‘CR9’: A New Highly Aromatic Catnip Nepeta cataria L. Cultivar Rich in Z,E-Nepetalactone

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Catnip (Nepeta cataria, Fam. Lamiaceae), an aromatic herb from southwestern Asia, is best known for causing a euphoric effect on domestic cats and other members of the feline family due to the volatile compound nepetalactone contained in the essential oil of the plant (Jamzad et al., 2003; McElvain et al., 1941; Waller et al., 1969). The aromatic volatiles of catnip are produced in the glandular trichomes on the leaf epidermis (Moon et al., 2009). Due to the morphological nature of the bilabiate bisexual flowers, this plant can self-pollinate and also has the ability to outcross (Claïnen et al., 2003). Current production methods use seeds and transplants from undomesticated populations. While normally cultivated for the pet toy industry as a safe attractant to cats and for ornamental applications, recent research has shown that essential oils from catnip are an efficient insect repellent and are at least comparable to repelling insects than the industry standard repellent DEET with far less toxicity (Bernier et al., 2005; Feaster et al., 2009, 2010, 2012). The peach-potato aphid is also repelled by nepetalactones suggesting that N. cataria could be evaluated as an organic repellent for peach orchards and potato fields (Fernandez-Grandon et al., 2013). In addition, both the American and German cockroach, which harbor disease causing organisms, were repelled by the nepetalactones present in N. cataria and showed better repellency than DEET (Peterson et al., 2002; Schultz et al., 2004, 2006). Common brown ticks and the deer tick that harbor the bacterium responsible for Lyme disease are repelled by the nepetalactones and dihydronepetalactone in N. cataria (Birkett et al., 2011; Feaster et al., 2009). Three species of subterranean termites that chew away at houses and other various wood-based structures causing significant financial loss were also repelled by the nepetalactones found in catnip oil (Chauhan and Raina, 2006; Haenke, 2003; Peterson and Ems-Wilson, 2003). The Z,E-nepetalactone isomer was also efficient in repelling many common house dust mite species and poultry mites (Birkett et al., 2011; Khan et al., 2012). In a body contact assay involving harvester ants, mortality was achieved faster with the Z,E-isomer than the other nepetalactones in catnip oil (Gkinis et al., 2003). A commercial repellent has been patented that uses the nepetalactones derived from N. cataria (Wagner, 2004). Pilot programs have been implemented to assess the ability to commercially produce the nepetalactones from N. cataria yet commercial viability of using catnip oil has been limited due to the high cost of the essential oil due to the physiochemical characteristics of the currently offered catnip plants (Birkett and Pickett, 2003; Park et al., 2007).

Catnip populations still remain largely undomesticated. Little breeding has been undertaken to improve catnip’s horticultural traits. Related to other members of the Lamiaceae family, catnip plants are susceptible to diseases and environmental stress including poor winter survival in northern temperate zones. Tolerant plants can be perennials but in commercially grown fields they are currently cultivated as annuals. Commercial fields from clonal transplants are more expensive as the labor cost is greater and the process is more difficult as the plants die off, produce less biomass and exhibit phenotypical architecture that does not lend itself to efficient mechanization. They also produce lower essential oil yields in comparison with peppermint and spearmint plants that produce copious amounts of aromatic oils that can be commercially harvested mechanically. In addition to lower essential oil yields, the plants have not been bred to increase Z,E-nepetalactone, the key bioactive constituent found in the volatile aromatic oil. These factors have made the commercialization of catnip as a source for aboveground biomass, essential oils, and the isolated compound for new insect repellent products most challenging (Park et al., 2007). These factors also make it difficult to effectively cultivate mechanically and commercialize to obtain the desired bioactive compound in the volatile oil (Park et al., 2007).

CR9 is the first cultivar of N. cataria in North America developed specifically for commercial agricultural production with a more upright growth habit and higher biomass, essential oil, and Z,E-nepetalactone yield (as a function of the relative percentage of the total essential oil yield). Essential oil from current catnip contains many aromatic volatile compounds including nepetalactone (Baser et al., 2000). This cultivar was developed and is distinct from other commercially available sources because it produces a uniform seeded offspring in the desired characteristics. The selfed progeny of ‘CR9’ produces higher amounts of biomass and essential oil yields, and the essential oil is richer in the production of the bioactive isomer Z,E-nepetalactone in these populations. The progeny of ‘CR9’ provides a superior type of catnip plant for commercial field production, for dried catnip or for the distilled aromatic essential oils that have multiple applications including the pet toy and insect repellent industries.

Origin

‘CR9’ was developed after six different randomized complete block growth trials by selecting the best field performing plants that grew the most upright, survived the winters in New Jersey and produced the highest aboveground biomass, essential oil, and Z,E-nepetalactone yields (Table 1). In 2001, the U.S. Department of Agriculture (USDA) N. cataria germplasm was comparably grown at the Rutgers Clifford E. & Melda Snyder Research Farm, in Pittstown, NJ, with a wide range of commercial catnip varieties in a seeded field trial. For two growing seasons, this population of plants had many individual plants that were off types, exhibited...
Table 1. Genealogy of the new catnip cultivar CR9 (*Nepeta cataria*).

| Year | Event |
|------|-------|
| 2001 | Original seeded field establishment for evaluation of the *N. cataria* U.S. Department of Agriculture (USDA) germplasm and commercial lines including the USDA germplasm PI no. W6 17691. Evaluation of desired morphological characteristics and the roughing out of poor performing plants was performed. |
| 2002 | Plants remaining in 2002 that successfully overwintered from 2001 and exhibited desired morphological characteristics formed the breeding lines (C244, C245, C246, C47, C248, C249, and G1) and were allowed to outcross. |
| 2005 | The outcrossed seeds from lines (C244, C245, C246, C47, C248, C249, and G1) were sown in a field trial and evaluated for desired phenotypic characteristics. Poor performing plants were rouged out. |
| 2006 | Plants remaining from the 2005 field trials and exhibiting desired phenotypic characteristics were selected forming the breeding line (CR). (CR) breeding lines were allowed to self-pollinate in a research greenhouse. |
| 2007 | The selfed (CR) lines were sown in a field trial in which individual plants were identified for desired phenotypic characteristics with emphasis on essential oils. |
| 2008 | Selections of plants (CR1, CR2, CR3, CR4, CR5, CR6, CR7, CR8, and CR9) from the CR breeding line were made after the 2007 winter with emphasis on essential oils. |
| 2010 | Clonal evaluation of advanced breeding lines (CR1, CR2, CR3, CR4, CR5, CR6, and CR9) for desired morphological characteristics and essential oils was conducted. |
| 2011 | Clonal evaluation of advanced breeding lines (CR1, CR2, CR3, CR4, CR5, CR6, and CR9) for desired morphological characteristics and essential oils was conducted. Breeding lines were allowed to self-pollinate in a research greenhouse. |
| 2013 | Final seeded evaluation of the selfed advanced breeding line ‘CR9’ and the five commercial lines for comparison. Selection of (CR9) for the new catnip cultivar *N. cataria* CR9. |

Table 2. Morphological and essential oil characteristics of the new catnip cultivar CR9 compared with commercial catnip varieties over two harvests, 2013.*

| Year       | Plant ht (cm) | Plant spread (cm) | Leaf length (cm) | Leaf width (cm) | Dry wt per plant (g) | Essential oil analysis | Z,E-nepetalactone yield per plant (g) |
|------------|---------------|-------------------|------------------|-----------------|----------------------|------------------------|---------------------------------------|
| 2013 harvest one |               |                   |                  |                 |                      |                        |                                       |
| CR9        | 65.9 A        | 92.1 BC           | 6.0 A            | 4.8 A           | 158.0 A              | Oil yield per plant (g) | 1.54 A                                |
| JON        | 56.5 B        | 98.0 AB           | 4.7 B            | 3.5 B           | 115.0 BC             | 1.05 B                  |
| RICH       | 55.4 B        | 100.9 A           | 4.8 B            | 3.6 B           | 113.3 BC             | 0.90 B                  |
| STOKES     | 53.3 BC       | 94.0 ABC          | 4.9 B            | 3.7 B           | 127.7 B              | 1.21 AB                 |
| TERR       | 55.9 B        | 101.3 A           | 4.4 BC           | 3.3 B           | 112.3 BC             | 1.16 AB                 |
| CFM        | 50.4 C        | 87.5 C            | 4.0 C            | 3.4 B           | 88.0 C               | 0.46 C                  |

*CR9 = Rutgers new cultivar release; CFM = Ferry Morse Seeds, Norton, MA; JON = Johnny’s Selected Seeds, Albion, ME; RICH = Richters Herbs, Goodwood, ON, Canada; STOKES = Stokes Seeds, Buffalo, NY; TERR = Territorial Seed Company, Cottage Grove, OR. *Values within columns followed by different letters are significantly different according to Duncan’s test at P ≤ 0.05. 

poor performance and/or winter injury removed from the study. In 2002, the remaining plants from the best performing USDA line PI no. W6 17691 were allowed to outcross by wind and bees, the seed was collected from the remaining individual plants and the new advanced breeding line was formed. In 2005, these seeds were sown in a field trial at the Rutgers Fruit and Ornamental Research Extension Center in Cream Ridge, NJ, to identify lines with the desired phenotypic characteristics and to evaluate their uniformity. Only the most promising plants were left in the field, all others were removed. In 2006 after the plants were subjected to the winter season and assessed for winter survival, selections were made on this field with respect to biomass and winter survival by taking cuttings of the individual plants and allowing them to self-pollinate in a research greenhouse. In 2007, those selfed seeds were planted in another 2-year evaluation at the Rutgers Clifford E. & Melda Snyder Research Farm, Pittstown, NJ. Selections took place on the 2nd year after the plants were subjected to the winter season; however, plant selections were largely based on total essential oil production (e.g., yield/plant) and Z,E-nepetalactone concentration. The selections from 2008 were then clonally evaluated for two additional years in 2010 and 2011 at the same research farm to ensure minimal environmental influence on the variation of essential oil yields and nepetalactone concentration. Those clones were then selfed and the seed used in the next growth trial in 2013.

Fig. 1. Single plant of catnip cultivar CR9 (*Nepeta cataria*) with insect pollinators (below the yellow arrows).
In 2013, the clones demonstrating uniform production of essential oil yields and nepetalactone concentration had their selfed progeny planted in a final seeded field evaluation that year at the New Jersey Agricultural Experiment Station Clifford E. & Melda Snyder Research Farm, Pittstown, NJ. The progeny of ‘CR9’ was field grown and compared with commercial seed companies offering catnip seeds (Johnny’s Selected Seeds, Albion, ME; Ferry Morse, Norton, MA; Stokes, Buffalo, NY; Territorial Seed Company, Cottage Grove, OR; Richters Herbs, Goodwood, ON, Canada). The land was cultivated by disc plowing, raised beds were then mechanically prepared followed by the placement of drip irrigation and plastic mulch. The land was fertilized at 900 lbs/acre of 15–15–15 and was irrigated through drip irrigation as needed and described (Park et al., 2007). The experimental design for 2013 was a randomized complete block design with 10 plants in each of the six lines having their morphological characteristics recorded for each of the three replications. The plants were spaced 61 cm apart within the rows and the rows were spaced 274 cm apart. Once the plants were in full flower, morphological characteristics were recorded, the plants were cut back to the ground level after 10 weeks and the entire plot was bulk harvested and dried on site at 37 °C. The plants in the field were allowed to grow again to maturity, when they were again bulk harvested as described above and dried on site at 37 °C. Essential oil yields were determined by the

Fig. 2. Gas chromatogram of the essential oil from catnip cultivar CR9 (Nepeta cataria) illustrating the peak of Z,E-nepetalactone.

Fig. 3. Mass spectra of Z,E-nepetalactone, the major compound found in the essential oil of catnip cultivar CR9 (Nepeta cataria).
hydro distillation of all of the aboveground biomass of the plant using a Clevenger-type distillation unit with 100 g of dry plant matter. The yields were calculated as percent of dry mass (gram essential oil/100 g aboveground biomass). Essential oil analysis was performed by quantitatively comparing the samples using a flame ionization detector and qualitatively by identifying the chemical constituents of the oil with mass spectrometry (Juliani et al., 2008).

**Description**

The progency of the CR9 cultivar of *N. cataria* have opposite triangular ovate leaves that have crenate edges. All of the leaves are light green soft leaves and a highly pleasant spice-like aroma. This new cultivar’s population lends itself more to mechanical harvesting as is required for larger-scale essential oil production and was developed for this purpose. Because of the increased essential oil the population makes, the commercialization of this catnip cultivar as an essential oil crop is more realistic than prior and current catnip lines. Producers of catnip essential oils and extracts designed for the insect repellent industry could increase their income significantly by planting this new cultivar given it was developed as an improved source of essential oil of catnip for larger growers with steam distillation facilities.

**Availability**

This new cultivar developed by the New Jersey Agricultural Experiment Station was licensed exclusively to Ball Horticultural Company, 622 Town Road, West Chicago, IL 60185 for distribution.

**Literature Cited**

Abdelkrim, A. and H. Melhorman. 2006. Repellency effect of forty-one essential oils against *Aedes, Anopholes* and *Culex* mosquitoes. Parasitol. Res. 99:478–490.

Adams, R. 2007. Identification of essential oil components by gas chromatography/mass spectrometry with alkane standards confirmed the presence of Z,E-nepetalactone (Figs. 2 and 3) (Adams, 2007).

**Performance**

‘CR9’ performed better than each of the commercial seed companies with which it was compared. ‘CR9’ has a mean dry weight per plant of 158.0 g/plant on the first harvest and 177.0 g on the second harvest for a total of 335 g/year with a 33% improvement over the plant of 158.0 g/plant on the first harvest and 0.35 g on the second harvest for a total of 1.7 g/year with a 77% improvement over the closest commercial line. On the first harvest 1.34 g/plant on the second harvest for a total of 2.92 g/year with a 54% improvement over the closest commercial line. Z,E-nepetalactone yield was 1.34 g/plant on the first harvest and 0.35 g on the second harvest for a total of 1.7 g/year with a 77% improvement over the closest commercial line. On the first harvest the concentration of Z,E-nepetalactone was 87% and 25% on the second harvest. All catnip lines evaluated had their concentration of Z,E-nepetalactone decrease to lower levels on the second harvest. This new cultivar survived winter conditions and exhibited the least winter injury and dieback compared with the commercial catnips that were evaluated. As a garden herb, ‘CR9’s progeny can live for many additional years on the landscape and could be considered aesthetically attractive with light green soft leaves and a highly pleasant spice-like aroma. This new cultivar’s population lends itself more to mechanical harvesting as is required for larger-scale essential oil production and was developed for this purpose. Because of the increased essential oil the population makes, the commercialization of this catnip cultivar as an essential oil crop is more realistic than prior and current catnip lines. Producers of catnip essential oils and extracts designed for the insect repellent industry could increase their income significantly by planting this new cultivar given it was developed as an improved source of essential oil of catnip for larger growers with steam distillation facilities.

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