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Catnip as a Source of Essential Oils

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Catmint (*Nepeta* spp., Lamiaceae) contains about 150 species and is largely in the horticultural trade as an ornamental. Catnip (*N. cataria* L.), a short-lived perennial herbaceous plant, is perhaps the best-known species, long recognized as the plant that induces a state of euphoria and stupor in domesticated cats (Clapperton et al. 1994; Herron 2003). Research has shown that the essential oil of catnip, containing nepetalactones, is largely responsible for the plants biological activities including its application as a cat attractant, insect pheromone, and insect repellent (Peterson and Coats 2001; Peterson et al. 2002; Baranauskiene et al. 2003; Herron 2003; Peterson and Ems-Wilson 2003, Chauhan et al. 2005; Amer and Mehlhorn 2006).

Limited commercial crop area of catnip has been centered in the Western US and Canada with most dedicated to the production of essential oils or for seed production; while smaller farms have been focused on the production of dry leaves for catnip toys and herbal uses. Despite the increased interest in this plant as a natural source of insect repellent activity, few studies have documented the horticultural attributes and yield potential. As a source of essential oil, the production of catnip on a large-scale presents numerous challenges in that the available varieties are relatively low biomass producers and produce low yields of essential oil which is difficult to efficiently separate and recover. Catnip is also sensitive to winter injury, handling and cutting and has been observed in many locations to re-grow poorly after the first season. As a result, catnip is also grown horticulturally as an annual rather than a perennial.

We report on field studies that were conducted to: (1) evaluate the yield potential of catnip in New Jersey, and (2) ascertain yield differences from available sources or lines of catnip relative to their growth and essential oil yields. We also report on our ongoing selection program that was initiated in 1996 to identify and develop new novel types of catnip and higher yielding lines rich in nepetalactones.

METHODS

Estimation of Catnip Yield

The plant population study was conducted at a commercial herb farm in Richland, New Jersey. Catnip (Johnny's Selected Seeds) was started by direct seeding in a greenhouse and later fall transplanted (10/06/2004) into the field using a randomized block design with three replications as a fall planting. The soil at this site was sandy with excellent drainage. Fall fertilizer was applied via the irrigation system at ca. 34 kg N/ha equivalent, plus the herbicide devrinol at 2.24 kg/ha was applied as a post-emergence. Field plots were handled similar to the adjacent commercial herbs using mechanical and manual weeding and irrigation. Plants were transplanted into raised beds, using five within row plant spacings at 30, 46, 61, 76, and 91 cm within triple rows on single beds to provide populations of 90 plants/plot (80,742 plants/ha); 60 plants/plot (53,818 plants/ha); 45 plants/plot (40,364 plants/ha); 36 plants/plot (32,291 plants/ha); and 30 plants/plot (26,909 plants/ha). Each plot was 9.14 m × 1.22 m.

Field Performance and Essential Oil Potential of Commercial Catnip and Advanced New Selections

After the original study was established in the field, we observed in early 2005 that the catnip from Johnny's Selected Seeds was low in nepetalactones (data not presented). As a result, we initiated parallel studies on additional commercial catnip sources and our own Rutgers selections, based on prior essential oil screening of single plants, to identify and sources producing higher essential oil yields and nepetalactones. Eleven sources

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of catnip were included in this study from plants originally established in 2005 including, a commercial catnip from Specialty Seeds of Oregon (SSO, Culver, Oregon), Seeds of Change (SOC, Sante Fe, New Mexico), and nine advanced Rutgers selection of catnips that had been selected for ornamental and traditional catnip quality relative to growth and essential oil yields. This study was established in northern New Jersey at the Clifford and Melda E. Snyder Research and Extension Farm in Pittstown, New Jersey using transplants and organic growing practices. Land was chisel plowed and then disked and made into raised beds with 2 m centers. Trickle irrigation and black plastic mulch were applied to each row. Organic fertilizer was applied pre-planting and during transplantation, Fertrell liquid fish emulsion 2-4-2 was applied to each transplant. Heavy straw mulch was then applied to the field and an organic herbicide mix of Matran 2 (37.5 L/ha) and sulfur (11.2 kg/ha) was applied between rows.

Essential Oil Extraction and Analysis

Essential oil yields from the plant population study were achieved using a pilot-scale 500 liter portable steam distillation unit (Alkire and Simon 1992). The essential oil of catnip is difficult to recover as the oil can elute in two fractions, one lighter and the other heavier than water, requiring differential oil collectors. We used a special separator designed by the Newhouse Manufacturing Co., Inc. (Redmond, Oregon) to also capture the essential oil fraction that was heavier than water. Essential oil yields are provided as both the actual oil collected under the pilot-scale system used as well as an adjusted total oil yield, which calculates the total essential oil yield that could be captured with an efficient recovery system.

The composition of essential oils were determined by using a gas chromatograph (GC) coupled to a mass spectrometer (MS) and FID detectors as described (Juliani et al. 2006; Vieira and Simon 2006). Individual identifications were made by matching their spectra with those from mass spectral libraries (Wiley 275.L) and the identity of oil constituents confirmed by comparison of its Relative Retention index with those from the literature (Adams 1995).

RESULTS AND DISCUSSION

Fall-transplanted catnip established in southern New Jersey survived the winter with little injury. As expected, both biomass and total essential oil (EO) yields increased with increasing plant populations (Table 1). Highest yields of biomass (7.7 t dry wt/ha) and essential oil (8.9 kg/ha) were recovered from the highest plant population. Essential oil yields more than doubled from the lowest to the highest plant population, increasing from only 3.4 to 8.9 kg/ha (Table 1). We observed that a significant amount of essential oil remained in the distillate water, clung to the walls of the collectors and poorly separated into both top and bottom oil fractions. We conducted preliminary studies on secondary oil recovery in the lab based upon the amount of oil remain-

Table 1. Catnip essential oil (EO) yields by plant populations in year 1 grown in Richland, New Jersey. Catnip source: Johnny's Selected Seeds, Albion, Maine.

Plants/ha	Total biomass yield (dw t/ha)	EO yield (kg/ha)^z	Adjusted EO yield (kg/ha)^y
26,909	4.1	3.4	4.7
32,291	4.4	4.4	6.1
40,364	4.3	4.7	6.6
53,818	5.5	6.2	8.7
80,742	7.7	8.9	12.5

^{z}Actual recovered EO using the pilot-scale portable still.

^{y}Adjusted total EO that could be recovered using an efficient extraction and recovery system. Lab studies along with the pilot-scale steam distillation unit showed significant essential oil losses using present commercial systems. The adjusted yields illustrate a more efficient capture of oil remaining in distillate water and/or not separating into distinct oil layers.

ing in the distillate water and in the collectors and then calculated the total EO yield when adjusted to a full recovery under lab conditions. When this was done, the adjusted EO yields were significantly higher than the actual pilot-scale steam distillation commercially simulated oil yields (Table 1). The adjusted EO yields then ranged from 4.7 to 12.5 kg/ha from the lowest to highest plant populations over the first season of growth with two harvest dates.

Genetic selections and commercial sources of catnip varied in essential oil yield and composition (Table 2). Oil yield ranged from 0.1 to 0.2 mL/100 g dry wt and nepetalactones ranged from 6.0% to 73.2% of the total EO. The Rutgers catnip selections that were made were based upon a variety of traits, one of which was nepetalactones. Among the advanced Rutgers selections, three lines (RU 243, RU 248, and RU G1) showed high amounts of nepetalactones, two of which also showed higher oil yields as well. The commercial lines all had considerably low nepetalactone content. This study illustrates that significant improvement in essential oil yield and composition can be achieved by selection.

Significant variation in several horticultural traits among the commercial lines of catnip and Rutgers selections were noted (Table 3). Catnip can be harvested twice in a growing season, some of the selections showed differential rates of maturity as evidenced by the varying biomass accumulated at both harvest times. Highest yields were achieved with RU G1 and RU 246.

The large-scale production of catnip as a source of essential oils will be most challenging. The plant yields of commercial catnips are low, both in terms of biomass and essential oil accumulation. Catnip can suffer damage from insects and disease, though none were observed in our studies. Unlike mint, the plant is delicate and can be physically damaged by mechanical and manual cultivation and weeding, from harvesting, and winter injury. Plant roots are not extensively deep, thus, irrigation may be required. Site selection will be an important criterion to consider in the commercialization of this crop. Catnip may be grown either as a short-lived perennial or as an annual crop. Similar to mint, we have observed catnip growing in regions where the biomass accumulation is very high, yet yields of essential oils were very low, suggesting that the environment plays a major factor in triggering essential oil accumulation. The essential oil of catnip is difficult to efficiently recover using present commercial separators. Two distinct oil fractions can form requiring improvements in commercial separators. The majority of the essential oil needs to be recovered from below the distillate water rather than above; the oil separates poorly from the distillate water and appears relatively unstable. Improved separation technology will be required at the farm level. There is significant potential in the improvement of this plant as an essential oil crop using selection and breeding, and commercial feasibility in large-scale production may require improved varieties bred for this application.

Table 2. Essential oil (EO) yields in catnip selections and cultivars.

Sources of catnip[z]	Total EO yield (ml/100 g dry wt)	Z, E-nepetalactone (rel. % total EO)	β-caryophyllene (rel. % total EO)
RU 243	0.2	73.2	0.5
RU 244	0.1	12.1	76.6
RU 245	0.1	36.7	0.8
RU 246	0.1	31.5	4.3
RU 247	0.1	32.7	0.9
RU 248	0.1	69.8	0.9
RU 249	0.1	18.1	63.5
RU G1	0.2	74.6	0.7
RU OF01	0.2	6.0	84.2
Oregon Specialty Seeds	0.2	9.5	79.4
Seeds of Change	0.2	13.3	75.0

[z]RU=Rutgers University catnip selections.

Table 3. Growth and development at harvest 1 and 2 for catnip selections and varieties grown in northern New Jersey, Pittstown.

Source[z]	Plant height (cm)	Plant spread (cm)	Vigor[y] (1–9)	Flower color[x]	Uniformity (1–5)[w]	1st harvest Dry wt/pt (g)	1st harvest Dry wt (kg/ha)	2nd harvest Dry wt/pt (g)	2nd harvest Dry wt. (kg/ha)	Seasonal total yield dry wt (t/ha)
RU 243	50.9	73.8	5.5	LP	3.3	98	746	113	852	1.6
RU 244	43.6	63.8	4	LP	3	182	1383	103	783	2.2
RU 245	49.6	70.2	5	LP	4	232	1772	114	847	2.6
RU 246	58.9	78.4	7.7	LP	4.2	185	1411	187	1445	2.9
RU 247	54.3	67.7	6	LP	3.3	160	1216	145	1114	2.3
RU 248	55.5	71.5	7.3	W	3.4	142	1077	187	1438	2.5
RU 249	51.6	71.1	8	W	2.8	80	610	205	1573	2.2
RU G1	60.5	71.8	8.3	W	3.8	156	1186	235	1820	3.0
RU OF01	45.5	64.1	4	MP	4	118	899	100	761	1.7
Oregon Specialty Seeds	56.8	76.8	9	LP	3.8	172	1307	182	902	2.2
Seeds of Change	48.1	66.3	5	LP	3.3	168	1278	138	1023	2.3

[z]Source: RU=Rutgers.
[y]Vigor: 1=lacks vigor, 9= highly vigorous.
[x]Flower color: LP=light purple, LP=light pink, MP=medium pink, W=white.
[w]Plot uniformity: 1=low uniformity, 5=high uniformity.

REFERENCES

Adams, R.P. 1995. Identification of essential oil components by gas chromatography/mass spectrometry. Allured Publ. Corp., Carol Stream, IL.

Alkire, B.H. and J.E. Simon. 1992. A portable steam distillation unit for essential oil crops. HortTechnology 2:473–476.

Amer A. and H. Mehlhorn. 2006. Repellency effect of forty-one essential oils against *Aedes*, *Anopheles* and *Culex* mosquitoes. Parasitology Res. 99(4):478–490.

Baranauskiene R., R.P. Venskutonis, and J.C.R. Demyttenaere. 2003. Sensory and instrumental evaluation of catnip (*Nepeta cataria* L.) aroma. J. Agr. Food Chem. 51(13):3840–3848.

Chauhan, K.R., J.A. Klun, M. Debboun, and M. Kramer. 2005. Feeding deterrent effects of catnip oil components compared with two synthetic amides against *Aedes aegypti*. J. Med. Entomol. 42(4):643–646.

Clapperton, B.K., C.T. Eason, R.J. Weston, A.D. Woolhouse, and D. Morgan. 1994. Development and testing of attractants for feral cats, *Felis-Catus* L. Wildlife Res. 21(4):389–399.

Herron, S. 2003. Catnip, *Nepeta cataria*, a morphological comparison of mutant and wild type specimens to gain an ethnobotanical perspective. Econ. Bot. 57(1):135–142.

Juliani, H.J., A. Koroch, J.E. Simon, N. Hitimana, A. Daka, L. Ranarivelo, and P. Langenhoven. 2006. Quality of geranium oils (*Pelargonium* species): Case studies in Southern and Eastern Africa. J. Essential Oil Res. 18:116–121.

Peterson, C.J. and J. Coats. 2001. Insect repellents-past, present and future. Pestic. Outlook 12:154–158.

Peterson, C.J. and J. Ems-Wilson. 2003. Catnip essential oil as a barrier to subterranean termites (*Isoptera:Rhinotermitidae*) in the laboratory. J. Econ. Entomol. 96(4):1275–1282.

Peterson, C.J., L.T. Nemetz, L.M. Jones, and J.R. Coats. 2002. Behavioral activity of catnip (*Lamiaceae*) essential oil components to the German cockroach (*Blattode : Blattellidae*). J. Econ. Entomol. 95(2):377–380.

Vieira, R.F. and J.E. Simon. 2006. Chemical characterization of basil (*Ocimum* spp.) based on aromatic volatiles. Flavor Fragr. J. 21:214–221.