COMPARATIVE STUDY ON SOME SPECIES OF THE GENUS CYMBOPOGON GROWN IN EGYPT

HARRIDY, I.M.A., S. GABR AND M.N. SHALAN


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Abstract

This work was conducted in two successive seasons 1998 & 1999 in the Experimental Farm of the Medicinal and Aromatic Plants in El-Kanater El-Khayria Egypt. The aim of the present work is to study the growth pattern, herbage yield, oil production and composition as well as oil properties of three cultivars belong to two species of the genus Cymbopogon which were C. citratus (El-Kanater type), C. citratus (El-Farafa type) and C. nardus.

Results were recorded for growth characters i.e. plant height, tillers no., fresh and dry weights (gm/plant). It was found that, there were some differences in growth characters between the three cultivars. C. citratus (El-Kanater type) recorded the highest values with respect to plant height, tillers no. fresh and dry weights (gm/plant). Also, it was observed that, absolute growth rate was found to be in harmony with growth behaviour of each cultivar.

With regard to essential oil, results pointed out that, C. nardus was highest in oil percentage, however the highest oil yield (ml/plant) was obtained from the C. citratus (El-Kanater type).

As for oil properties it was found that, values of physicochemical properties of the three oils met those of standards.

Regarding oil composition it could be concluded that, the oil of the El-Kanater lemongrass contained citral (the main component) and geranial (the second main component) higher than those in the oil of El-Farafa lemongrass.

Citronella oil contained values of geraniol, citronellol and citronellal agreed with the values of standards.

INTRODUCTION

The genus Cymbopogon, includes 50-60 species of tropical, perennial, course-growing tufted grasses, many having highly aromatic foliage (Weiss, 1997).

Among them, Cymbopogon citratus (DC.) Stapf. (West Indian lemongrass) syn. Andropogon nardus var. cenererus Hack; A. citratus DC. Weiss (1997), is a tufted perennial grass with numerous stiff stems arising from a short rhizomatous rootstock and it
seldom flowers in cultivation. The plant tillers strongly and leaf blade narrow, linear, glaucous and drooping Guenther (1961). The number of stems (tillers) significantly affects the amount of leaves produced and any increase in total herbage produced by C. citratus is related to extent of tillering Weiss (1997).

Quantitative comparisons between the growth of living systems can be made from two point of view. One can measure and compare their absolute growth rate i.e. the total growth of each per unit time or one can compare their relative growth rates (Street & Opik, 1984).

Misra and Srivastava (1991) working on lemongrass, mentioned that, increase in shoot biomass, photosynthesis and chlorophyll were significantly correlated with essential oil content.

West Indian lemongrass oil usually a rather viscous liquid, yellow to dark yellow or dark amber becoming more red with age (Weiss, 1997).

Standard characteristics of lemongrass oil are presented in Table (1)

Table 1. Standard characteristics of lemongrass oil.

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Solubility</td>
<td>...</td>
<td>...</td>
<td>Candy up to 10 vol of 60%</td>
<td>1.3 vol of 90%</td>
<td>0.2 vol of 80%</td>
<td>Inoil in 70%</td>
<td>...</td>
</tr>
</tbody>
</table>

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<thead>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp. gravity at 15 °C</td>
<td>0.9206</td>
<td>0.8876-0.9215</td>
<td>0.8890</td>
<td>0.9290</td>
<td>0.9010</td>
<td>0.8534</td>
<td>0.8005</td>
</tr>
<tr>
<td>Ref. index at 20 °C</td>
<td>1.448</td>
<td>1.4892-1.4992</td>
<td>1.4895</td>
<td>1.4875</td>
<td>1.4854</td>
<td>1.4883</td>
<td>1.4818</td>
</tr>
<tr>
<td>Optical Rotation</td>
<td>-0.15</td>
<td>-2.20 to+12.75</td>
<td>-0.13</td>
<td>-0.74</td>
<td>-0.19</td>
<td>-0.11</td>
<td>-0.78</td>
</tr>
<tr>
<td>Acid No.</td>
<td>11.04-14.4</td>
<td>...</td>
<td>...</td>
<td>...</td>
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<td>...</td>
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<tr>
<td>Ester No.</td>
<td>19.1-39.6</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Ester No. after Aesyl</td>
<td>176.1-244.3</td>
<td>241.5</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Chemical composition of C. citratus (DC.) Stapf was studied by many scientists. The quality of the oil is determined by its content of aldehyde (chilly citral). The largest constituent next to citral in the west Indian type of lemongrass is mercene (12-20%) (Guenther, 1961). El-Zahawy et al. (1992) found that, citral (49.04%) was the
main component of lemongrass oil and geraniol was amounted by (34.98%). GLC analysis proved also D-limonene, linalool acetate, citronellol and geranyl acetate. In the same way, Gabr (1994) emphasized that, lemongrass oil contains the following components, α-pinene (1.3%), 1-8 cineole (1.235 %), limonene (4.764%), citral (33.759 % the main component), linalool (2.089 %), linalool acetate (3.829 %), geranyl acetate (1.62%), geraniol (24.082 %), anlicic (2.898 %), menthone (0.979%) and thymol (4.852%). Salem, Soad (1995) pointed out that, 10 peaks were indentified from 16 constituents (peaks) in lemongrass oil, the identified components were citral (47.4%), geraniol (34.5%), linalool (1.43 %), α-pinene (2.71%) and limonene (0.83%) as well as menthone, linalool acetate, geranyl acetylacte, anlicic and thymol.

Torres and Ragadio (1996), mentioned that, citral 69.39% was the main component of philippine lemongrass oil and the following components were also found, geraniol, myrcene, α and β-pinene, ethyl laurate, 1-8 cineole, limonene, phellandrene, methyl heptanone, citronellol, linalool, caryophyllene, menthol, terpineol and citronellol.

Whole oils are mainly used as a source of citral. Citral has numerous uses and can be further processed to isolate the ionone group which possess a violet-like fragrance important in perfumery, and vitamins especially vitamin A (Weiss, 1997).

Another important species of the genus Cymbopogon is C. nardus, L. Randle Syn. Andropogon nardus ceylon, de Jong. It is a tufted, perennial grass with long narrow leaves and numerous stems arising from short rhizomatous roots (Weiss, 1997).

Many authors pointed out that, plants of the Cymbopogon species were differed in growth and oil production, Behura et al. (1991) in a comparative study included some species of Cymbopogon, found that plants of C. nardus were the shortest ones (76.69 cm). There was a marked difference between species in the production of tillers. Also, citronella plants gave the lowest yield, however it had the highest oil content (3.36%).

The oil content of C. nardus, L. Randle in Sri lanka average 0.5%. Leaf oil content varies with age time of cutting and soil fertility (Weiss, 1997).

Standard characteristics of ceylon type of citronella according to the British Standard Specification (BSS) and Essential Oil Association of USA (EOA), were shown in Table (2).
Table 2. Standard characteristics of citronella oil (Ceylon type)*.

<table>
<thead>
<tr>
<th>Characters</th>
<th>BSS</th>
<th>EOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solubility in alcohol</td>
<td>1.2 vol.</td>
<td>1.1 - 2.0 vol.</td>
</tr>
<tr>
<td>Sp. gravity at 20 °C</td>
<td>0.890 - 0.898</td>
<td>0.890 - 0.910</td>
</tr>
<tr>
<td>Ref. Index at 20 °C</td>
<td>1.4790 - 1.4850</td>
<td>1.4790 - 1.4850</td>
</tr>
<tr>
<td>Optical rotation</td>
<td>-0.18 ° - 9 °</td>
<td>-0.18 ° - 9 °</td>
</tr>
</tbody>
</table>

* After Weiss (1997).

The oil content of the leaves of citronella differs significantly and young leaves synthesize and accumulate most essential oil. During leaf expansion, citronellal, geraniol and citronellol content increase, but decrease with maturity (Luthra et al., 1991).

Chemical composition of C. nardus (ceylon type) essential oil was studied by Weijseker et al. (1973) and found the following components, tricycleten (1.6%), α-pinene (2.6%), camphene (8.0%) α-phellandrene (0.8%), limonene (9.7%), cis-cicocene (1.4%), trans ocimene (1.8%), citronellal (5.2%), comphor (0.5%), borneol (1.0%), linalool (1.2%), linaloyl acetate (0.8%), ß-caryophellene (3.2%), terpineol (0.7%), citronellyl acetate (1.9%), borneol (6.6%), geranyl formate (4.2%), citronelol (8.4%), nerol (0.9%), geraniol (18.6%), geranyl butyrate (1.5%), methyl iso eugenol (7.2%) and farnesol (trace).

Major components of citronella oil "Ceylon" in percent are geraniol to 60, citronellal to 15 and citronellol to 10, not necessarily in the same sample (Weiss. 1997).

The oil is frequently used as a domestic insect repellent. Also, the oil is a raw material for geraniol, citronellol, citronellal and menthol production. The oil is considered an industrial oil and used extensively in detergents, waxes, household soap and cleansers for masking unpleasant odours of insecticides and similar preparations and to a minor extent in cheaper perfumes and toiletries (Weise, 1997).

This work aimed to study the growth, absolute growth rate i.e. the total growth of each organ per time unit biomass yield, essential oil production and its physicochemical properties as well as chemical composition of three plants belong to two species of the genus Cymbopogon fam. Gramineae, namely:

1. C. citratus (El-Kanater) and commercially cultivated in Egypt.
2. C. citratus cultivated in El-Farafra (New Valley Governorate).
3. C. nardus.
The former and later ones were grown in the Experimental Farm of Medicinal and Aromatic Plants in El-Kanater El-Khayria, Egypt.

MATERIALS AND METHODS

This study was carried out in the Experimental Farm of Medicinal and Aromatic Plants in El-Kanater El-Khayria, Egypt during two successive seasons 1998 and 1999. Plants of *Cymbopogon citratus* (DC.) Stapf. and *C. nardus*, L. Rendle were obtained from El-Kanater El-Khayria Farm and the third plant *C. citratus* (D.C) Stapf was introduced from El-Farafrin in the New Valley region and put under normal cultivation in the new environment in El-Kanater El-Khayria Farm till the plants became well adapted. All tested plants were cultivated using tillers in a suitable size separated from mother plants. Cultivation was done on October, 19 for the two seasons in a well prepared soil in plots (2.5 x 3.0 m). Each contain 4ridges at a distance of 40 cm between plants and 60 cm apart. Fertilization and irrigation as well as all agronomical practices were done as usual.

The plants were harvested three times during the growing season, at July, 3; August, 28 and November, 3 for the two seasons.

Data were recorded for growth characters and absolute growth rate for plant height, tillers number, plant fresh weight and dry matter (gm/plant). Also, essential oil content, oil yield (ml/plant) and physicochemical properties of the oil of the 2nd cut only (according to Guenther, 1961) as well as oil composition using Hewlett Packard 5890 GLC with a column HP 20 N carbowax 25 M x 0.32 mm x 0.3 micrometer (film thickness).

Flow rates N2 : 2 ml/min

H2 : 30 ml/min

Air : 330 ml/min

Program temp. : 50 – 140 °C (50°C/2 min increased by 5 °C/min till 100 °C for 1/2 min and increased by 3 °C/min, till 140°C for 1/2 min)

Injector temp. 180°C

Detector temp. 200°C

The experimental design was complete randomized blocks and the statistical analysis was done according to Snedecor and Cochran (1972).
RESULTS AND DISCUSSION

I. Growth characters:

Data in Table (3) indicated that growth pattern of Cymbopogon plants showed differences in some characters i.e. length, tillering, biomass and dry matter production.

The El-Kanater of Cymbopogon citratus (DC.) Stapf produced the maximum growth during the two growing seasons 1998 and 1999 in comparison with the others (El-Faraa) C. citratus and C. nardus plants.

It was found that, the highest values of plant height, tillers no. per plant, fresh and dry weight (gm/plant) were recorded in case of C. citratus plants (the El-Kanater), while the lowest values in this respect were found in the plants of C. nardus (L.).

Data clearly emphasized that, grand period of growth in the Cymbopogon plants' was existed in an extended period started from the early summer till the beginning of autumn with some differences. The rapid phase of grand growth was established from July to November. It was observed that, growth of leaves (elongation) showed maximum values at the time of 3rd cut (Nov.) in all species. This behaviour was also shown with regard to tillers formation. Maximum values of tillers no. was recorded after the 2nd cut (August, 28) till the time of the 3rd cut (Nov. 3) for all plants especially the plants of C. citratus (DC.) Stapf (El-Kanater).

Vegetative growth as well as dry matter production was shown to follow a course similar to that of plant height and tillers growth. Greatest growth was attained mostly during summer period to the beginning of autumn and reached its maximum during the period from Aug. 28 to Nov. 3.

II. Absolute growth rate:

Absolute growth rate (according to Street & Opik, 1984) as shown in Table (4) was found to be in harmony with the previous results i.e. elongation growth in term of plant height attained maximum rate (cm/day) during the period from July to Nov. in the two seasons for all species.

Tillers formation "horizontal growth" showed maximum growth rate (tiller/day) mostly at a time starting later than that of plant height mainly in August for C. citratus (El-Faraa) and at Nov. for the rest of the plants in the two seasons.

'Biomass and dry matter of the three plants have a highest growth rate (gm/
Table 3. Growth characters of *Cymbopogon* plants.

<table>
<thead>
<tr>
<th>Species</th>
<th>Cuts</th>
<th>Plant height (cm)</th>
<th>Tiller no. /plant</th>
<th>Fresh weight (gm /plant)</th>
<th>Dry weight (gm /plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt;  2&lt;sup&gt;nd&lt;/sup&gt;  3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;  2&lt;sup&gt;nd&lt;/sup&gt;  3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;  2&lt;sup&gt;nd&lt;/sup&gt;  3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>1&lt;sup&gt;st&lt;/sup&gt;  2&lt;sup&gt;nd&lt;/sup&gt;  3&lt;sup&gt;rd&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>Cymbopogon citratus</em> (1)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>139.66 150.00 165.00</td>
<td>55.00 66.66 140.00</td>
<td>984.66 1756.7 1443.3</td>
<td>4184.6 2028.6 359.16</td>
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<tr>
<td><em>Cymbopogon citratus</em> (2)</td>
<td></td>
<td>104.66 120.00 120.30</td>
<td>28.66 68.66 92.6</td>
<td>348.33 798.3 935.0</td>
<td>2083.7 76.65 225.21</td>
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<tr>
<td><em>Cymbopogon nardus</em></td>
<td></td>
<td>86.66 91.66 103.33</td>
<td>27.33 35.33 76.00</td>
<td>288.33 498.3 573.3</td>
<td>1360.0 68.47 162.87</td>
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</tr>
<tr>
<td><em>Cymbopogon citratus</em> (1)</td>
<td></td>
<td>135.33 144.66 152.00</td>
<td>53.33 69.66 174.00</td>
<td>846.66 1511.7 1550.0</td>
<td>3908.3 171.60 414.31</td>
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</tr>
<tr>
<td><em>Cymbopogon citratus</em> (2)</td>
<td></td>
<td>109.33 130.33 125.60</td>
<td>29.00 61.66 85.00</td>
<td>401.68 900.0 1021.6</td>
<td>2332.3 87.46 199.30</td>
</tr>
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<td></td>
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<td>a b b b b b b b b b b b b b b b b b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cymbopogon nardus</em></td>
<td></td>
<td>85.33 96.66 111.66</td>
<td>32.66 48.60 77.00</td>
<td>311.66 620.0 731.7</td>
<td>683.3 71.92 126.02</td>
</tr>
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<td>c c c c b b c c c c b b c c c c c</td>
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</tbody>
</table>

(1) El-Kanater
(2) El-Farafra
day) at different periods in each case. For *C. citratus* (El-Kanater), it was on August followed by Nov., while *C. citratus* of El-Fara'a and *C. nardus*, the highest growth rate (gm/day) was recorded in Aug. and Nov.

Table 4. Absolute growth rate of *Cymbopogon* plants.

<table>
<thead>
<tr>
<th></th>
<th>Absolute growth rates</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Plant height</td>
</tr>
<tr>
<td></td>
<td>(cm/day)</td>
</tr>
<tr>
<td></td>
<td>1st seas. 2nd seas.</td>
</tr>
<tr>
<td><em>C. citratus</em></td>
<td></td>
</tr>
<tr>
<td>(El-Kanater)</td>
<td>:</td>
</tr>
<tr>
<td>1</td>
<td>0.471</td>
</tr>
<tr>
<td>2</td>
<td>2.364</td>
</tr>
<tr>
<td>3</td>
<td>2.077</td>
</tr>
<tr>
<td><em>C. citratus</em></td>
<td>(El-Fara'a)</td>
</tr>
<tr>
<td>(El-Fara'a)</td>
<td>:</td>
</tr>
<tr>
<td>1</td>
<td>0.333</td>
</tr>
<tr>
<td>2</td>
<td>1.818</td>
</tr>
<tr>
<td>3</td>
<td>1.538</td>
</tr>
<tr>
<td><em>C. nardus</em></td>
<td>:</td>
</tr>
<tr>
<td>1</td>
<td>0.263</td>
</tr>
<tr>
<td>2</td>
<td>1.309</td>
</tr>
<tr>
<td>3</td>
<td>1.277</td>
</tr>
</tbody>
</table>

1: 1st cut (255 days from planting)  
2: 2nd cut (55 days from 1st cut)  
3: 3rd cut (65 days from 2nd cut)

This highest growth rate of biomass and dry matter (gm/day) was positively correlated with the highest elongation rate (cm/day) existed in Aug. rather than tillering rate (tiller/day) in case of *C. citratus* (El-Kanater). However, it was observed that, the highest growth rate of these two characters was correlated with highest growth rates of both elongation and tillering in *C. citratus* (El-Fara'a) and *C. nardus*.

It could be concluded that, plants of the Genus *Cymbopogon* showed differences in growth characters in term of plant height, tillering, biomass and dry matter production. These results hold true in case of absolute growth rate of each organ (per day) of the three plants. These findings were found to be in accordance with those of Behura et al. (1991). Also, it was found that herbage yield fresh or dry of *Cymbopogon* plants was affected by elongation and tillering, these results agreed with those stated by
III. Volatile oil:

1. Oil content:

Results in Table (5) pointed out that, *C. nardus* plants recorded the highest oil percentage (fresh and dry weight basis) in all cuts in comparison with the plants of *C. citratus* of both two locations in the two seasons.

Plants showed a gradual increase in oil production in term of oil content (fresh and dry weight basis) as the plants advanced in age during the growing season.

*C. citratus* plants (El-Kanater) showed a slight increase in oil percent (fresh weight) while this trend was not clear in case of oil percent (dry weight basis).

El-Farafra *C. citratus* showed a fluctuation in oil percent (fresh weight basis) during the growing seasons, while it tended to decrease when dry weight basis was considered.

2. Oil yield:

Lemongrass (El-Kanater) produced the highest oil yield (ml/plant) though its oil content is significantly lower in comparison with the rest plants. This is due to the significant highest production of biomass as well as the dry matter production in the plant.

Essential oil production in the plants of these three species tended to increase during the growing season and the plants produced maximum yield (ml/plant) at the time of the 3rd cut in Nov. 3 in most cases.

Total yield of essential oil (ml/plant/year) showed the highest values in case of *C. citratus* (El-Kanater) followed by El-Farafra *C. citratus*, while the lowest one was obtained from *C. nardus* plants (Table 5).

This behaviour was found to be in harmony with the biomass and dry matter production of these plants.

In general, these results clearly emphasized that, *Cymbopogon* plants showed differences in essential oil content i.e. citronella plants recorded the highest oil content followed by El-Farafra plants and the lowest one was detected in lemongrass (El-Kanater).
Table 5. Volatile oil content of *Cymbopogon* plants.

<table>
<thead>
<tr>
<th>Growth characters</th>
<th>Oil percentage based on fresh weight</th>
<th>Oil percentage based on dry weight</th>
<th>Oil yield (ml/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Species</strong></td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
</tr>
<tr>
<td>Cymbopogon citratus (1)</td>
<td>0.22 b</td>
<td>0.25 c</td>
<td>0.28 c</td>
</tr>
<tr>
<td>Cymbopogon citratus (2)</td>
<td>0.47 a</td>
<td>0.41 b</td>
<td>0.44 b</td>
</tr>
<tr>
<td>Cymbopogon nardus</td>
<td>0.51 a</td>
<td>0.56 a</td>
<td>0.73 a</td>
</tr>
<tr>
<td><strong>First season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Second season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cymbopogon citratus (1)</td>
<td>0.26 b</td>
<td>0.26 c</td>
<td>0.28 c</td>
</tr>
<tr>
<td>Cymbopogon citratus (2)</td>
<td>0.46 a</td>
<td>0.39 b</td>
<td>0.43 b</td>
</tr>
<tr>
<td>Cymbopogon nardus</td>
<td>0.50 a</td>
<td>0.61 a</td>
<td>0.66 a</td>
</tr>
</tbody>
</table>

(1) El-Kanater
(2) El-Farafra
Also, essential oil biosynthesis and accumulation (in term of oil yield ml/plant) showed variation according to many factors, such as growth stage and growth behaviour of both elongation and tillering in which the biomass and dry matter production were influenced.

These findings met those of Misra and Srivastava (1991), Behura et al. (1991) and Weiss (1997).

3. Physicochemical properties of *Cymbopogon* plants essential oil:

Data in Table (6) pointed out that, physicochemical properties of the essential oil of the three plants of *Cymbopogon* recorded values met those of the standard specification, Rutovskil and Vinogranova (1930), Squibbs (1933), Guenther (1961), Ibrahim (1965), El-Zahwey et al. (1992), Gabr (1994) and S.Soad (1995). However, found that, lemongrass oil (El-Kanater) showed the lowest values in this respect.

Table 6. Physicochemical properties of *Cymbopogon* plants essential oil.

<table>
<thead>
<tr>
<th>Properties</th>
<th><em>Cymbopogon citratus</em> (1)</th>
<th><em>Cymbopogon citratus</em> (2)</th>
<th><em>Cymbopogon narus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Solubility in alcohol</td>
<td>Soluble in 1.7 vol. of 90% alcoh.</td>
<td>Soluble in all vol. of 90% alcoh. 50% in 0.8-1.1 vol. of 80% alcoh.</td>
<td>Soluble in 3.5 vol. of 90% alcoh. Sol. in 0.8-1.1 vol. of 80% alcoh.</td>
</tr>
<tr>
<td>Specific gravity at 15 °C</td>
<td>0.8886</td>
<td>0.9154</td>
<td>0.0990</td>
</tr>
<tr>
<td>Refractive index at 20°C</td>
<td>1.4971</td>
<td>1.4901</td>
<td>1.4896</td>
</tr>
<tr>
<td>Specific optical rotation</td>
<td>-2.81</td>
<td>-3.7</td>
<td>-3.2</td>
</tr>
<tr>
<td>Colour</td>
<td>Light yellow</td>
<td>Light yellow</td>
<td>Light yellow</td>
</tr>
<tr>
<td>Acid number</td>
<td>4.74</td>
<td>16.00</td>
<td>13.14</td>
</tr>
<tr>
<td>Ester number</td>
<td>14.62</td>
<td>36.72</td>
<td>26.89</td>
</tr>
<tr>
<td>Ester no. after acetylation</td>
<td>208.68</td>
<td>219.88</td>
<td>219.84</td>
</tr>
</tbody>
</table>

(1) El-Kanater
(2) El-Farafra

IV. Essential oil chemical composition:

Data in Table (7) and Figs (1 and 2) represent the chemical composition of lemongrass oil of the two sources (the El-Kanater and El-Farafra one). It was found that, citral (aldehyde) was the main component in the two plants of lemongrass and geranial (alcohol) was the 2nd main component. Citral content showed an increase during the growing season and attained maximum values at the time of the 3rd cut (70.24 and 59.13%) in the oil of the El-Kanater lemongrass and El-Farafra, respectively.
Geraniol content showed its maximum in the oil of the 2nd cut (36.94 and 27.78% for the El-Kanater and El-Farafra lemongrass oil, respectively).

Table 7. Essential oil chemical composition in percent of Cymbopogon plants.

<table>
<thead>
<tr>
<th>Species</th>
<th>El-Kanater lemongrass</th>
<th>El-Farafra lemongrass</th>
<th>Citronella</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st cut</td>
<td>2nd cut</td>
<td>3rd cut</td>
</tr>
<tr>
<td>Citronellal</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Linalool</td>
<td>0.75</td>
<td>0.65</td>
<td>0.71</td>
</tr>
<tr>
<td>Linalool acetate</td>
<td>1.69</td>
<td>1.56</td>
<td>2.35</td>
</tr>
<tr>
<td>Citronellol</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Geraniol</td>
<td>26.04</td>
<td>36.94</td>
<td>21.43</td>
</tr>
<tr>
<td>Citral</td>
<td>42.72</td>
<td>45.46</td>
<td>70.24</td>
</tr>
<tr>
<td>Geranyl acetate</td>
<td>0.50</td>
<td>0.95</td>
<td>1.03</td>
</tr>
<tr>
<td>Nerol</td>
<td>0.95</td>
<td>2.08</td>
<td>0.05</td>
</tr>
</tbody>
</table>

It was observed that, the oil of the two plants showed differences in the contents of these two main components (citral and geraniol) and others i.e. citral content recorded the highest values in the oil of El-Kanater lemongrass in the 3rd cut (70.24%) in comparison with El-Farafra oil (59.13%). However, the opposite trend was found in the oil of 1st and 2nd cut for the two plants.

Also, it was found that, geraniol showed a higher content in the oil of the El-Kanater lemongrass than that of El-Farafra oil especially in the 1st and 2nd cut.

Myrcene content decreased gradually as the plants advanced in age during the growing season. So, it increased from (26.76 and 26.32%) in the 1st cut to (3.85 and 8.79%) in oil of the 3rd cut for the El-Kanater lemongrass and El-Farafra, respectively. These relations may be explained by the interconversion of geraniol to myrcene and citral and vice versa.

Also, the following components linalool, linalool acetate geranyl acetate and nerol were detected in the two oils.

In general, it could be concluded that, the oil of lemongrass (El-Kanater) C. citronellus (DC.) Stapf have the best quality as its citral and geraniol contents were highest than those of El-Farafra lemongrass oil.
These findings were in accordance with many authors, El-Zahawy et al. (1992), Gabr (1994), Salem, Soad (1995) and Torres & Ragaño (1998) worked on lemongrass and came to the conclusion that, citral was the 1st main component of the oil followed by geraniol as the 2nd one.

As for citronella (Ceylon) oil, data in Table (7) and Fig. (3) emphasized that, geraniol oil (alcohol) was found to be the main component. The highest content of geraniol was detected at the time of the 1st cut (46.13%), however the oil of the 2nd and 3rd cuts contain geraniol (42.6 and 45.59%, respectively) slightly less than the oil of the 1st cut.

Citronellol, another alcohol was found in the oil by about (20.89%) in the 1st cut (16.78%) in the 2nd and (17.48%) in the 3rd one. It showed a slight decrease during the growing season, the same behaviour previously observed in case of geraniol.

The second main component in Ceylon citronella oil was citronellal (aldehyde) it was estimated by (28.98, 38.16 and 33.91%) in the oil of 1st, 2nd and 3rd cuts, respectively.

It was observed that, the highest geraniol and citronellol contents were accompanied with the lowest content of citronellal and vice versa. This observation was expected due to enzymatic reactions that interconvert a great variety of the monoterpene derivatives to each other.

The oil contained linalool acetate and traces of linalool, geranyl acetate and nerol. These results agreed with those of Weijerskera et al. (1973) and Weiss (1997).

**General conclusion:**

It could be concluded that, lemongrass *Cymbopogon citratus* (DC.) Stapf (El-Kanater cultivated commercially) was superior in growth, herbage yield, essential oil production and higher contents of citral and geraniol in comparison with the other plant of lemongrass (El-Farafra).

Citronella plant, gave good parameters in growth, herbage yield and essential oil production as well as its geraniol, citronellol and citronellal contents, under the environmental conditions of Egypt.
Fig. 1. Gas chromatogram of local lemongrass oil.

Fig. 2. Gas chromatogram of El-Frafa lemongrass oil.

Fig. 3. Gas chromatogram of citronella oil.

1- Myrcene
2- Linalool
3- Linalyl acetate
4- Geraniol
5- Citral
6- Gerany acetate
7- Nerol

1- Myrcene
2- Linalool
3- Linalyl acetate
4- Geraniol
5- Citral
6- Gerany acetate
7- Nerol

1- Citronellal
2- Linslcool
3- Linalyl acetate
4- Citronellol
5- Geraniol
6- Gerany acetate
7- Nerol
REFERENCES


دراسة مقارنة على بعض أنواع جنس Cymbopogon المنزوعة في مصر

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قسم بحوث النباتات الطبية والعطرية - معهد بحوث البساتين - مركز البحوث الزراعية - مصر

أجري هذا البحث في موسمين متتاليين 1998 و 1999 لدراسة النمو والحصول وإنتاج الزيت ومواصفاته ومكوناته في ثلاثة نباتات لتنوع من جنس Cymbopogon. وقد تم تسجيل بيانات النمو للنباتات الثلاثة فيما يخص ارتفاع النباتات وعدد الفروع ونسبة النباتات والوزن الطازج والجاف، G. citratus (م/ثلاج) وقد أوضحت النتائج وجود اختلافات في النمو، حيث سجلت نباتات النوع المزرعة في القناطر الغربية (والذى يزرع على نطاق صغير) أعلى القيمة من حيث ارتفاع النباتات وعدد الفروع والوزن الطازج والجاف.

أما من حيث الزيت الطيار ومكوناته ومواصفاته والحصول النتائج من كل نوع من الأنواع المنزوعة C. citratus والثلاثة فقد أظهرت النتائج أعلى نسبة زيت في نباتات نباتات G. nardus و G. citratus. في القناطر من حيث محتوى النباتات (ملليتر/ثلاج) على بالي الأنواع وقد تم تسجيل النتائج فيما يخص مواصفات الزيت والأضرع أن كل قيم النبات الطبيعية للزيت متلفة مع الأرقام القياسية.

ومن ناحية مكونات الزيت فقد توقفت حشيطة اللليمون (التمور) من القناطر زادة نسبة استمرار (الكين الرئيسي) والهيرانيول (ثاني مكون رئيسي)، أما حشيطة السترونيولا فقد كانت نسبة الهيرانيول والسترونيول والسترونيول متلفة مع القيم القياسية.