) for large clove treatments of 'California Early', 'Inchelium Red', and 'Spanish Roja' (table 13). Larger diameter bulbs, longer leaves, and greater neck diameters were produced when large cloves were planted for all varieties.

### Garlic Pungency

Garlic pungency and flavor vary according to variety and environmental conditions. Several flavor precursors (S-methyl, S-allyl, and S-propyl-cysteine sulfoxide) undergo a series of reactions when garlic tissue is crushed, bruised, or cut. These reactions are catalyzed by the enzyme alliinase, and create garlic's characteristic flavor and pungency. Pyruvic acid, a by-product of the reaction, is measured in the laboratory and correlates well with pungency (Wall and Corgan, 1992). The concentration of the precursors and other compounds needed for the flavor reaction are influenced by genetics and environment. Higher pungency is usually desirable with garlic, especially when the bulbs are intended for dehydration by the spice industry. However, some gardeners and chefs may prefer a milder garlic flavor for cooking.

In our study, garlic pungency varied according to location (table 14). In general, garlic varieties harvested in Mesilla were more pungent (mean of 38  $\mu$ moles pyruvic acid/gram fresh weight) than the other two locations. The hot summer temperatures prior to harvest may have contributed to increased pungency at Mesilla, however, sulfur fertility and water stress may also affect garlic pungency. 'Inchelium Red' was significantly less pungent than the other seven varieties at Mesilla ( $P \leq 0.05$ ). At Edgewood, 'Mild French' and 'Skuri #1' were the most pungent varieties. 'Locati', which was pungent at Mesilla, had relatively low pungency when grown at Edgewood. Varietal differences were less clear at Mora,

where pungency values ranged from 27.3  $\mu$ moles pyruvic acid/gfw for 'Inchelium Red' to 33.8  $\mu$ moles pyruvic acid/gfw for 'Mild French'. At all locations, 'Inchelium Red' was among the mildest varieties, whereas 'Mild French' and 'Skuri #1' were among the most pungent varieties.

### CONCLUSIONS

'California Early' was the most productive variety at all locations and ranged from good to excellent quality. Bulbs tended to be larger than other varieties. 'Spanish Roja' bulb production was poor in Mesilla but good in both Edgewood and Mora. For all other varieties, bulb quality was generally poor in Mesilla and good to excellent at northern locations.

At all locations, planting large cloves generally resulted in greater initial emergence, more vigorous plants, greater plant and bulb yields, and larger bulbs (weight and diameter). As a result, growers may find it more profitable to grade cloves by size before planting.

Warmer growing conditions in Mesilla tended to result in poorer quality bulbs. Stress also tended to increase pungency for all varieties at this location.

### LITERATURE CITED

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**Table 13. Plant dimensions, percent bolting, and quality characteristics for nine garlic varieties at Mora, NM, 1994.**

| Variety                        | Leaf length (in.) | Neck diameter (in.) | Bulb diameter (in.) | Percent bolting | Comments             |
|--------------------------------|-------------------|---------------------|---------------------|-----------------|----------------------|
| California Early - L           | 25.3              | 0.65                | 3.0                 | 0               | fair to good quality |
| California Early - S           | 22.9              | 0.39                | 2.1                 | 0               |                      |
| Asian Tempest - L <sup>2</sup> | 26.6              | 0.60                | 2.6                 | 73.3            | fair quality         |
| Spanish Roja - L               | 24.2              | 0.69                | 2.8                 | 100.0           | good quality         |
| Spanish Roja - S               | 23.5              | 0.51                | 2.1                 | 100.0           |                      |
| Inchelium Red - L              | 25.1              | 0.65                | 2.9                 | 0               | excellent quality    |
| Inchelium Red - S              | 20.7              | 0.45                | 2.2                 | 0               |                      |
| Mild French <sup>3</sup>       | 23.7              | 0.53                | 2.0                 | 0               | small, good quality  |
| Carpathian - L                 | 21.3              | 0.51                | 2.4                 | 100.0           | fair quality         |
| Carpathian - S                 | 20.6              | 0.45                | 1.8                 | 100.0           |                      |
| Locati <sup>3</sup>            | 20.7              | 0.44                | 1.9                 | 0               | small, good quality  |
| Skuri #1 - L                   | 21.8              | 0.59                | 2.7                 | 0               | small, good quality  |
| Skuri #1 - S                   | 17.1              | 0.33                | 1.8                 | 0               |                      |
| German Red - L                 | 23.8              | 0.55                | 2.5                 | 100.0           | small, fair quality  |
| German Red - S                 | 22.0              | 0.49                | 2.0                 | 100.0           |                      |

<sup>1</sup> L = Large cloves, S = Small cloves. Means based on 2 replications. <sup>2</sup>Only large cloves were planted, and means are based on 3 replications. <sup>3</sup>Only medium cloves were planted, and means are based on 3 replications.

**Table 14. Pungency evaluation of eight garlic varieties grown at three locations in New Mexico.**

| Variety          | μmoles pyruvic acid/gfw |                      |                     |
|------------------|-------------------------|----------------------|---------------------|
|                  | Mesilla                 | Edgewood             | Mora                |
| Inchelium Red    | 30.2 <sup>1</sup> a     | 27.0 <sup>1</sup> ab | 27.3 <sup>1</sup> a |
| German Red       | 37.1 b                  | 28.2 abc             | 33.3 b              |
| Carpathian       | 37.8 b                  | 29.4 bc              | 27.6 a              |
| Skuri #1         | 38.1 b                  | 32.7 cd              | 31.7 b              |
| California Early | 38.9 b                  | 24.2 ab              | 30.1 ab             |
| Spanish Roja     | 39.9 b                  | 26.0 ab              | 30.9 ab             |
| Mild French      | 40.7 b                  | 36.7 d               | 33.8 b              |
| Locati           | 40.9 b                  | 23.1 a               | 33.6 b              |
| Mean             | (38.0)                  | (28.4)               | (31.0)              |

<sup>1</sup>Means followed by the same letter in each column are not significantly different ( $P \leq 0.05$ ).

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