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Full Length Research Paper

A comparative study on essential oil yield and composition of rose-scented geranium (P. c. v. Rose) commercially grown on three different sites of the Amathole region in the Eastern Cape, South Africa

Lwandiso Dyubeni, B. Mayekiso* and M. L Magwa

Botany Department, University of Fort Hare, Private Bag X1314, Alice, Eastern Cape, South Africa

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Rose-scented geranium, the cultivar Rose, is a cross between *Pelargonium capitatum* and *Pelargonium radens.* They are all belonging to the Geraniaceae family. The essential oil from this plant is commercially viable. The Rose-scented geranium was planted in three sites within the Amathole region of the Eastern Cape. These sites were Auckland, Lushington and Cathcartvale. The essential oil from this plant was obtained by steam distillation in all the sites on seasonal basis. A high amount of essential oil was obtained during the autumn season for Auckland and Lushington sites and in spring for the Cathcartvale site. The gas chromatography mass-spectroscopy (GC-MS) reveals that the chemical composition differed with harvesting time. The main characteristic volatile constituents of essential oil, citronellol, geraniol, linalool, cyclohexanone, trans-rose-oxide and β-caryophyllene was found in the seasons.

Key words: Rose-scented geranium, essential oil, composition, Eastern Cape, South Africa.

INTRODUCTION

The use of plants for commercial purposes has increased in an alarming rate over the past years. This increase can be associated with the utilization of plant products by most industries throughout the world. Most of these companies have changed their focus on producing synthetically materials, but rely mostly on natural products (Burt, 2004; Lima et al., 2004). Such products are used for preparation of different commodities such as antiseptics, spices, fragrance for commercial purposes (Nguefack et al., 2004; Auge et al., 2003; Tan et al., 2002). Consequently, most medicinal, essential oil, flower and fragrance producing plants are subjected to extensive research for their products. These plants are classified under different families such as Compositae, species which are regarded as herbs, essential oil producing species and other species have high medicinal Solanaceae, Geraniaceae, Cannabiaceae and Lamiaceae etc. The Lamiaceae family for example, contains value. Some of these species have been recommended because of their strong affinity for digestive and metabolic processes as well as, respiration and blood formation (Sur et al., 1991; Sivropoulou et al., 1997; Dorman and Deans, 2000; Seaman, 2005; Kamatou et al., 2008; Dyubeni and Buwa, 2012). In literature, the *Thymus vulgaris L*, *Ocimum sanctum, Salvia serotina, Acinos arvensis, Rosmarinus officinalis* are few examples of species belonging to these families that have often been used to treat ailments associated with the weakness of vital centers such as diabetes, digestive problems, respiratory problems, and anaemia (Sivropoulou et al., 1997; Chalchat et al., 1998; Auge et al., 2003; Kamatou et al., 2008).

The Geraniaceae family is among the largest family of flowering plants whose species are well-known for medicinal and fragrant properties. Its name originates from its genus Geranium which includes cranesbills and garden plants (Miller, 2002). Through the advancement of classification system these genera were changed and

*Corresponding author. E-mail: bmayekiso@ufh.ac.za, bmayekiso@yahoo.com. Tel: +27 406022324. Fax: +27 8066 282 325.

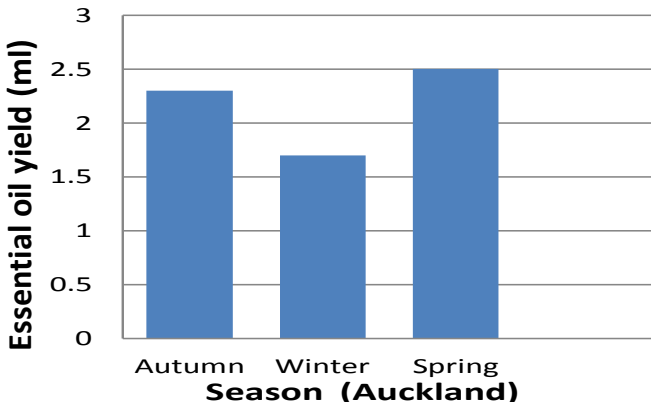

Figure 1. A graph showing Auckland site with a difference in the essential oil quantity in relation to seasonal change.

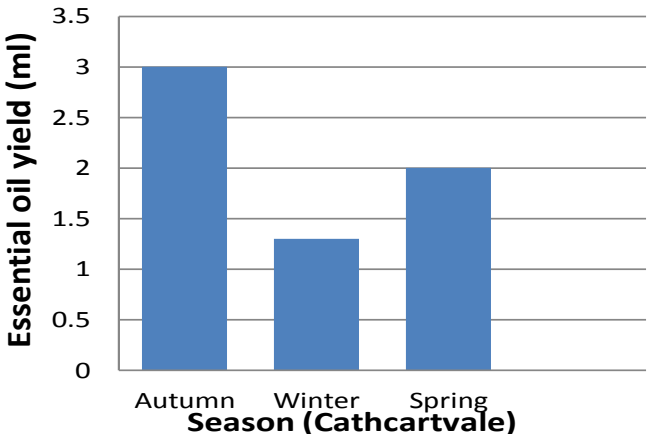

Figure 2. A graph showing Cathcarvale site with a difference in the essential oil quantity in relation to seasonal change.

named *Pelargonium* which includes other related genera (Wikipedia Foundation, 2009).

Pelargonium species are believed to originate from the Southern tip of Africa and were introduced to other countries like Britain and Holland through spice trade and medicinal plant collection by sailors (Miller, 2002). It is believed that the first species of *Pelargonium* (*P. cucullatum*) was collected and identified in South Africa in Cape Town (Table Mountain) in 1672 (Wikipedia Foundation, 2009). Currently, there are about 250 species of *Pelargonium* that were collected and identified (Mcdonald and Powrie, 1992; Martin et al., 1987). Most of these species were studied and a dozen of them were regarded as scented geraniums. Some were found to be producing essential oil which is highly valuable and commercially viable (Swamy et al., 1960; Weiss, 1997; Miller, 2002; Peterson et al., 2005; Bhan et al., 2005). These species are *P. capitatum, P. graveolense, P. odoratissium* and *P.radens*. The prolific essential oil producer is the cultivarRose, a cross between *P. capitatum* and *P. radens* which produces the so-called Bourbon oil (Lupuwana, 2008). The essential oil of this cultivar possesses a tenacious rose-like odour with various nuances, such as citrus and minty undertones (Swamy et al., 1960; Weiss, 1997; Miller, 2002; Peterson et al., 2005). The commercial viability of rose-scented geranium resulted in the establishment of essential oil producing companies in Southern region of South Africa (Bhan et al., 2005).

In South Africa, the following provinces are involved in the essential oil production, Mpumalanga, KwaZulu-Natal, Western Cape, Eastern Cape and Limpopo provinces; usually this occurs under rain-fed farming (Sanda, 2006). In the Eastern Cape, the Essential Amathole (Pty) Ltd is a start-up Essential Oils Company based in the Amathole region and was established on the basis of an innovative- private partnership model. The Amathole region is geographically and climatologically diverse, with rainfall ranging from 500 mm per annum in the drier valleys to over 1 000 mm per annum on the escarpment (Van Averbeke, 1995; Low and Rebelo, 1996).

Three sites were chosen to cultivate this type of a species and this was done on the basis of their diverse agricultural conditions and micro-climate prevailing. These sites are located on the following villages, Cathcartvale, Auckland and Lushington (Figures 1 to 3). The Auckland and Cathcartvale village sites are on the river banks while Lushington village had the advantage of a high rainfall pattern thus making it potentially suitable for dry-land cultivation.

In spite of the use of rose-scented geranium essential oil for commercial purposes in other provinces of South Africa, the right time, age and frequency of harvesting rose-scented geranium for essential oil purpose for the chosen sites in the Eastern Cape are still unknown. This means that there is no documentation or study of the adaptability of rose-scented geranium in the diverse geographical and climatic conditions of the Amathole region in the Eastern Cape. The stage at which the plant can produce the greatest amount of essential oil is also unclear. This case-study is designed to address the following objectives:

1. To provide a sound knowledge on the response of rose-scented geranium essential oil to seasonal changes in three different site chosen by Essential Amathole (Pty) Ltd of the Eastern Cape.
2. To suggest a suitable area for a plantation of rose-scented geranium to produce a high essential oil yield for commercial purposes.

MATERIALS AND METHODS

Plant material

Rose-scented geranium (P. cv. Rose) plants were collected at three

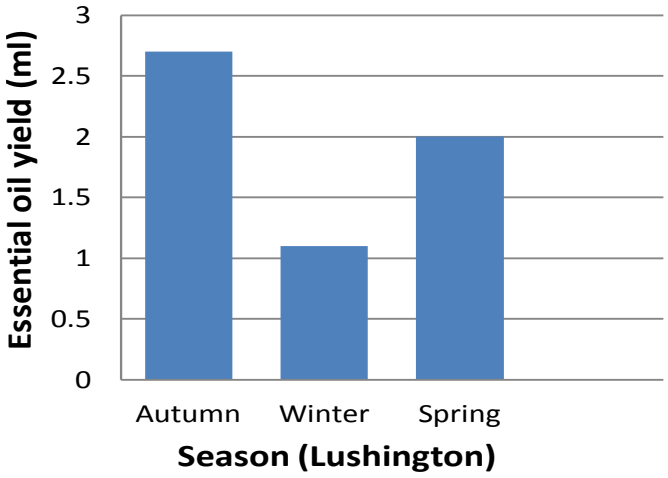

Figure 3. A graph showing Lushington site with a difference in the essential oil quantity in relation to seasonal change.

different sites that is, Auckland village (32° 37′ 14′′ to 32° 37′ 24′′ S and 26° 55′ 30′′ to 26° 55′ 40′′ E), Lushington village (32° 37′ 45′′ to 32° 38′ 00′′ S and 26° 49′ 30′′ to 26° 49′ 50′′ E) and Cathcartvale (32° 32′ 13′′ to 32° 32′ 27′′ S and 26° 47′ 11′′ to 26° 47′39′′ E) for three different seasons of the year (autumn, winter and spring) in the Amathole region of the Eastern Cape Province in South Africa. The plants were collected and pressed at Fort Hare Herbarium. They were identified by the curator of the Schonland Herbarium at Rhodes University, Graham's town. A voucher specimen was deposited at the Griffen Herbarium, University of Fort Hare, Eastern Cape.

Extraction of the essential oil

The weighed mass (1 kg) of the sample was subjected to hydro-distillation for 3 h using a Clevenger unit according to the British Pharmacopeia. This process was repeated thrice using the constant mass of 1 kg in order to obtain statistical accepted results. The fresh essential oil sample was collected and allowed to cool and was analyzed in the GC/MS.

Gas chromatography mass spectroscopy (GC-MS) analysis

The essential oil was analyzed on a Hewlett Packard HP 5973 Mass Spectrometer interfaced with an HP – 6890 Gas Chromatograph. The column consisted of a cross-linked 5% pH ME Siloxane on 30 m × 0.25 mm × 0.25 mm film thick and the column head pressure was 55 Kpa. The carrier gas used was Helium and the flow was 55 cm/s split flow 30 to 40:1. The temperature was programmed at an initial temperature of 50°C and accelerated to a temperature of 240°C at an acceleration of 3°C/min. Identification of chemical compounds was achieved by mass spectroscopy.

RESULTS

Essential oil yield from Auckland, Cathcartvale and Lushington

The essential oil extracted from fresh leaves (1 kg) of rose-scented geranium from Auckland, Cathcartvale and Lushington varied in quality, colour, and composition. The results were as follows: The volume of the essential oil obtained from Auckland site during autumn was 2.1 ml/kg. The characteristic colour of the oil was green. In winter season, a volume of 1.1 ml/ kg was obtained from the very same site and the colour had change (light green). A volume of 2 ml/kg essential oil was obtained in spring and the colour remained the same even in this season (Table 1). A 1 kg of plant material from Cathcartvale yielded 2.3 ml of the essential oil during the autumn season. The characteristic colour of the oil was light green. In winter, a volume of 1.7 ml per 1 kg was obtained and there was no change in colour. In spring, 1 kg of the sample yielded a volume of 2.5 ml of the essential oil and a slight change in the same characteristic colour from light green to green was observed (Table 1). In Lushington, a hydro-distillation of 1 kg of the plant material yielded a 3 ml of the essential oil with a light green colour for the autumn season. In winter, a volume of 2.5 ml/kg was obtained and the colour remained the same. In spring, a volume of 2 ml of the essential oil per 1 kg was obtained and the colour remained light green (Table 1).

Characteristics of the essential oil extracted from *R. geranium* (P. cv. Rose) leaves

The essential oil extracted from Auckland, Cathcartvale and Lushington by hydro-distillation during autumn, winter and spring was analysed using the GC-MS. The analysis of the essential oil from Auckland village during autumn showed the following dominant compounds citronellol (30.16%), geraniol (15.07%), cyclohexanone (4.93%) and Guaiadiene (3.26%) respectively (Table 2). In winter, the essential oil was characterized by the following dominant compounds, Geraniol (20.32%), Cyclohexanone (8.59%), Linalool (5.81%), Guaiadiene (3.90), Citronellyl formate (1.88%), Nerol (1.88%) (Table 3). In spring, the essential oil contained the following dominant compounds, Citronellol (37.74%), Geraniol (13.47%), Linalool (10.58%), and Cyclohexonone (5.07%). major compounds identified in essential oil from Auckland are presented in Table 4. In Cathcartvale, the composition of the essential oil during autumn was dominated by Citronellol (31.40%), Geraniol (19.75%), Linalool (14.05%), Cyclohexa-none (4.48), Guaiadiene (3.17%), myrcene (1.19%) (Table 2). The winter essential oil was dominant by the following compound Citronellol (45.70%), Geraniol (8.26%), Linalool (6.45%), Cyclohexanone (5.07%), Guaiadiene (2.53%) and Trans rose oxide (2.17%) (Table 3).

However, during spring, the dominant compounds were Citronellyl formate (18.11%), Geraniol (15.77%), Benzene (10.82%), Monsanto (10.82%), Linalool (9.84%), Cyclohex)anone (4.47%), 2, 6-Octadien-1-ol, 3, 7-dimethyl (4.02%) and Guaiadiene (3.25%) (Table 4).

The Lushington essential oil was dominated by

Table 1. The essential oil extracted from three sites showing their quantities and colour.

Sites	Season	Mass (kg)	Volume (ml)	Colour
Auckland	Autumn	1	2.70	Green
	Winter	1	1.10	Light green
	Spring	1	2.00	Light green
Carthcatvale	Autumn	1	2.30	Light green
	Winter	1	1.70	Light green
	Spring	1	2.50	Green
Lushington	Autumn	1	3.00	Light green
	Winter	1	2.50	Light Green
	Spring	1	2.00	Light green

Table 2. Major compounds identified in the essential oil of *R. geranium* in all sites (autumn).

Compound	Composition (%) autumn		
	Auckland sites	Lushington sites	Cathcartvale sites
Myrcene	0.87	1.24	1.19
Linalool	0.71	11.71	14.05
Trans rose oxide	0.94	0.86	0.98
Cylohexa-none	4.93	5.24	4.48
Linalylpropionate	1.10	0.92	-
Citronellol	30.16	30.09	31.40
Geraniol	15.07	20.99	19.75
α-Citral	0.38	-	-
β-Bourbonene	0.53	0.81	0.60
β -Caryophyllene	0.92	0.95	0.78
Guaiadiene	3.26	4.04	3.17
Germacrene-D	0.73	0.87	0.51

Table 3. Major compounds identified in the essential oil of *R. geranium* in all sites (winter).

Compound	Composition (%) (Winter)		
	Auckland sites	Lushington sites	Cathcartvale sites
α -Pinene	-	0.81	-
β-Pinene	-	0.64	-
α-Phellandrene	-	0.13	-
Limonene	-	0.39	-
Linalool	5.81	0.26	6.45
Trans rose oxide	-	6.87	2.17
Cyclohexanone	8.59	6.29	5.07
Citronellol	-	2.35	45.70
Citronellyl formate	1.88	1.82	-
Geraniol	20.32	0.14	8.26
α-Copaene	-	0.56	
β-Bourbonene	-	1.08	1.50
β-Caryophyllene	-	1.32	-
β-Cubebene	-	0.11	1.23
Guaiadiene	2.53	2.02	3.90

Table 3. Contd.

α-Humulene	-	0.26	-
Geranyl	-	1.79	-
Germacrene	1.21	1.37	-
Isoledene	-	0.39	-
Octadiene	-	1.31	-
Naphthalene	-	0.16	-
Butanoic acid	-	1.19	-
α-Terpineol	1.03	-	-
2,6 – Octadien-1-ol, 3,7-dimethyl	2.36	-	-
Nerol	1.88	-	
Citral	-	-	1.47

Table 4. Major compounds identified in the essential oil of *R. geranium* in all sites (spring).

Compound	Composition (%) (Spring)		
	Auckland sites	Lushington sites	Cathcartvale sites
Linalool	10.58	16.00	9.84
Trans rose oxide	-	1.23	-
Cylohexa-none	5.07	7.74	4.47
Citronellyl formate	-	-	18.11
Trans- Caryophyllene	-	11.03	-
Citronellol	37.74	-	-
Geraniol	13.47	1.11	15.77
Benzene	-	-	10.82
Monsanto	1.88	-	10.82
Isoledene	-	4.90	-
Guaiadiene	3.90	-	3.25
2.6-Octadien-1ol, 3,7 dimethyl	2.36	-	4.02

Citronellol (30.09%), Geraniol (20.99%), Linalool (11.71%), Cyclohexanone (5.24%), Guaiadiene (4.04%), myrcene (1.24%) during the autumn harvest (Table 2), while the winter essential oil was composited of Cyclohexanone (6.29%), Trans rose oxide (6.87%), Citronellol (2.35%), Guaiadiene (2.02%), Citronellyl formate (1.82%), Geranyl, Germacrene (1.82%), geranyl (1.79%), germacrene (1.37%) β-caryophyllene (1.32%), Butanoic acid (1.19%), β-bourbonene (1.08%) as dominant compounds (Table 3). The spring essential oil was characterized by Linalool (16.00%), Trans-Caryophyllene (11.03%), Cyclohexanone (7.74%), Isoledene (4.90%), Trans rose oxide (1.23%), and Geraniol (1.11%) as dominant constituent of the oil (Table 4).

DISCUSSION

The essential oil of rose-scented geranium was characterized by a light green colour and had a tenacious rose-like odour with various nuances, such as citrus and minty undertones. This kind of an odour had been reported in literature by many authors (Sway et al., 1960; Weiss, 1997; Miller, 2002; Peterson et al., 2005).

Essential oil of rose-scented geranium leaves from all the three sites during autumn revealed that the dominant compounds according to their percentage composition were: citronellol, geraniol, and linalool. In winter, the dominant compounds were found to be citronellol, cyclohexanone, 6-Octen-1-ol, 3, 7-dimethyl.

In spring, citronellol was found to contain the highest dominance followed by citronellyl formate and geraniol in all the three sites. However, it should be noted that benzene although, in small concentrations was also detected in the oil from Cathcartvale during spring.

The presence of benzene (Monsanto) can be associated with the application of pesticides into the crop that were cultivated before rose-scented geranium in that area and have persisted in the soil for long periods of time or it can be attributed to the fact that it is contained in cyclohexanone which is produced by reacting benzene and hydrogen.

Many of the compounds from the rose-geranium

essential oil except for benzene are widely used in the fragrance or perfume industry, for example, the monoterpenoids (1) myrcene, (2) Geraniol, (3) linalool (in addition to its use as a scent in domestic products such as soap, detergent, shampoo, and lotion, linalool is also used as a chemical intermediate. Linalool is also used by pest professionals as a flea and cockroach insecticide.

Cyclohexanone is used as a non-polar solvent for the chemical industry, and also as a raw material for the industrial production of adipic acid and caprolactam, both of which are intermediates used in the production of nylon (Wikipedia Foundation, 2009).

The compound β caryophyllene was found in the essential oil of the rose-scented geranium leaves from Lushington during the winter season. β Caryophyllene is a common sesquiterpene that is widely distributed in plants (Knudsen et al., 1993; Kubo et al., 1996). Herbs which contain this compound have been consistently used in the pharmaceutical industries as they possess anti-inflammatory and anti-carcinogenic activities (Zheng et al., 1992; Kubo et al., 1996; Tambe et al., 1996).

Geraniol is reported to have low concentrations when the plant material is old (Rajeswara et al., 1993) and this was evident in this study because this compound was relatively low and the plant was about 15 months old when its oil was analysed.

The concentration of citronellol was not very high in the autumn season but it is high in spring as compared to guaiadiene during the respective seasons. The citronellol behaviour followed the same pattern as reported by Doimo et al. (1999) that citronellol concentrations were minimal in autumn. Findings by Rajeswara et al. (1996) indicated that citronellol concentrations increased in summer as a mechanism to adjust to thermal stress. The increase or decrease might be caused by changes in climatic conditions at different seasons (Doimo et al., 1999).

Conclusion

The following recommendations can be made to the Amatole Essential Oils Company of the Eastern Cape South Africa:

1. The monoterpene citronellol appeared to be the dominant compound in the essential oil of rose-scented geranium from all the three sites in all the three seasons. Citronellol is used in perfumes and insect repellents, and as a mite attractant. From the results obtained, harvesting the rose-scented geranium would be an ideal during the autumn season in the sites of Auckland and Lushington. This is because more oil was produced during this season than in any other season. 2. In Cathcartvale it would be an ideal if the plant would be harvested in spring as there was more oil produced during this season.
3. However, this may depend on what the producers want they can manipulate the harvesting time to suit their desired oil composition considering the differences in oil composition collected at different seasons of the year.
4. Similarity of the morphological structures in both the leaves and stems indicated that the morphology had little or no influence in the essential oil yield and oil composition.

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