The Connecticut Agricultural Experiment Station, New Haven

Perennial Medicinal Herb Trials 1996-1999

BY MARTIN P.N. GENT

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Herbs are either herbaceous or woody plants that enrich the flavor and aroma of foods, or have therapeutic value in medicine. Most of these plants were known to prehistoric man; for instance, they recognized all sources of caffeine that are known today (Anderson, 1960). The medical use of herbs is documented throughout written history. The earliest account comes from the Mycenean culture in the 13th Century BC (Mabberley, 1990). Cultivated herbs spread from the Mediterranean throughout Europe during the Roman Empire (Page, 1971) and ultimately to America.

Herbs contain essential (aromatic) oils, alkaloids and other complex chemicals. Advances in analysis have identified many of these constituents (Bisset, 1994; Lawless, 1995; Duke, 1997). Several recent texts cover the pharmaceutical aspects of medicinal herbs, (Hoffmann, 1994; Duke, 1997; McGuffin et al., 1997; Tyler, 1999) and much of this information can be found on the internet (*see references*).

Consumers are interested in alternative medicine and medicinal herbs. In the United States today, herbs are found not only in health food stores, but also in the pharmacy sections of drugstores and supermarkets. Commercial production of potted and fresh-cut herbs in greenhouse and field has increased greatly in the last 20 years (Craker, 1999).

Many herbs can be grown in Connecticut. Knowledgeable gardeners have been growing them since Colonial times. However, information concerning the culture and yield of herbs is limited. In the recent Proceedings of the Second World Congress on Medical and Aromatic Plants, there was only one reference to yield of plant material from repeated harvests (Jeliazkova et al., 1999). Most reports were on the quality and quantity of the constituents of the herbs. Some recent work in the United States has examined the yield of herbs as affected by row covers and plastic mulch (Bower, 1998) or differing rates of fertilizer application (Csinzinsky, 1998).

There are many books on the culture of herbs, particularly with reference to their use as ornamentals in the garden (Mabberly, 1990). Such books include information on suitable soil types and microclimate for growing herbs. However, as the plants are grown as isolated specimens, or in irregular clusters, no information can be gleaned about likely yield from a larger and more regimented planting.

This bulletin describes the yield of 13 species of perennial medical herbs grown in the field in Connecticut. Our particular focus is the variation in yield due to the source of seeds, and changes in yield over time for several years after planting. Previous bulletins described yield of culinary herbs (Hill, 1992), and yield in the year of planting of some of these medicinal herbs (Butterfield, 1997). The information presented here will help determine the quantity of plants or the size of plot necessary to produce a desired yield of herbs for retail or wholesale trade.

METHODS AND MATERIALS

Fourteen companies supplied seeds for this study. Contact information and the abbreviation used for each company is listed in Appendix A. Appendix B lists the names of the varieties and the common name and Latin binomial of each species supplied by each seed source.

Seed Germination. The rate of germination was determined for the seeds used in plantings in 1996 and 1998. In 1996, seeds were sown in flats containing ProMix in a greenhouse maintained at 72F. Germination was counted for 36 to 72 seeds per source over a period of 3 weeks. In 1998, germination rates were determined from 100 seeds per sample. Seeds were sown in ProMix and grown in a controlled environment of 75F and a 12-hour photoperiod with light equivalent to 1/10 full sun.

In 1996, seedlings were grown for 6 weeks in the greenhouse before transfer to a cold frame to acclimate for 10 days. In 1998, seedlings were grown for 4 weeks in the controlled environment before transfer to a cold frame to acclimate for 7 days. Before they were transplanted in 1996, seedlings were fertilized with Hoagland's solution. In 1998, seedlings were fertilized before and at transplanting with a complete fertilizer containing 20-9-16 N-P-K applied at 400 ppm nitrogen.

Field Planting. Trials were conducted at Lockwood Farm in Hamden, CT. The soil was Cheshire fine sandy loam, a well-drained soil with a moderate moisture holding capacity. An area of 5,000 square feet was prepared and amended with 50 lbs. of 10-4-8 N-P-K fertilizer and 400 lbs. of limestone. Seedlings were transplanted into the field on May 24,1996. Some blocks were tilled and replanted with sage, thyme and yarrow on April 29, 1998.

The species were planted in blocks surrounded by walkways. A block contained one species, with plants of a given seed source in adjacent rows of five plants per row. The plant spacing was 2-ft x 2-ft. The walkways were 4 feet wide. In 1996, there were usually two rows per seed source and one block per species. In 1998, there were three rows per seed source planted in each of two replicate blocks of each species.

The plot received full sun. It was watered as necessary in summer to maintain growth. Weeds in walkways between species were controlled with glyphosate herbicide and hand cultivation. Black landscape cloth was used to control weeds within blocks in 1996. This was removed early in 1997, and thereafter weeds within the rows of plants were removed by hand. Many species tended to spread until there was no bare ground between adjacent plants. The area around the plants was hoed to prevent spread into walkways and to maintain a space of 6 inches between plants. In each year after planting, soil tests indicated good fertility for all elements except nitrogen in the established perennial plots. In early spring of each year, these plots were fertilized with a broadcast application of ammonium nitrate at 4 lbs. per 1000 square feet.

Harvesting and drying. The species were harvested at various times due to differing growth and development. The entire block of one species was harvested at one time, when flowers were open, but before they went to seed. This timing is recommended by herbalists to maximize phyto-chemicals in the foliage (Dobelis, 1986). In the year of planting, there was one harvest. In the following years, there were generally two harvests, in early June and mid to late August. Herbs were harvested by cutting the shoots at a height of 4 inches above ground level. The shoots were dried in an open greenhouse at maximum temperatures of 75 to 100F for 3 weeks. The entire sample was weighed. A sub-sample was dried in an oven at 140F for 3 days to determine water content and to express results on a dry weight basis. In some harvests, the yield of individual plants was recorded by position within row and row within plot. This information was used to determine the effect on yield of growing on the edge of the plot. Border plants yielded 30% to 100% more than those growing in the interior of the plots. The increased yield of border plants varied among species and with time after planting. The yields were corrected for these edge effects. In this report we give yields of the entire shoot on a dry weight basis in grams/plant, as calculated for an individual plant entirely within a large plot. To convert these values for larger areas, multiply by 24.0 to give pounds/acre, and by 21.4 to give kilograms/hectare. The roots of three species were harvested after two years of growth. A longer growth period of 3 to 5 years is recommended for roots to develop in echinacea and valerian. Flowering shoots were removed periodically from echinacea and valerian, which may have lowered root yield. Shoots of lovage were not cut before the root was harvested.

RESULTS

Seed germination. Although all seeds were germinated under controlled conditions or in a greenhouse, there was great variability in the fraction of seeds that germinated (Table 1). This variability was seen for each of the species studied. There was no consistent pattern in germination rates across species that could be attributed to the source of seeds. These results should not be used to estimate the germination of other batches of seed from these or other seed sources, as they are likely to vary as much as the range of germination percentages shown here.

The herbs differed in time to germinate. Feverfew and hyssop were among the fastest species to germinate. Cotyledons appeared within 3 days, and full germination was reached by day 12. Thyme and yarrow appeared in 5 days and reached a maximum germination after 10 days. Beebalm and horehound began to germinate after 7 days, and the maximum germination was reached by day 14. Lovage did not appear until 10 days, and only 30% of the sage had germinated by this time. Lemon balm germinated more slowly, only 50% of the seeds had germinated after 2 weeks. Catnip also germinated poorly. Seedlings began to emerge after 7 days, and maximum germination occurred at 20 days. The germination of mint seeds was not quantified, because they are extremely small. The seedlings emerged within 5 days. Early in germination, a cold treatment of 40F in the dark was applied to echinacea for 12 days and valerian for 6 days. For both species, some cotyledons were visible after 5 days, and germination was complete at 11 days.

Yield of flowering shoots. Three of the herbs planted in 1996 were harvested over four years. These species were horehound, hyssop, and lemon balm. Yield changed as the plants aged in this long-term study, and the difference in yield for spring compared to summer cuttings also varied from year to year.

Other species in this trial were only harvested for two years after planting in 1996. The growth characteristics of beebalm and mint were similar to that of lemon balm, while catnip was similar to horehound. Feverfew had poor survival over the winter and the stand was sparse in the second year. Echinacea was grown to harvest the roots, but the flowering shoots were also harvested in each year.

The species, sage, thyme and yarrow, were planted in 1998 and harvested for two years. Although sage and thyme are primarily grown as culinary herbs, they also have medicinal value. These species had production characteristics similar to balm or hyssop, with a higher yield in the second year than in the first.

Table 1. Percent of seed that germinated by species and seed source

	Seed source												
Latin binomial	CP	CF	FB	GC	HS	JS	NG	PS	PT	SG	TG	TS	WB
Achillea millefolium			9%					90%	92%			85%	86%
Echinacea purpurea	77%			63%	72%	80%	70%		88%	40%	90%		
Hyssopus officinalis	53%	62%		79%	96%	58%	50%		6%		94%		
Levisticum officinale			51%			45%		69%					37%
Marrubium vulgare	60%	37%		42%	40%	53%	90%				77%		
Melissa officinalis	16%	87%			43%	36%			46%	66%	75%		
Mentha species													
Monarda didyma				93%	54%	21%	46%				0%		
Nepeta cataria		28%		5%	4%	32%	30%		38%	38%	31%		
Salvia officinalis			50%			45%		62%					
Tanacetum parthenium		66%			98%	32%	66%			54%	67%	37%	
Thymus vulgaris						71%		52%	50%				71%
Valerania officinalis					26%	56%	18%				89%		

Achillea millefolium *L. (yarrow, milfoil)*

The flowering shoots should be harvested and dried. Yarrow is a polymorph aggregate of species with tetra-, hexa- and octa-ploidy. The ploidy affects composition. There is 0.2 to 1.0% essential oil. In the tetra-ploid, 50% of this oil is chamazulene, but in the octa-ploid it is primarily linalool (Bisset, 1994). Yarrow also contains sesqui-terpene lactones, such as achillin and its esters, and alkaloids. Yarrow is a diaphoretic and is used to relieve fevers (Hoffmann, 1994).

Yarrow flowered intermittently in the first year, resulting in a poor yield. Plants flowered more uniformly in the spring of the second year, and the majority of the 2-year yield came from this cutting (Table 2). Plants flowered intermittently in the summer, and it was not worthwhile harvesting the few shoots flowering at any one time. The plants were well established and should yield well in the third year.

The seed sources differed in flower color and variation in flower color within seed source. This may reflect differences in ploidy. All flowers from the PG seed source were dark pink. Flowers from PS seeds were also all pink but more variable in hue. The WB and TS seed sources resulted in plants with pink, white or yellow flowers. WB was more predominantly pink than TS. The yield of PS was less than half that of other seed sources, due to erratic flowering in spring. All plants spread vigorously and neither insect nor fungus pests were apparent. A higher yield per plant would be obtained at a 2.5-ft or 3-ft spacing.

Table 2. Shoot yield in grams per plant of yarrow by seed source and cutting time.

Seed Source	1st year 9/10/98	2nd year 6/25/99	2-year sum
PS	28	67	95 b+
PT	51	205	256 a
TS	19	192	211 a
WB	36	179	215 a
All	33	161	194

+ Averages followed by different letters are significantly different at the 5% probability level.

Echinacea purpurea L. Moench.
(common echinacea, purple coneflower, Kansas snakeroot)

SHOOTS

Echinacea is often grown to harvest the roots. However, shoots of *E. purpurea* contain 0.1 to 1.0% essential oil, composed of humulene, caryophyllene and its epoxide, germacrene-D, and methyl-*p*-hydroxycinnamate (Bisset, 1994). The foliage is used in teas and may be saleable.

Some plants flowered in the first year, and these shoots were harvested 130 days after planting. Because development was erratic, the yield was low. A high yield was obtained the following spring when all plants flowered (Table 3). There was erratic regrowth and flowering through the summer of the second year. The 2-year yield was among the highest of the species examined, due to high yield in the spring. The GC seed source gave the highest yield, and PT gave the lowest.

Echinacea is a member of the aster family, and susceptible to the same insects. Sunflower moth larva damaged more than 80% of blooms cut in late summer. They were not a problem in spring. Aster yellows was a more serious problem. It is a phytoplasma-mediated disease that alters shoot- and flower-structure (Hwang et al., 1996). It is vectored by leafhoppers, so early-season control of the insect is critical. This disease was not evident in 1996, but one third of the plants developed signs of disease through 1997. Diseased plants were removed, and not included in harvests or calculation of yield per plant. Border plants yielded 35% more than those inside the plot. A 2.5-ft x 2.5-ft spacing may promote root and shoot growth.

Table 3. Shoot yield in grams per plant of echinacea by seed source and cutting time.

Seed Source	1st year 10/1/96	2nd year 6/25/97	2nd year 9/9/97	2nd year sum	2-year sum
CP	122	152	48	200	322 ab+
GC	94	242	64	306	400 a
HS	42	145	35	180	222 bc
JS	78	203	38	241	319 ab
NG	42	183	59	242	284 b
PT	46	159	40	199	245 bc
SG	61	154	41	195	256 b
TG	29	115	26	141	170 c
All	64	169	44	213	277

+ Averages followed by different letters are significantly different at the 5% probability level.

Echinacea purpurea L. Moench. (common echinacea, purple coneflower, Kansas snakeroot)

ROOTS

The root of *Echinacea angustifolia* is highly valued for echinacoside, a glycoside with antiviral and immuno-stimulant properties (Weiner, 1990). However, many other biologically active substances are present in *Echinacea purpurea* as well as in *E. angustifolia*, and there is evidence that these constituents work synergistically (Hoffmann, 1994). In 1996, one seed source of *E. angustifolia* was planted in this trial. Few *E. angustifolia* plants survived the winter, and none survived long enough to harvest the roots.

There was a relatively low yield of fibrous roots when *Echinacea purpurea* was harvested in early September of the second year of growth (Table 4). The roots accounted for only a small fraction of the biomass of the plant. The yield of roots did not differ by seed source.

Table 4. Root yield in grams per plant of echinacea by seed source.

Seed Source	Root Yield
CP	20
GC	20
HS	15
JS	19
NG	15
PT	17
SG	12
TG	13
All	16

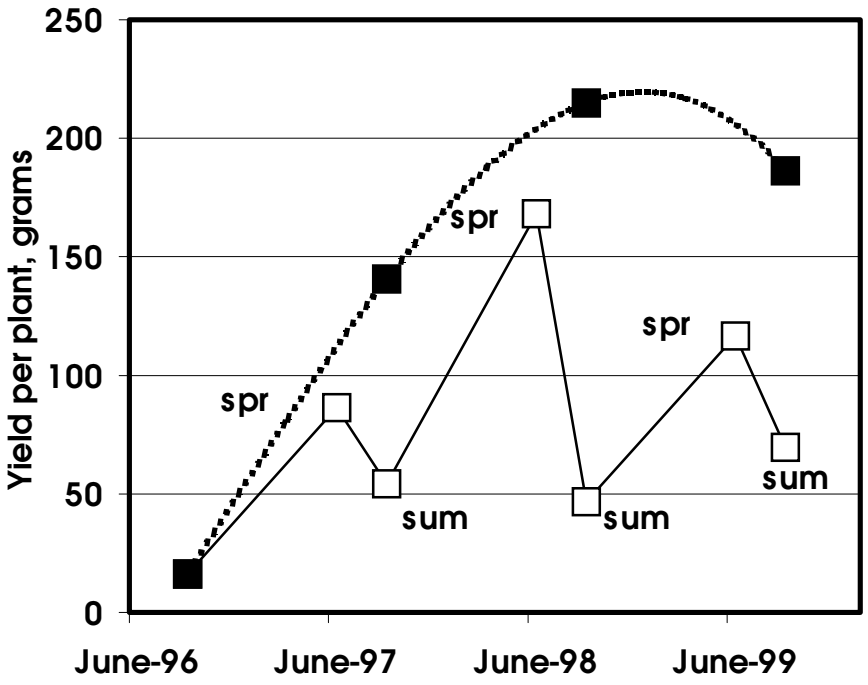

Figure 1. Shoot yield per plant for hyssop averaged over all seed sources in the trial. The line indicates yield per cutting, and solid symbols indicate yield per year over four years after planting.

Hyssopus officinalis L. (hyssop)

The woody shoots of hyssop should be harvested while in flower and dried in the sun. Hyssop contains a di-terpene, marrubiin, a glucoside, hyssopin, and tannins. The essential oil is composed mainly of camphor, pinocamphone and thujone (Hoffmann, 1994). Hyssop is used as an expectorant and to soothe sore throats (Ody, 1993).

Although hyssop grew slowly in the year of planting, it flowered only 53 days after transplant. A cutting at this time was not worthwhile as it only resulted in 16 grams/plant (Figure 1). Yields from cuttings in spring increased dramatically over the next two years. There was a particularly high yield in spring 1998, due to a delay in cutting, about 15 days after the other species. In other years, hyssop was harvested only a few days after horehound. The yield of a late-summer cutting was similar in each year after planting. Hyssop continued to produce well in the fourth year.

There were differences in yield between seed sources (Table 5). The yield of GC and HS was low because spring cuttings resulted in low yield. The CF, CP and JS seed sources had the best yields. All seed sources had similar growth habit, but some resulted in plants with either blue or pink flowers, while others were all blue.

The plants remained in flower for a long period, and bees frequented hyssop blossoms throughout. No deleterious insects or pests were noted. Over the four-year period, only three plants died in the entire plot. In the second year, border plants yielded 35% more than interior plants. In the third year, this difference in yield increased to 80%. Thus older plants were crowded by the 2-ft x 2-ft spacing.

Table 5. Shoot yield in grams per plant of hyssop by seed source and year after planting.

Seed Source	1st year	2nd year	3rd year	4th year	Sum of 1st 2 years	Average per year
CF	24	158	250	222	182	163 a+
CP	18	185	225	221	203	162 a
GC	16	89	146	125	105	94 c
HS	19	133	191	135	152	120 bc
JS	18	132	251	218	150	155 a
NG	13	136	240	182	149	143 ab
PT	10	120	195	205	130	133 ab
TG	11	171	220	183	182	146 ab
All	16	141	215	186	157	140

+ Averages followed by different letters are significantly different at the 5% probability level.

Levesticum officinale W. Koch. (lovage)

The roots of lovage should be harvested in the second year when the plants flower. The dried roots contain 0.6 to 1.0% essential oil of which 70% are alkyl-phthalides. The herb is used as a diuretic to cure edema (Bisset, 1994). Lovage gave a high yield of roots after only 1 year of growth (Table 6). At the time of harvest, on June 8, 1999, all plants appeared to be healthy. The seed sources did not differ in yield. A part of the tuberous roots with a shoot attached was replanted to see if this would provide plants for the following year. None of the replanted roots survived the summer.

Table 6. Root yield in grams per plant of lovage by seed source.

Seed Source	Root Yield
FB	96
JS	115
PS	100
WB	84
All	99

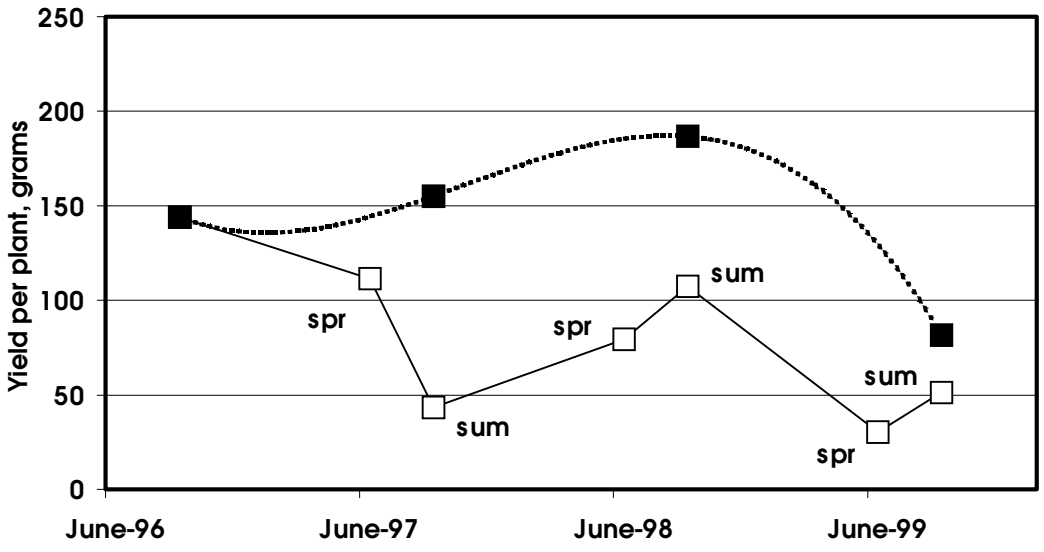

Figure 2. Shoot yield per plant for horehound averaged over all seed sources in the trial. The line indicates yield per cutting, and solid symbols indicate yield per year over four years after planting.

Marrubium vulgare L. (white horehound)

The flowering shoots of horehound should be harvested and dried in the shade at temperatures less than 95F. The main constituent of horehound is marrubiin, a di-terpene lactone. It also contains diterpene alcohols, essential oil and alkaloids (Bisset, 1994). An extract of horehound is used for cold-soothing properties in candies (Dobelis, 1986) and the dried herb is used in teas (Weiner, 1990).

Horehound began to flower 80 days after planting in 1996, and shoots were harvested 2 weeks later. This first cutting yielded more than any later cutting (Figure 2). However, the yield per year remained high for 3 years and then declined (Table 7). Horehound flowered early and was one of the earliest species to be harvested each spring. In the third and fourth year, yields were higher in late summer than in spring, because the early harvest gave plants a long period to recover in summer. The spring harvest was about 1 month later in the second year than in other years.

Yield did not differ among seed sources, except the yield from CF was significantly greater than the lowest yields (Table 7). Plants from all seed sources had a similar growth habit. There was sporadic death of plants. Only 80% of plants from CF, CP and JS seed sources survived through 4 years. All plants survived from other seed sources. Yield of horehound was restricted by the 2-ft x 2-ft spacing. Border plants yielded 80% more than did those inside the plot. A 3-ft x 3-ft spacing would be more appropriate. There were no insect problems. A sporadic yellowing and necrosis of leaves on main stems was likely due to self-shading of the plants.

Table 7. Shoot yield in grams per plant of horehound by seed source and year after planting in grams per plant.

Seed Source	1st Year	2nd Year	3rd Year	4th Year	Sum First 2 years	Average
CF	189	146	222	115	335	168 a+
CP	110	134	176	84	244	126 b
GC	139	170	150	67	309	131 b
HS	127	131	219	111	258	147 ab
JS	130	156	205	54	286	136 b
NG	165	181	139	57	346	135 b
TG	148	168	197	83	316	149 ab
All	144	155	187	82	299	142

+ Averages followed by different letters are significantly different at the 5% probability level.

Melissa officinalis L. (lemon balm, balm, or melissa)

The entire shoot of lemon balm is harvested. It contains 0.02 to 0.30% essential oil, comprised of 60% mono-terpenes and 30% sesqui-terpenes. The dominant terpenes are citronellal, 30 to 40%, and citral, 10 to 30% (Bisset, 1994). Lemon balm is used as filler in teas to hide unpleasant flavors and add fever-reducing and anti-depressant action (Ody, 1993). Externally, it is used on skin eruptions and as an insect repellent (Lawless, 1995).

Lemon balm did not flower in 1996, but a cutting late in the season gave a good yield. However, when it was cut two times in the second and third years, the yield per year was twice that in the first year (Figure 3). Yield from the June cutting declined from year to year, and yield from the late-summer cutting was always less than that in spring. Flowering of lemon balm was delayed and inconspicuous. Lemon balm was cut later than horehound, which may explain why spring harvests resulted in a higher yield of balm than of horehound. There was very little regrowth of foliage in summer 1999, and a fall harvest was not considered. The plants were still healthy, and could have been cut the following year. Overall yield from the diverse seed sources of lemon balm only differed by 20% (Table 8). Due to poor yield in the year of planting, overall yields from CF and TG seed sources were significantly less than the highest yields. This variation in yield was due to differences in growth habit. Vegetative growth of CF and TG seed sources was low and spreading, while others were more upright.

An unidentified necrosis was similar to that reported above for horehound. Self-shading was more severe in lemon balm as leaves were larger than in horehound. In the second year, plants on the edge of the plot yielded 60% more than those in the middle. This yield difference increased to 100% in the third year. Lemon balm should be planted at 3-ft x 3-ft spacing.

Table 8. Shoot yield in grams per plant of lemon balm by seed source and year after planting.

Seed Source	1st year	2nd year	3rd year	4th year	Sum of 1st 2 years	Average per year
CF	57	188	175	72	245	123 b+
CP	86	220	204	109	306	155 a
HS	85	183	212	59	268	135 ab
JS	140	186	207	64	326	149 a
PT	131	218	200	70	349	155 a
SG	159	212	185	63	371	155 a
TG	48	194	203	86	242	133 b
All	101	200	198	75	301	143

+ Averages followed by different letters are significantly different at the 5% probability level.

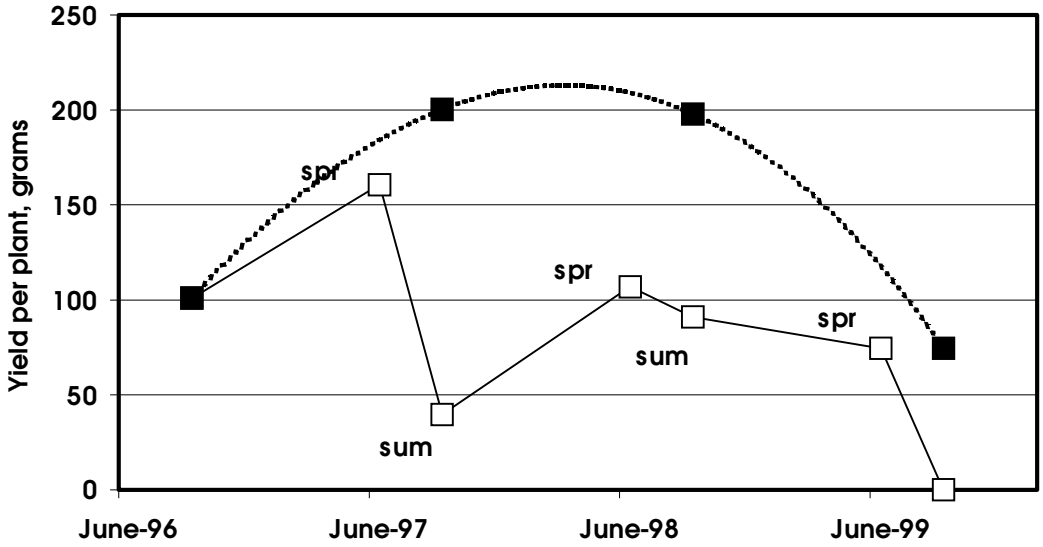

Figure 3. Shoot yield per plant for lemon balm averaged over all seed sources in the trial. The line indicates yield per cutting, and solid symbols indicate yield per year over four years after planting.

Mentha spicata L. and *Mentha x piperata* (mint, spearmint, peppermint)

These seeds were likely spearmint, as peppermint is 99% sterile and is propagated from cuttings (Tucker, 1993). The aerial shoot is used fresh or dried. Mint contains 0.8 to 2.5% essential oils. In peppermint most of this is menthol, but in spearmint about 50% is a related mono-terpene, carvone (Bisset, 1994). Mint is a flavoring agent commonly used in products for oral hygiene and cold and flu treatment. Both types of mint are used in teas to settle digestion (Weiner, 1990).

Mint flowered sporadically 96 days after planting in 1996. A cutting at this time gave a relatively low yield. The plants flowered consistently in the following spring, and this cutting gave a higher yield (Table 9). There was relatively little regrowth through the summer of the second year. The 2-year yield for mint was lower than for beebalm, because the yield from a spring cutting was only half that for beebalm. The seed sources of mint did not differ in yield or growth habit.

Mint spread more quickly than other species, and was hard to contain. The substantial root pruning necessary to maintain the distinction between individual plants may have reduced yield. Border plants yielded 80% more than those inside the plot. All plants survived and showed no sign of insect pests or disease.

Table 9. Shoot yield in grams per plant of mint by seed source and cutting time.

Seed Source	1st year 8/26/96	2nd year 7/15/97	2nd year 9/9/97	2nd year sum	2-year sum
CF	37	93	40	133	170
NG	49	83	41	124	173
PT	37	97	29	126	163
TG	36	84	24	108	144
All	40	89	34	123	163

Monarda didyma L. (beebalm, Oswego tea)

The entire flowering shoots of beebalm should be dried at 75 to 95F. Both the foliage and flowers of beebalm contain active ingredients such as thymol, a powerful antiseptic for both internal and external use (Grieve, 1992). The foliage, cut and dried, is used as a tea to aid in digestion and for respiratory ailments (Erichsen-Brown, 1979).

Beebalm did not flower in 1996, and a cutting was delayed until 130 days after planting. Even so, the first cutting had a low yield compared to that in the following spring (Table 10). After the cutting in spring, regrowth and flowering was erratic through the summer of the second year. The seed sources did not differ significantly in yield. The HS seed source had a high yield only in the second year.

No insect pests were observed on beebalm. Powdery mildew, a white mold on the leaves, was a problem in late summer but not in spring. In addition, some leaves developed black necrotic spots, followed by yellowing and abscission of the leaf. As border plants yielded 35% more than did those inside the plots, a 2.5-ft x 2.5-ft spacing may be more appropriate for beebalm.

Table 10. Shoot yield in grams per plant of beebalm by seed source and cutting time.

Seed Source	1st year 10/1/96	2nd year 7/10/97	2nd year 9/2/97	2nd year sum	2-year sum
GC	59	124	31	155	214
HS	33	217	42	259	292
JS	38	145	33	178	216
NG	31	147	31	178	209
All	40	158	35	193	233

Nepeta cataria L. (catnip, catmint)

The entire flowering shoots are collected and dried. Catnip is another member of the mint family, with an essential oil containing carvacrol, citronellal, nerol, geraniol, pulegone, and thymol. It also contains nepetalactones, compounds with antiseptic properties (Bourrel et al., 1993). Catnip is used as a sedative and to relieve stomach pains (Dobelis, 1986).

Because catnip grew vigorously after transplant, the first stems were cut shortly after planting to encourage bushy growth. All plants were in flower 91 days after planting in 1996. A cutting at this time gave a higher yield of catnip than a cutting the following spring (Table 11). There was relatively little regrowth through the summer of the second year. The 2-year yield for catnip was as high as for horehound, because all shoots elongated and flowered in the first year. The PT seed source had the highest yield overall and in the spring cutting. Due to slower growth in the first year, the CF and SG seed sources gave the lowest yields.

All seed sources resulted in a similar growth habit. There were no disease problems. Border plants yielded 50% more than interior plants. A 3-ft x 3-ft spacing would increase yield per plant.

Table 11. Shoot yield in grams per plant of catnip by seed source and cutting time.

Seed Source	1st year 8/27/96	2nd year 6/25/97	2nd year 8/20/97	2nd year sum	2-year sum
CF	130	78	19	97	227 c+
GC	171	142	45	187	358 ab
HS	204	62	33	95	299 bc
JS	171	111	56	167	338 b
NG	166	97	55	152	318 bc
PT	163	194	51	245	408 a
SG	141	88	50	138	279 c
TG	173	108	43	151	324 b
All	165	110	44	154	319

+ Averages followed by different letters are significantly different at the 5% probability level.

Salvia officinalis L. (garden sage, common sage, red sage)

Leaves of sage should be gathered at flowering and dried in the shade at temperatures less than 95F. Sage contains 1.0 to 2.5% essential oil, of which 35 to 60% is thujone, and also cineole, borneol, and camphor. It also contains, di-terpenes, flavonoids, and tannins including rosmarinic acid (Bisset, 1994). Sage is used to remedy inflammation of the mouth, throat and tonsils (Hoffmann, 1994).

Sage did not spread, but grew from a single stem. A 2-ft x 2-ft spacing was appropriate for this growth habit. There was a relatively low yield per plant. The highest yield was obtained from the late-summer cutting in the second year (Table 12). The yields reported here are for the whole shoot, but only the leaf blades are of value. About 35 to 55% of the shoot weight was in leaves. The fraction in leaves was higher in late summer than in spring. The seed sources did not differ in yield, except in the last harvest, when PS yielded more than JS. All seed sources resulted in a similar growth habit. There were no disease problems.

Table 12. Shoot yield in grams per plant of sage by seed source and cutting time.

Seed	1st year	2nd year		2nd year	2-year
Source	9/16/98	6/1/99	9/12/99	sum	sum
FB	53	58	92	150	203
JS	60	69	74	143	203
PS	51	69	110	179	230
All	55	65	92	157	212

Tanacetum parthenium L. (feverfew)

Both the flowers and foliage of feverfew contain active ingredients. The essential oil contains camphor, pinene and derivatives. Other constituents are bornylacetate, pyrethrin, and sesqui-terpene lactones known as parthenolides (Hoffmann, 1994). Parthenolides may reduce the incidence and severity of migraine headaches (Ody, 1993).

Feverfew had the lowest yield of all the herbs in this trial. Only half the plants survived over-winter, and those plants yielded less in the second than in the first year (Table 13). This species grew like a biennial. A better yield may be obtained by planting in mid-summer and harvesting the following spring.

The PT seed source resulted in the lowest yield in the year of planting, 5 g/plant, and no plants survived the winter. There was no difference in yield per plant among seed sources that did survive the winter (Table 13). The various seed sources resulted in single- and double-flowered varieties. Single-flowered varieties had the highest yield in the year of planting, but the seed sources did not differ in yield in the second year, or overall. No pest or disease problems were noted. Feverfew spread only slightly, and there was no crowding of the plants within the plot. Plant spacing could be reduced to 1.5 x 1.5 ft.

Table 13. Shoot yield in grams per plant of feverfew by seed source and cutting time.

Seed Source	1st year 8/26/96	2nd year 7/23/97	2-year sum
CP	44	24	68
GC	33	21	54
HS	71	20	91
JS	62	23	85
SG	36	30	66
TG	22	36	58
All	45	26	71

Thymus vulgaris L. (common thyme, garden thyme)

Branches are collected at flowering and dried, after which leaves are rubbed off. Thyme has 1.0 to 2.5% essential oil, with the mono-terpene isomers, thymol (30 to 70%), and carvacrol (3 to 15%). It also contains flavonoids and tannins (Bisset, 1994). The oil is antiseptic and it is used externally as a lotion for infected wounds (Hoffmann, 1994).

Thyme grew more slowly than did sage. A late summer cutting in the year of planting gave a low yield. However, growth of thyme was better than sage during the second year, and the 2-year yield was higher (Table 14). The seed sources did not differ in overall yield; those seed sources giving a high yield in spring had a low yield in late summer. All seed sources resulted in similar growth habit and flower color. There were no disease problems. A closed canopy of plants was not obtained until the end of the second year. The 2-ft x 2-ft spacing was appropriate at this stage. If the plants were to be grown for several more years, the spacing should be increased.

Table 14. Shoot yield in grams per plant of thyme by seed source and cutting time.

Seed Source	1st year 9/15/98	2nd year 6/1/99	2nd year 9/12/99	2nd year sum	2-year sum
JS	45	68	117	185	230
PS	52	74	126	200	252
PT	44	75	99	174	218
WB	53	94	102	196	249
All	49	78	110	188	237

Valeriana officinalis L. (valerian, garden heliotrope)

The dried tuberous roots or stolons of valerian contain 0.3 to 0.7% essential oil, composed of bornyl esters of isovalerianate and related compounds, such as eugenyl isovalerates, and valerianol. A number of these components hydrolyze over time to isovaleric acid, a pharmaceutically inactive compound that provides a distinctive odor. Roots also contain up to 0.1% alkaloids (Bisset, 1994). Valepotriates, another class of compounds isolated from valerian, are claimed to regulate the autonomic nervous system. One fraction is a suppressant, another is a stimulant, and the combination has an equalizing effect referred to as amphoteric (Hoffmann, 1994). Valerian is used to relieve anxiety and sleeplessness.

Although the yield of valerian roots varied greatly among seed sources (Table 15), only a few plants survived until roots were harvested, so these differences in yield were not significant. Most plants survived the winter, but many died at or after flowering in late spring of the second year. Only one-third of the plants survived until the roots were harvested. Roots of the dead plants showed evidence of damage by a boring insect. It is likely that the insect damage was followed by systemic disease. Valerian is a large plant, and yield should benefit from a wider spacing than the 2-ft spacing used in this trial.

Table 15. Root yield in grams per plant of valerian by seed source.

Seed Source	Root Yield
HS	68
JS	75
NG	29
TG	20
All	48

DISCUSSION

The fraction of perennial herb seeds that germinated was variable, even when grown under controlled conditions. This variability was seen for all species, and there was no consistent pattern among seed sources. Seed viability likely depends on climate and the time of year when seed is collected, which can vary greatly for these species which flower over a long period. In addition, most of these perennial herbs can propagate vegetatively by spreading, so there is little selection pressure for a high seed germination rate. A germination test should be done whenever a large planting of perennial herbs is contemplated, to insure a sufficient number of seedlings for transplanting.

The species of perennial herbs differed in the yield of shoots, and in the year-to-year variation in yield. Some species produced a high yield of shoots in the year of planting, while for other species, the yield increased for 3 years after planting. Those species whose yield in the first year was as great as in subsequent years could be grown as annuals. Catnip and horehound were species that fell in this category. These species grew vigorously and flowered relatively early in the year of planting.

Lemon balm, beebalm and mint grew well in the first year, but yielded more in the second year than in the year of planting. These related species have similar growth habits. They have large leaves and a dense canopy. They tended to flower erratically or not at all in the first year. These species should be grown for 2 or 3 years to maximize returns. Yield of lemon balm declined in the fourth year. This may be related to the narrow 2-ft x 2-ft spacing used in this trial. The yield of border plants as a ratio of plants inside the plot increased from the second to the third year. Planting at a wider spacing of 3 feet would increase yield per plant and likely would prolong the useful life of a planting of any of these three species of herbs.

Hyssop, sage, thyme, and yarrow had low yields in the year of planting. The yield of hyssop increased over 3 years. Sage and thyme had a growth pattern similar to hyssop over the 2 years that they were observed. These woody species should be grown for at least 3 years to maximize the return of investment costs related to planting. Although these species did not spread as rapidly as the species described above, the plants became crowded by the end of the second year. A 2.5- or 3-ft spacing may be more appropriate to optimize yield per plant in a long-term planting.

All the species of herbs mentioned above should yield well if grown as perennial plants for commercial production in Connecticut. Feverfew was the only herb in this study that did not do well when grown as a perennial. It may be better to plant this species at a closer spacing and grow it as a biennial.

Of the species grown for their roots, only lovage gave a high yield of roots when grown as a biennial. Dividing and replanting the roots did not yield viable plants, so lovage would have to be grown from seed. Echinacea and valerian are true perennials that could be grown for more than two years. However, insect and/or disease problems in this trial caused a substantial loss of plants after only two years. In addition, *Echinacea angustifolia*, the more valuable species of coneflower, did not survive the winter. These problems must be addressed in order to grow these herbs on a commercial basis in Connecticut.

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The Internet contains good sources of information about the use of herbs.

http://www.herbs.org Herb Research Foundation site, features scientific, political, and business news concerning herbs.

http://www.herbnet.com The Herb Growing and Marketing Network site, features *The Herbalist* magazine and links to courses, associations, software, and seed sources.

www.herbmed.org Alternative Medicine Foundation site, provides hyperlink access to the scientific data underlying the use of herbs for health.

www.medherb.com A site by the journal *Medical Herbalism*, provides links to medical information and resources relevant to medicinal herbs.

www.egregore.com Medicinal Herbs Online site, indexes herbs and diseases and links to other sources of information.

http://www.ars-grin.gov/duke/ Dr. Duke's Phytochemical and Ethnobotanical database, allows searches for a chemical within a species, and for species which contain a chosen chemical.

APPENDIX

Appendix A. Companies that supplied seed for the herb trials.

Company	Address	Phone	Symbol
Comstock, Ferre & Co.	263 Main Street;Wethersfield, CT 06109	860-571-6590	CF
Companion Plants	7247 N Coolville Ridge; Athens, OH 45701	614-592-4643	CP
The Flowery Branch	POB 1330; Flowery Branch, GA 30542	na	FB
Goodwin Creek Gardens	PO Box 83; Williams, OR 97544	800-846-7359	GC
Horizon Seeds	PO Box 69; Williams, OR 97544	503-846-6704	HS
Johnny's Select Seeds	310 Foss Hill Road; Albion, ME 04910	207-437-4301	JS
Nichol's Garden Nursery	1190 Pacific Coast Hwy; Albany, OR 97321	541-928-9280	NG
Park Seed Co.	1 Parkton Ave; Greenwood, SC 29647	800-845-3369	PS
Pinetree Garden Seeds	Box 300; New Gloucester, ME 04260	207-926-3886	PT
Shepard's Garden Seeds	30 Irene Street; Torrington, CT 06790	860-482-3638	SG
Stokes Seed Ltd	POB 548; Buffalo, NY 14240	800-263-7233	SS
The Thyme Garden	20546-H Alsea Hwy; Alsea, OR 97324	541-487-8671	TG
Twilley Seed Co	POB 65; Trevose, PA 19053	800-622-7333	TS
W.A. Burpee Seed Co.	300 Park Ave; Warminster, PA 18991	800-487-5530	WB

Appendix B. Perennial herb species, common names, and seed sources.

Latin binomial	Common name	Named variety	Year planted - Sources
Achillea millefolium	yarrow	Summer pastel	98 – FB, TS
		Cerise Queen	98 - PS, PG
		Colorado mix	98 – WB
Echinacea purpurea	purple coneflower	Starlight	96 – SG
		no name	96 - CP, GC, HS, JS, NG, PT, TG
Hyssopus officinalis	hyssop	no name	96 - CP, CF, GC, HS, JS, NG, PT, TG
Levisticum officinale	lovage	no name	98 - FB, JS, PS, WB
Marrubium vulgare	horehound	White	96 - CF, TG
		no name	96 - CP, GC, HS, JS, NG
Melissa officinalis	lemon balm	no name	96 - CP, CF, HS, JS, PT, SG, TG
Mentha species	mint	Common mint	96 – PT
		Peppermint	96 – CF, TG
M. x Spicata	spearmint	Spearmint	96 – NG
Monarda didyma	bee balm,	no name	96 – GC, HS, NG, TG
	bergamot	Panorama mix	96 – JS
Nepeta cataria	catnip	no name	96 – CF, GC, HS, JS, NG, PT, SG, TG
Salvia officinalis	sage	Broadleaf	98 – FB
		Extrakta	98 – JS
		no name	98 – PS
Tanacetum parthenium	feverfew	White wonder	96 – SG
		Double flowered	96 – GC
		Single	96 – TG
		Golden ball	96 - PT
		no name	96 - CP, HS, JS
Thymus vulgaris	thyme	German winter	98 - JS
		English	98 -PS
		Common	98 - TS, WB
Valerania officinalis	valerian	no name	96 - HS, JS, NG, TG