Geraniol-rich essential oil from *Monarda Fistulosa* L.

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The genus *Monarda*, named after a Spanish physician, Nicholas de Monardes, is widely distributed throughout North America, most of which is *Monarda fistulosa* L. var. *menthifolia* (Graham) Fern (Scora 1967). Marshall and Scora (1972) reported on new hybrids of *Monarda fistulosa* developed by Marshall, which yielded up to 1.0% oil on a fresh weight basis, and contained up to 90% geraniol, previously unreported in *Monarda*.

Monarda hybrids from Marshall's breeding program come in a wide range of colours, including white, pink, scarlet, and purple. His first interest in the Monarda group was as a perennial flower. However, several triploid hybrids from Marshall's crosses produce high amounts of geraniol. One such hybrid, Morden No. 3, has particularly high levels of geraniol, somewhat in excess of 90%. This hybrid is a perennial, somewhat drought tolerant and winter hardy under the severe winter conditions in Manitoba. The plants grow 60 to 80 cm in height, depending on the soil moisture availability.

Quality Parameters

Oil samples were obtained by steam distillation of either the whole plant or individual plant parts. In 1975 and 1976, steam distillation was carried out in a 25-liter stainless steel still, using a boiler operating pressure of 5.6 kg/cm^2. Distillation was carried out for approximately 2.5 hrs, after which time only negligible amounts of oil were left in the plant tissue. Since 1977 all steam distillation has been carried out using pilot scale equipment, approximately 0.1 of commercial size, with a capacity of 385 kg fresh weight of mechanically chopped plant material.

Laboratory Method

The amount of geraniol present in the oil samples was determined by gas-liquid chromatography. While minor constituents were present they were not identified in this study. Separation was achieved using a Hewlett-Packard 5754 gas chromatograph with a flame ionization detector fitted with a 0.48 (O.d) x 300 cm stainless steel column containing 4% carbowax 20M and 1% diethyl glycol adipate (Chubey and Dorrell 1976). The FI detector was maintained at 235°C while the oven was programmed to hold at 150°C for 3 min, then increased by 8°/min to 200°C and held at 200°C for an additional 8 min.

Oil Yield and Quality

The quality of oil steam distilled from fresh plant material varies with the vigour and condition of the plants. In 1975 and 1976 the small scale laboratory equipment extracted low yields of .60 and .55%, respectively. Since 1977, more efficient pilot equipment has improved yields, ranging from .65 to .80%.

In all years, the plants were grown under dryland conditions, which were less than optimum in 1977-79. In 1980, with better soil moisture, the plants were more vigorous and, therefore, produced more oil. The yields of oil have ranged from 85 to 110 kg/ha, but through the use of irrigation and optimum fertilization substantial increases in oil yield should be possible.

In 1975, a study was conducted to determine the optimum time of harvest. Plants were harvested at six different physiological stages,

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ranging from the first initiation of flower buds up to the stage where partial defoliation began, a period of six weeks. The oil yield and geraniol content of each of the plant stages is shown in Table I.

The oil yield began increasing with the onset of flowering, and remained relatively high until the petals began drying off. Although the oil yield varied with the age of the plant, the geraniol content remained generally constant from the tight bud to the post flower stage but decreased considerably with the onset of defoliation.

Table I. Yield and geraniol content of oil extracted from plants at different stages of growth

Date of Harvest	Plant Stage	Oil Yield (% F.W.)	Geraniol %
July 2	Tight bud	.50	92.0
July 9	Loose bud	.55	91.2
July 16	Full flower	.69	91.5
July 23	Advanced flower	.62	92.3
July 30	Post flower	.52	91.7
August 6	Partial defoliation	.34	89.0

Table II. Geraniol content of oil from different time fractions during steam distillation

Fraction (Minutes)	Geraniol Content (%)
0 - 15	79.0
15 - 30	96.7
30 - 45	98.8
45 - 60	98.8
60 - 90	98.5
90 - 120	97.1
120 - 150	95.5
150 - 180	94.0

It has been determined that the heads and leaves yield the highest amounts of oil, while the petals and stems yield oil with the highest geraniol content. The stems, however, yield only .001% oil, and although they represent approximately 30% of the total green weight they contribute a negligible amount of the total oil yield. The leaves and the flower heads are the main oil sites, but their geraniol content is lower than that of the petals and stems. Since the oil from petals has a high geraniol content, it becomes evident that the optimum harvest time is when the plants reach full flower stage.

The geraniol content of the oil as influenced by duration of hydrodistillation is shown in Table II. The oil collected during the first 15 min of distillation had a geraniol content of 79%, whereas the fractions collected between 15 min

and 2 hrs had over 97% under the conditions of this study. The data indicate that by withholding the oil extracted in the first 15 min of distillation the oil from the remainder of the distillation would have a significantly higher geraniol content.

The geraniol content over a period of six years varied from a low of 90.8% in 1978 to a high of 93.3% in 1977. These data indicate that the geraniol content is relatively stable from year to year, and remained well above 90% in five years out of six.

Agronomic Factors

Propagation

Since the Morden No. 3 hybrid is a triploid it does not bear seed and must be propagated annually. Asexual propagation is easily achieved through crown divisions, but this method is cumbersome and inefficient. To enable a more rapid increase of new plants, propagation methods used in mint culture were investigated. These methods proved unsuccessful.

The most effective and rapid method of propagation has been found to be through plant cuttings of actively growing stems. Stem cuttings, approximately 10-12 cm in length, were taken and all but two leaves were removed, including the shoot tip. The bases of the cuttings were dipped in 1000 ppm IBA rooting compound and placed in sand in a misting chamber. Cuttings taken in early July when the plants were actively growing produced root initials within one week and were ready for transplanting within 14-16 days. As the mother plants advanced in growth the rooting percentage decreased rapidly. The decrease in rooting ability coincides with maturation of the plant, and the cuttings become very difficult to root if taken from plants approaching the flower bud stage. The rooted cuttings were mechanically transplanted into the field.

At present, research is underway to attempt to produce high-yielding tetraploid geraniol lines from seed.

Weed Control

Weeds do not pose a problem in the production of Monarda. Herbicides such as Trifluralin, Terbacil, Solan, and Paraquat used together with good cultural practices can maintain a weed-free plantation. Trifluralin at 1.12 kg/ha should be used preplant, with thorough incorporation prior to transplanting followed by Solan at 4.5 kg/ha after the Monarda is established and before the weeds exceed 5-6 cm in height, approximately 6-8 weeks after transplanting. In the second year and every year thereafter, Paraquat can be applied before the Monarda shoots reach a height of 5 cm, to kill the early spring weeds. This also kills off the Monarda shoots. This is immediately followed by Terbacil at 1.68 kg/ha and approximately 1-2 cm of irrigation to soak the chemical into the soil.

Disease Control

In 1977 a severe rust infestation was found in a two-year-old planting. The rust was identified to be *Puccinia menthae* Pers., which attacks the mint family. The rust caused defoliation, girdling of stems, and degeneration of plants. The disease is spread by aerial rust spores under cool, cloudy, moist weather conditions. Relatively good control has been achieved by applying a contact herbicide, Paraquat, in early spring when the Monarda shoots are only about 5 cm tall to destroy all vegetation and thereby remove the required host for the spores.

Insect Control

Insects have not posed any serious problems with Monarda. In 1979, however, for the first time a number of stem tips were severed by an insect identified to be the strawberry weevil *(Brachyrhinus ovatus).* The insect was readily controlled by applying carbofuran at 0.5 kg/ha and no further infestations have been observed.

Conclusion

At present, adequate information has been developed on the agronomic and oil extraction procedures to enable the initiation of commercial geraniol production using the Morden No. 3 Monarda hybrid. This hybrid grows well under the dryland culture in central Canada. It is winter hardy and of a perennial nature; the oldest plantation is six years old and is still in good production.

Acknowledgement

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References

B. B. Chubey and D. G. Dorrell, Changes in the chemical composition of dill oil during hydrodistillation, Can. J. Plant Sci. **56**, 619-622, 1976.

H. H. Marshall and R. W. Scora, A new chemical race of Monarda fistulosa (Labistae). Can. J. Bot. **50**, 1845-1849, 1972.

R. W. Scora, Interspecific relationships in the genus Monarda (Labistae). Univ. Calif. Publ. Bot. **41**, 1967.