Lavender Cultivar Trial Results for North-Central New Mexico, 2003 Through 2005

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ABSTRACT

Two cultivars of *Lavandula angustifolia* Mill. ('Compacta' and 'Hidcote') and four cultivars of *Lavandula* x *intermedia* ('Emerisa', 'Grosso', 'Provence', and 'Super') were planted from 4-inch (10.2 cm) commercially obtained nursery stock in a randomized complete block design on June 24, 2002, at the New Mexico State University Sustainable Agriculture Science Center at Alcalde in north-central New Mexico at an elevation of 5,724 feet (1,745 m). Plantings were made into a Fruitland sandy loam on raised beds with 36-inch (91.4 cm) spacing within and between rows. All plots were furrow irrigated. Weed control was achieved by hand weeding and the use of woven polypropylene landscape fabric. After allowing the plants to establish for one growing season, plant survival numbers, flower and stem fresh and dry weights, and camphor content were measured during the growing seasons of 2003, 2004, and 2005 as indicators of local adaptability, yield, and plant material quality. 'Hidcote' and 'Provence' survival after the first season was 93% of the original stand; survival of all other cultivars was 100%. *Lavandula* x *intermedia* cultivars produced significantly more than *L. angustifolia* cultivars all three years. 'Super', 'Grosso', and 'Emerisa' produced the highest three-year average yields, with 1,575, 1,439, and 1,176 lb/ac (1,763, 1,612, and 1,317 kg/ha) dry weight, respectively. 'Emerisa' reached its highest dry weight yield in 2004, yielding 1,411 lb/ac (1,580 kg/ha); all other cultivars yielded highest in 2005. 'Super' and 'Grosso' produced the highest dry weight yields in 2005, with 2,219 and 2,197 lb/ac (2,484 and 2,461 kg/ha), respectively. 'Grosso' and 'Super' contained the highest percentages of camphor at 1.46 and 0.73% (g compound/g dry plant material), respectively. Yield and camphor content were consistently higher among *Lavandula* x *intermedia* cultivars; laboratory chemical analysis did not detect any camphor in the two *Lavandula angustifolia* cultivars, 'Compacta' and 'Hidcote'. Results indicate that both lavender species are adaptable to USDA

***Figure 1. Lavandula* sp. in flower.**

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Hardiness Zone 5 high-elevation growing conditions in New Mexico, and that species and cultivar selection are important criteria for commercial lavender plantings.

INTRODUCTION

Lavender (*Lavandula* spp., Figure 1) is a medicinal and culinary herb with historical uses dating as far back as ancient Egypt. This herb was first introduced to and used throughout the Southwest by early Spanish settlers. Traditionally, *alhucema* (its Spanish name) has been used in Hispanic folk medicine in New Mexico as a mild stomach tonic for colic in infants, for congestion in older children, and as an aid in adult stomach disorders (Curtin, 1947). For phlegm in small babies, a tea of the boiled seeds was either drunk by the nursing mother or was administered by dipping a cloth in hot *alhucema* tea and placing it on the chest of the child (Curtin, 1947). "Sick rooms" were cleaned and freshened with lavender, and a blend of *alhucema* and *manzanilla* (chamomile, *Chamaemelum nobile*) provided relief for menopause (Curtin, 1947). Because of its versatility, *alhucema* was a well-trusted and widely used herb in New Mexico. Modern uses for lavender include aromatherapy, air freshening, bath and cosmetic products, and culinary purposes. Lavender has a sedative effect that makes it an excellent calmative for migraine headaches and nervousness, as well as a sleep aid. New uses for lavender are also being researched, including as an anti-bacterial agent (Hui et al., 2010) and for its bioactivity against grain beetle (Rozman et al., 2006). Recently, lavender and lavender products have experienced a renaissance of interest among consumers and producers (Adam, 2006).

Lavender is an increasingly popular specialty crop in New Mexico and other parts of the U.S. Southwest because of its suitability for cultivation in alkaline, sandy, and low-fertility soils; its relative heat and drought tolerance; and its preference for arid conditions with low humidity. Lavender is also of increasing interest to small-scale farmers in New Mexico and other parts of the Southwest as a high-value alternative crop. Small-scale production may be feasible for some farmers with fewer acres if using alternative marketing strategies (Adam, 2006).

Species and cultivar selection are especially important criteria for small-scale growers because of varying environmental response, performance, and essential oil quality. Of the numerous species of *Lavandula*, English lavender (*L. angustifolia*) and lavandin (*Lavandula* x *intermedia*) are commonly recognized as being the most hardy for colder temperate environments, and are the most popular species for commercial essential oil production. *Lavandula angustifolia* is the common "English" or "true" lavender. This species is the most valued of all lavenders both for its high-quality oil and as a garden plant (Upson and Andrews, 2004). It is the original species from which *Lavandula angustifolia* cultivars have been developed and is also one of the parents of the lavandin hybrids. Lavandin, *Lavandula* x *intermedia*, is a sterile interspecific hybrid between *L. angustifolia* and *L. latifolia*. It typically is larger, more robust, hardier, and produces higher oil yields than *L. angustifolia*, but its essential oil is also higher in camphor and camphor-related compounds. Popin (2011) notes that, when it comes to lavender oil, "more is not always better." "Yields of lavandin oil (7-9%) are two to three times greater than those from true lavender (*L. angustifolia*) oil (2-5%). However, true lavender is regarded as the highest quality lavender. Lavandin is also higher in camphor content compared to true lavender oil, and the higher camphor content is considered a negative indicator of quality (higher camphor content is inversely related to quality lavender). True lavender is reported to represent the highest quality lavender oil based on the presence of linalyl acetate (found in highest concentrations in true lavender)" (Popin, 2011). Camphor is also toxic in significant doses and can cause contact dermatitis (Beneforce, 2011). The FDA has banned camphor as a liniment because it is readily absorbed through the skin and is toxic in larger doses, even when applied topically. In lavender essential oil, camphor is usually regarded as an undesirable constituent; lavender oil that lacks the distinct camphor smell commands a higher price (Beneforce, 2011). However, consumer preference remains highly subjective with regard to camphor content in lavender and lavender products. In the cosmetic and beauty therapy industry, camphor is widely used for its preservative properties in creams, hair products, aftershave lotions, and other skin products, and has the added benefit of giving a cool, refreshing feeling to the skin (Beneforce, 2011).

Selection of lavender cultivars should also take into consideration local growing conditions. The USDA has divided North America into eleven major hardiness zones (USNA, 2011). Of the eight hardiness zones within the continental United States, New Mexico has five, making it one of the most environmentally diverse areas of the nation (USNA, 2011). Because of the interaction of environment and cultivar type on essential oil quality, growers must carefully select cultivars that are adapted to their particular growing conditions but still meet quality preferences and criteria of their consumers. For the same lavender cultivar grown under two different growing conditions in Greece, Hassiotis et al. (2010) recorded small differences in oil yield. However, the percentages of major compounds showed differences between the two experimental sites.

The objective of this trial was to assess how selected cultivars performed in northern New Mexico under temperate growing conditions (USDA Hardiness Zone 5; annual minimum extreme temperature range of -15 to -10°F [-26 to -23°C]). Performance criteria were plant survival, measured as a percent of the original plant number in each plot; fresh and dry flower and stem yield per acre; and camphor content of dried flower and stem material. For the purposes of this cultivar trial, two English lavender cultivars and four lavandin cultivars were selected based on their popularity, availability from nurseries, and proven success as commercial cultivars elsewhere. The following is a brief description of each, beginning with the English lavender cultivars:

a) **'Hidcote'** – A small, dense, dark-blossomed cultivar of *L. angustifolia*, it is said to have originated in France and was brought to England in the 1920s (Upson and Andrews, 2004).
b) **'Compacta'** – Another of the smaller-sized, compact cultivars of *L. angustifolia*, with small, light-colored blossoms on erect stems (Upson and Andrews, 2004). This cultivar arrived from the nursery labeled 'Munstead'. However, according to Tucker (2001), the cultivar offered as 'Munstead' in the U.S. is apparently 'Compacta'. True 'Munstead' is described as dark violet or very dark purple, not light-colored (Upson and Andrews, 2004).
c) **'Emerisa'** – This unidentified lavandin was obtained from Emerisa Gardens in Santa Rosa, CA, and was therefore designated 'Emerisa' to distinguish it from the other lavandin cultivars in the trial. The specific pedigree could not be determined. This erect, vigorous lavandin resembled 'Provence' in its growth habit, inflorescence, and flower color.
d) **'Grosso'** – A vigorous, very hardy, large, globe-shaped lavandin with dark flowers and long stems, originating in France. It is very productive, making it a popular commercial cultivar, but the oil is high in camphor (Upson and Andrews, 2004).
e) **'Provence'** – This is an extremely robust, erect-growing lavandin hybrid, with light-colored blossoms on long stems. It is a hardy cultivar introduced to the United States from Canada. 'Provence' is hardy to Zone 5 (Upson and Andrews, 2004).
f) **'Super'** – Developed in France, this is a robust lavandin, with long upward-sweeping branches and long stalks terminating in soft violet flowers. Its fragrance is light and flowery, with low camphor. Its oil yield is lower than other lavandins but higher than *L. angustifolia*. It is mainly used for soap fragrances and aromatherapy (Upson and Andrews, 2004).

MATERIALS AND METHODS

The experimental design for this trial was a randomized complete block design with three replications; lavender cultivars served as the treatment variable. The null hypothesis stated that there was no significant difference in plant survival or yields among cultivars. Plots were 9 by 15 feet (2.74 by 4.57 m) and consisted of three rows per plot, with five plants per row. The plots were stacked two deep per block. The total plot number for each replication was six, one for each lavender cultivar.

The cultivar trial was established June 24, 2002, on a field consisting of Fruitland sandy loam (USDA-NRCS, 2009). The field had been cover-cropped in previous years with alternate plantings of hairy vetch and wheat as winter cover crops and sorghum-sudangrass as a summer cover crop. The cover crops were mowed with a rotary mower and incorporated each season with a disk harrow. For the lavender, the field was prepared prior to planting by disking and rototilling. Raised beds were

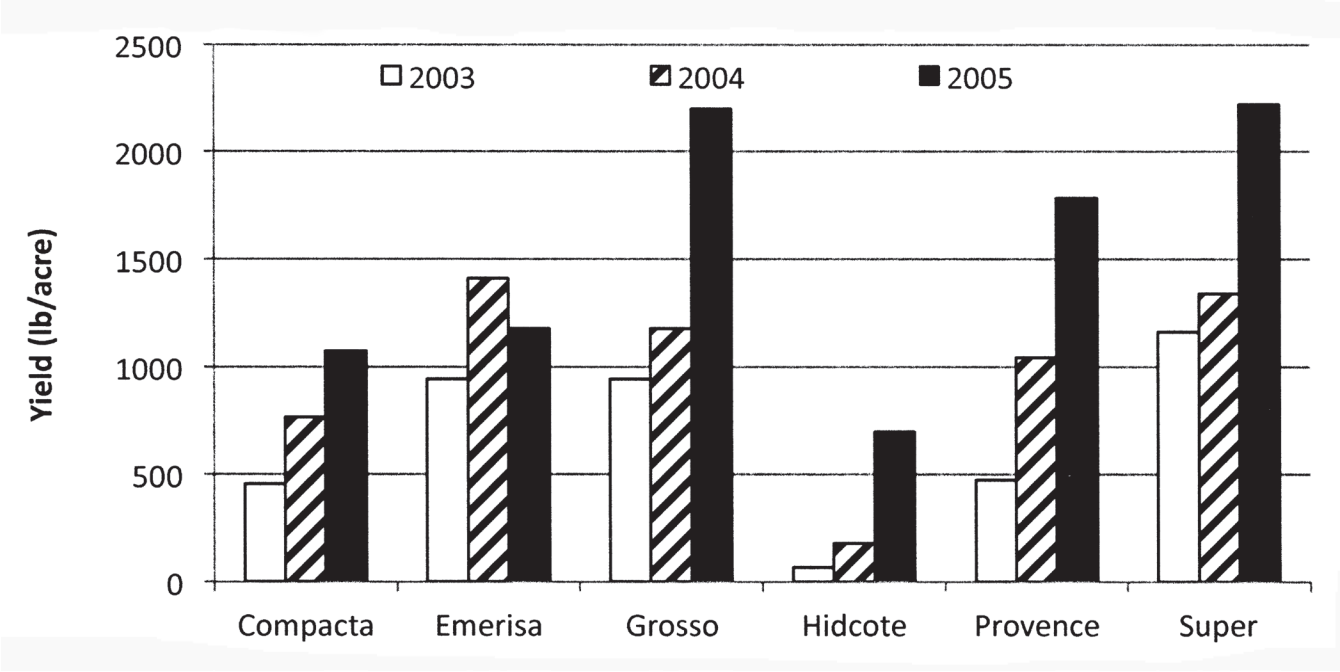

***Figure 2*. Lavender cultivar yield (dry weight) at different years. (The critical value for pairwise comparison was 470 lb/ac.)**

established on 36-inch (91.4 cm) centers using a Lilliston rolling-tine cultivator.

The lavender was planted from 4-inch (10.2 cm) commercially obtained nursery stock and planted on the tops of the raised beds 36 inches (91.4 cm) apart between and within the row, giving a final equidistant square planting arrangement. Precipitation a few days before transplanting created ideal moist, loose soil conditions. Irrigation immediately after transplanting was not necessary because of adequate soil moisture. All plants were side-dressed in August of the first growing season with Yum Yum Mix 2-1-1 organic fertilizer. This product is a blend of alfalfa meal, cottonseed meal, kelp meal, soft rock phosphate, and greensand (High Country Gardens, 2009). This dry fertilizer was applied by hand to the base of each plant as a split application, two weeks apart, at a rate equivalent to 400 lb/ac (448 kg/ha). Irrigation was by furrow application as needed. During the first growing season, the irrigation schedule was approximately weekly to ensure survival and establishment. In the following seasons, the irrigation schedule was approximately twice per month, taking into account intermittent rainfall. Weekly hand pulling and hand hoeing controlled weeds the first season. In the spring of the second season, 8-mil polypropylene woven landscaping fabric was installed over all plots for weed control, effectively eliminating hand weeding. The fabric was split, collared and then pinned around each plant up to the base to minimize weed emergence from beneath each lavender plant.

All cultivars began blooming in the second growing season (2003). Flowers and stalks were cut when the first few lower flowers had bloomed on the spike. This is the peak time to harvest, since the quality of the buds is highest at this stage of development (Beus, 2006). The three interior plants of the center row of each plot were sampled, leaving the outer plants of each plot as a border. Flowers and stalks were cut by hand to the first pair of leaves on each stem. Fresh sample weights were taken; samples were then dried at 149°F (65°C) for 48 hours and re-weighed. This sampling procedure was repeated in 2004 and 2005. Additionally, in 2004 dried subsamples were chemically analyzed for camphor content.

For camphor content determination, dried plant subsamples were ground to a fine powder and triplicate extractions (0.5 g each) were performed using an ISCO SFE 3560 supercritical fluid extractor, with CO_2 at 3,200 psi, temperature at 100°C, and the essential oil extract trapped in methanol. The chemical composition and camphor levels of the methanol extracts were determined using gas chromatography/mass spectrometry (GC/MS) on a Varian 3400 GC with a DB-5 column (30 m x 0.25 mm) coupled to an ion trap MS (EI, 70EV). Chromatography conditions were column temperatures of 60 to 250°C at a ramp of 3°C/min, then 250 to 295°C at increases of 10°C/min, then held for 3 min; injector temperature of 220°C, split flow 1:20; MS temperature of 200°C; and carrier gas flow of He at 1 mL/min. A calibration curve for camphor (0 to 1,000 mg/L) was used to quantify the abundance of camphor detected in the GC/MS peaks of the extracts. These extraction conditions resulted in extracts with chemical compositions very similar to traditional steam-distilled lavender oils. Data analyses were performed using SAS proc mixed version 9.2 (SAS Institute, 2008, Cary, NC).

RESULTS

Inherent differences in plant characteristics (growth habit and size) between species and among cultivars largely accounted for the differences in yields. 'Hidcote' and 'Provence' plots experienced some plant loss in the first growing season, reflected by the lower survival rates compared to the other cultivars (Table 1).

Fresh yields of 'Super' and 'Grosso' were different than 'Emerisa' (Table 2), but due to cultivar moisture content differences, the dry weight was more reliable. Subsequent analyses focused on dry weight yields to account for varying moisture content; fresh weight and dry weight percentages are also listed in Table 2 for comparison only.

Dry yield comparisons by species indicated significantly greater yields for *L.* x *intermedia* species compared to *L. angustifolia* species in all years. This was determined statistically via a contrast of species effect. The contrast is a weighted average, with *intermedia* means weighted by 0.25 and *angustifolia* means weighted by 0.5. Each year was analyzed separately. The P value for species differences in

Table 1. Lavender Cultivar Survival (%)[a]

Cultivar	Survival (%)
Compacta	100
Emerisa	100
Grosso	100
Hidcote	93
Provence	93
Super	100

[a]Remaining plant number/beginning plant number x 100, measured after the first growing season (2002). Cultivars are listed alphabetically.

Table 2. Lavender Yield and Moisture Content of Different Cultivars (averaged across years) and Among Different Years[a]

Cultivar	FW (lb/ac)	DW (lb/ac)	DW %
Super	6,021a	1,575a	26.1b
Grosso	5,541ab	1,439ab	25.9b
Provence	4,651bc	1,176bc	23.2c
Emerisa	4,093cd	1,099c	28.7a
Compacta (E)	3,352d	764d	22.8c
Hidcote (E)	1,401e	315e	22.3c
Year[b]			
2005	6,143a	1,525a	24.7a
2004	3,794b	986b	25.0a
2003	2,592c	673c	24.8a

[a]FW = fresh weight yield, DW = dry weight yield, E = English type. Among cultivars or years in the same column, different letters denote significant differences at P ≤ 0.05 using the Least Significant Difference method.

[b]Cultivar × year interaction was significant; see Figure 2 for details.

Table 3. Average Camphor Content (g compound/g dried plant material), 2004 Only[a]

Cultivar	Camphor (%)
Grosso	1.46a
Super	0.73b
Provence	0.34c
Emerisa	0.30c
Compacta[b]	0.00d
Hidcote	0.00d

[a]Cultivars are listed in decreasing order of camphor content. Means denoted by different letters are significantly different at P ≤ 0.05.

[b]'Compacta' and 'Hidcote' had no detectable camphor content.

2003 was 0.0059, and in 2004 and 2005 the P value was < 0.0001.

Pairwise comparisons of dry yield means of each cultivar (Table 2 and Figure 2) indicate that 'Super' and 'Grosso' had the highest dry yields, both in 2005 and for the three-year average, but higher yields for these cultivars can be expected due to their exceptionally long flower stalks. 'Grosso' and 'Super' dry yields were not significantly different from each other in any of the years (Figure 2). 'Hidcote' and 'Compacta' had the lowest fresh and dry yields; 'Hidcote' is a semi-dwarf cultivar that has been bred mostly for ornamental purposes and 'Compacta' likewise is a semi-dwarf, compact plant with short flower stalks compared to the other cultivars tested. However, 'Compacta' bloomed earlier than all other cultivars studied in this trial, flowering in mid-June, about two weeks earlier than the rest. This feature makes it a valuable cultivar for extending the harvest window when planted in combination with later-blooming cultivars. 'Emerisa' and 'Provence' are intermediate both in overall plant size and length of flower stalks. Qualitatively, 'Provence' flower color was pale, and individual plants exhibited more yellowing and leaf spotting than other cultivars. Leaf symptoms appeared to be temporary; plant samples submitted to the NMSU Plant Diagnostic Clinic tested negative for any disease.

'Grosso' had significantly higher camphor content than all other cultivars, followed by (in descending order) 'Super', 'Provence', and 'Emerisa' (Table 3). 'Compacta' and 'Hidcote', the two English cultivars, contained no detectable camphor. These results are consistent with percentage composition of camphor comparisons between *L. angustifolia* and *L.* x *intermedia* species found elsewhere (Chatzopoulou and Goliaris, 2003). 'Grosso' had twice the camphor as the next highest cultivar, 'Super'. Interestingly, while 'Provence' is usually preferred for culinary purposes because of its low camphor content, it had more than either 'Compacta' or 'Hidcote', cultivars not usually considered for culinary purposes. Given the absence of camphor, 'Compacta' or 'Hidcote' may be equally satisfactory for culinary use, and both have an added advantage of early bloom time. Overall, 'Super' and 'Grosso' are recommended as superior cultivars for northern New Mexico.

CONCLUSIONS

The results of this study indicate that selected cultivars of both *L. angustifolia* and *L.* x *intermedia* can be successfully grown commercially in north-central New Mexico under high desert irrigated agricultural conditions. *Lavandula* x *intermedia* cultivars were consistently hardier, had significantly greater yields, and had higher levels of camphor than *L. angustifolia* cultivars. However, yields are not the only consideration for cultivar selection. Consumer preferences, end use, and market demand, as well as other cultivar traits such as precocity, bloom time, stem length, or inflorescence color, will also affect a grower's choice of cultivar. Further study is recommended to determine the adaptability, yield, and oil quality of other cultivars of both English lavender and lavandin.

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