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Essential Oil Content Response of Lemongrass, Palmarosa and Citronella to Post Harvest Wilting and Chopping

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ABSTRACT

An experiment was set to determine effects of wilting period and chopping on essential oil content of three aromatic grasses vis. *Cymbopogon winterianus* Jowitt, *C. citratus* Stapf and *C. martinii*. A completely randomized design with three replications was used in the experiment. Wilting the harvested part of *C. citratus*, *C. winterianus* and *C. martinii* for 96 hr yielded significantly higher essential oil (av. 1.31, 2.44 and 1.45%, respectively) than other treatment levels, except for 72 hr. Chopping to any level generally reduced essential oil content by 20.9% for *C. citratus*, 8.9% for *C. winterianus* and 9.24% for *C. martinii.* Thus, commercial production of essential oils from these plants needs to consider these two factors in order to optimize the quality and yield.

Keywords: aromatic grasses, *Cymbopogon*, distillation, essential oil, post harvest management

INTRODUCTION

The genus *Cymbopogon* comprises about 140 species (Kumar *et al.* 2007), of which some yield essential oils (EOs) are used for perfumery (Chagonda and Makanda 2000; Linares *et al*. 2005; Kumar *et al*. 2009), as botanical pesticides (Chomchalow 2002) and for treating human ailments (Hassan *et al.* 2007). *Cymbopogon citratus* (lemongrass), *Cymbopogon winterianus* (citronella) and *Cymbopogon martini* (palmarosa) are economically most important species among EO-yielding species in the genus (Hassan *et al.* 2007; Eltahir and AbuEReish, 2010). Major EO components of lemongrass are citral, geranial, neral myrcene, geraniol and linalool (Folorunso and Oyetunji 2007; Andrade *et al.* 2009).Citronella is a species rich in citronellal, geraniol and citronellol (Chagonda and Makanda 2000; Pino and Rosado 2000). Geraniol and geranyl acetate are rich EO components of Palmarosa (Sarma *et al*. 1998; Srivastava *et al*. 2000). They are perennial grasses with fibrous roots requiring sufficient moisture for good growth and yield of leaves (Virmani *et al*. 1979; Husain *et al*. 1988).

Palmarosa (called *Yabesha Tej Sar*, in local Amharic language) and lemongrass (*Lomi sar*, in Amharic) are abundantly distributed in various parts of Ethiopia. They are locally used as bedding in some special traditional occasions together with *Artemisia* spp. Citronella however, is not known to the local people of the country.

Distillation of lemongrass and palmarosa was carried out since 1966 by the then EOs Research Sub Center of Ethiopia, at Wondogenet. However, there was no recorded data on the quantity, quality and other related aspects of EOs obtained from these plant species. On the other hand, local demand of citronella oil for soap making and other similar purposes is getting increasing.

A number of factors need to be considered to optimize the yield and quality of EOs produced by aromatic grasses, including proper temperature, humidity, handling techniques, atmospheric condition and control of pathogens (Chomchalow 2002). Virmani *et al*. (1977) and Anonymous (2009) described that wilting of the distillable material reduces the moisture content and allows larger quantity of grass to be packed into the distillation vessel, thus economizing the fuel use; and chopping, since increases the surface area of the distillable material, speculated to increase the speed of distillation period thus increasing EO yield.

Looking the local and export market potential of aromatic grass species, studying some components of post harvest technologies in order to minimize energy consumption and increase the efficiencies of distillation is important. Therefore, the prime objective of this study was to determine optimum wilting period and chopping size of three aromatic grasses for maximum EO content.

MATERIALS AND METHODS

The experiment was conducted during 2006-2007 cropping season at the then Wondo Genet EOs Research Sub Center located 265 Km far from Addis Ababa and 17 Km far from the nearest town, Shashemene, in the Southern Administrative Region, Sidama Zone Wondo Genet Woreda. The annual mean rainfall of the area is 1880 mm and the mean annual maximum and minimum temperatures are 27.8 and 10.1°C, respectively. Experimental plants vis. lemongrass, palmarosa and citronella were planted one after the other on January, February and March 2006 on 100 m^2 plots.

The source of planting materials for this experiment was found from conservation site of Wondo Genet Agricultural Research Center. Weeding, cultivation and irrigation activities were done when required to facilitate effective establishment and growth of the species. For the three grass species, first harvest was taken after six months of planting and this was not used for oil analysis. The consequent second and third harvests were taken in three months of interval time and were considered for evaluation of EO contents. 18 kg of leaves were harvested from each species for the experiment. A total of 20 treatment combinations were used for the study, comprising 5 levels of wilting periods after harvest before distillation (0, 24, 48, 72 and 96 hr) and 4 levels of chopping size (unchopped, chopping in to two parts, chopping in to three parts and chopping in to four parts). The design for the experiment was completely randomized design with three replications. Samples were subjected to air-drying in a shade having an average temperature of 24.9°C. An average of 3 hr of hydro distillation was conducted to quantify EO content of each sample weighing 260 g using a Clevenger apparatus (Khouzani *et al.* 2007) and EO contents of each treatment were calculated as a ratio

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Table 1 Main effects of wilting and chopping on essential oil content of lemongrass.

Treatment	Essential oil content (%)	
	Second harvest	Third harvest
Wilting		
0 hr	0.47 d	0.450 c
24 hr	0.76 c	0.580 c
48 hr	0.96 bc	0.758 bc
72 hr	1.11 ab	1.056 ab
96 hr	1.305 a	1.314 a
Chopping		
C0	1.061 a	1.019 a
C1	0.863 b	0.810 b
C2	0.888 ab	0.737 b
C3	0.878 b	0.761 b
CV%	18.03	14.47

Means followed by the same letter within a column are not significantly different at the 5% level. C0, no chopping; C1, chopping in to two pieces; C2, chopping in to three pieces; C3, chopping in to four pieces

Table 2 Main effects of wilting and chopping on essential oil content of palmarosa.

Treatment	Essential oil content (%)	
	Second harvest	Third harvest
Wilting		
0 hr	0.48 d	0.78 d
24 hr	0.62 c	1.17 c
48 hr	0.81 b	1.55 b
72 hr	1.00 a	1.73 a
96 hr	1.11 a	1.78 a
Chopping		
C0	0.93 a	1.44
C1	0.76 b	1.38
C2	0.75 b	1.42
C4	0.77 b	1.37
LSD0.05	-	ns
CV%	17.3	8.3

Means followed by the same letter within a column are not significantly different at the 5% level. C0, no chopping; C1, chopping in to two pieces; C2, chopping in to three pieces; C3, chopping in to four pieces

of EO yield obtained and sample weight of distilled grasses (Bhuiyan *et al*. 2010; Zheljazkov *et al.* 2010).

To analyze differences in EO content between treatments, three samples were taken and distilled as replication from each treatment. The data obtained were subjected to analysis of variance following the procedure depicted in MSTATC computer software at $P < 0.05$ (MSTATC, 1991). Least Significant Difference was used to separate the means.

RESULTS AND DISCUSSION

Lemongrass

Wilting of lemongrass up to 72 hr had significantly ($P < 0.05$) increased EO content in both harvestings (**Tables 1, 4**). In the second harvest, percent EO content increase from 0 hr wilting time was ranged from 38.1 to 63.8 at 24 and 96 hr, respectively. The increase in EO content was 22.4, 40.6, 57.4 and 65.8% at respective wilting time of 24, 48, 72 and 96 hr as compared to 0 hr wilting at the third harvest. This may be due to the loss of moisture with subsequent wilting of the grass which contributed to the increase in the percent composition of essential oil as was described by Virmani *et al*. (1977) and Eltahir and AbuEreish (2010). The data indicated the significant ($P < 0.05$) reduction of EO content with chopping of lemongrass. The reduction varied from 16.3 to 18.7% in the second harvest and from 20.5 to 27.7% in the third harvest (**Table 1**). Maximum value of EO content with an average 1.04% was registered when no chopping was practiced. The list (0.82%) was observed when the maximum chopping was made. Barbosa *et al.* (2008) also reported that the process of grinding the leaves of lemon grass significantly decreased (by up to 68%) the EO content The reduction in EO content with increased level of chopping is probably because the glandular trichomes or specific oil cells that are present in parenchymal tissues of *Cymbopogon* (Lewinsohn *et al*. 1998; Sangwan *et al*. 2001; Luthra *et al.* 2007) are fragmented upon chopping and EO become exposed to the air for early volatilization.

At the third harvest, interaction of wilting and chopping significantly ($P < 0.05$) affected EO content (**Table 4**). At 0 hr of wilting period, no significant difference of EO content was observed due to chopping. When wilting was delayed to 24 hr, EO content was ranged between 0.5 and 0.65, and its variation between C0 and C1, and between C2 and C3 was not significant. At this wilting period the significant variation was observed between C1 and C2. At 48 hr wilting period no chopping had significantly high EO content, 21.1 to 37.9% increases than all chopping practices. During this time the list, 0.59 was observed at C2. Similarly at both 72 and 96 hr wilting time, chopping of lemongrass had resulted significantly reduced EO content by the range 21.4 to 43.6% and 25 to 31.3%, respectively. The variation between C1, C2 and C3 at 96 hr wilting time was reduced, when it was compared with 72 hr wilting time (**Fig, 1**).

Table 3 Main effects of wilting time and chopping size on essential oil content of citronella.

Treatment	Essential oil content (%)	
	Second harvest	Third harvest
Wilting time		
0 hr	0.77 d	0.96 c
24 hr	1.26 c	2.14 b
48 hr	1.72 b	2.45 b
72 hr	2.10 a	2.60 ab
96 hr	2.16 a	2.72 a
Chopping size		
C0	1.70 ab	2.33 a
C1	1.75 a	2.22 a
C2	1.41 c	2.19 a
C3	1.55 bc	1.96 b
CV%	15.2	11.4

Means followed by the same letter within a column are not significantly different at the 5% level. C0, no chopping; C1, chopping in to two pieces; C2, chopping in to three pieces; C3, chopping in to four pieces

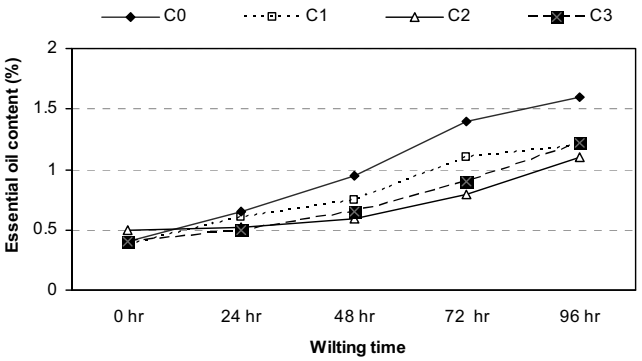

Fig. 1 Interaction between chopping size and wilting period on essential oil content of lemongrass. $LSD_{0.05}$ = 0.054; C0, no chopping; C1, chopping in to two pieces; C2, chopping in to three pieces; C3, chopping in to four pieces.

Palmarosa grass

Though wilting time of *C. martinii* significantly affected EO content in both harvests, chopping size affected the parameter ($P < 0.05$) only in the second harvest (**Table 4**). On average third harvest resulted in 41.9% increase in EO content over the second harvest. Wilting time showed similar increasing results on EO content in both the second and third harvests up to 72 hr, which was statistically at par with 96 hr. In the second harvest, EO content was increased from respective preceding treatment levels by 23.6, 22.5, 19.1 and 10.3% at 24, 48, 72 and 96 wilting hours. Similarly in

Table 4 Analysis of variance for essential oil content of three aromatic grasses.

Source of variation	Degrees of freedom	Means squares					
		Lemongrass		Palmarosa		Citronella	
		Second harvest	Third harvest	Second harvest	Third harvest	Second harvest	Third harvest
Wilting	4	1.227*	1.492*	0.807*	2.131*	4.126*	6.063*
Chopping	3	0.129*	0.243*	0.109*	0.015ns	0.353*	0.351*
Wilt X Chop	12	0.035ns	0.039*	0.018ns	0.029ns	0.081ns	0.085ns
Error	40	0.061	0.021	0.029	0.028	0.059	0.061
CV%		18.03	14.47	17.81	8.25	15.18	11.37

*: significant at 0.05; ns: no significant difference.

the third harvest the percent increase in EO content was ranged between 2.9% at 96 hr wilting time to 33.8% at 24 hr wilting time, from each respective preceding treatment levels. Though there was no statistical difference between chopping size at third harvest, the significant EO content difference ($P < 0.05$) was observed at the second harvest. Accordingly there was 17.9 and 19.5% reduction in EO content when chopping was practiced (**Table 2**).

Citronella grass

Main effect of wilting period and chopping size significantly ($P < 0.05$) influenced percent oil content in both harvests (**Table 4**). There was an average of 26.2% increase in EO content of nardos grass at the third harvesting compared to the second harvesting. In both harvests, wilting for 72 hr gave statistically similar result with 96 hr but out yielded the rest of wilting treatments significantly ($P < 0.05$). Nearly linear increase in EO content with an average value of 27.82 and 24.5% was observed with the increase of wilting time from 0 to 24 hr, from 24 to 48 hr and from 48 to 72 hr in the second and third harvestings respectively. The least oil content (0.77% and 0.96%) was recorded at 0 wilting period in harvest 2 and 3, respectively (**Table 3**). A general overall EO content reduction was observed with increase in chopping levels. In the second harvest there was irregularity in EO content with chopping level treatments where statistically high EO content was observed at C1 which was statistically similar with un-chopped treatment. EO content of the un-chopped treatment was also not different from C3 where the grasses were chopped in to four parts. In the third harvest, however, there was a reduction trend in EO content with increase of chopping levels with an average value of 0.07 up to C2. The least EO content (1.96) was recorded at C3.

CONCLUSION AND RECOMMENDATIONS

This experiment has clearly shown the impact of wilting and chopping on EO content of the three grass species. Wilting after harvest before distillation of grass species up to 72 hr gave significantly high EO content than early distillations. The amount increase varies between 0.21 and 0.85% for lemongrass, 0.27 and 0.82% for palmarosa and 0.83 and 1.57% for citronella. This may be due to the loss of moisture with subsequent wilting which contributed to the increase in the percent composition of essential oil. Chopping the material for distillation has also negative effect on EO content. It reduced the value from 12.9 to 22.1% for lemongrass, 8.4 to 10.1% for palmarosa and 2.97 to 12.9% for citronella grass. The reduction in EO content with increased level of chopping is probably because the glandular trichomes or specific oil cells that are present in parenchymal tissues of *Cymbopogon* are fragmented and EO become exposed to the air for early volatilization.

Therefore, it can be concluded from the experiment that wilting the grass species for 72 hr and distilling it without prior chopping can give high EO content. This result has significant importance to save time and energy for commercially produce EOs from the species studied.

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REFERENCES

Andrade EHA, Zoghbi MGB, Lima MP (2009) Chemical composition of the essential oils of *Cymbopogon citratus* (DC.) Stapf cultivated in North of Brazil. *Journal of Essential Oil-Bearing Plants* **12**, 41-45

Anonymous (2009) *Production Guidelines for Lemongrass*, Department Agriculture, Forestry and Fisheries, South Africa, 19 pp. Available online: http://www.nda.agric.za/docs/Brochures/EssOilsLemongrass.pdf

Barbosa LCA, Pereira UA, Martinazzo AP, Maltha CRÁ, Teixeira RR, Melo EC (2008) Evaluation of the chemical composition of Brazilian commercial *Cymbopogon citratus* (D.C.) Stapf samples. *Molecules* **13**, 1864-1874

Bhuiyan MNI, Akter F, Chowdhury JU, Begum J (2010) Chemical constituents of essential oils from aerial parts of *Adenosma capitatum* and *Limnophila aromatica*. *Bangladesh Journal of Pharmacology* **5**, 13-16

Chagonda LS, Makanda C (2000) Essential oils of cultivated *Cymbopogon winerianus* (Jowitt) and of *C. citratus* (DC) (Stapf) from Zimbabwe. *Journal of Essential Oil Research* **12**, 478-480

Chomchalow N (2002) Production of herbs in Asia: An overview. *Assumption University Journal of Technology* **6 (2)**, 95-108

Eltahir AS, AbuEReish BI (2010) Comparative foliar epidermal studies in *Cymbopogon citratus and Cymbopogon schoenanthus* in Sudan. *Journal of Chemical and Pharmaceutical Research* **2 (4)**, 449

Folorunso AE, Oyetunji OA (2007) Comparative foliar epidermal studies in *Cymbopogon citratus* (Stapf.) and *Cymbopogon giganteus* (Hochst.) Chiov. in Nigeria. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **35 (2)**, 7-14

Hassan VU, Saleem M, Shaffi N, Din KU, Qasier M, Asfandyar (2007) Lemongrass: Botany, ethnobotany and chemistry - A review. *Pakistan Journal of Weed Science Research* **13 (1-2)**, 129-134

Husain A, Virmani OP, Sharma A, Kumar A, Misra LN (1988) *Major Essential Oil-Bearing Plants of India*, Central Institute of Medicinal and Aromatic Plants, Lucknow, India, 237 pp

Khouzani HL, Fini OS, Safari J (2007) Essential oil composition of *Rosa damascena* Mill. cultivated in Central Iran. *Scientia Iranica* **14 (4)**, 316-319

Kumar J, Verma V, Goyal A, Shahi AK, Sparoo R, Sangwan RS, Qazi GN (2009) Genetic diversity analysis in *Cymbopogon* species using DNA markers. *Plant Omics Journal* **2 (1)**, 20-29

Kumar J, Verma V, Shahi AK, Qazi GN, Balyan HS (2007) Development of simple sequence repeat markers in *Cymbopogon species*. *Planta Medica* **73 (3)**, 262

Lewinsohn E, Dudai N, Tadmor Y, Katzir I, Ravid U, Putievsky E (1998) Localization of citral accumulation in lemongrass leaves (*C. citratus* DC Stapf Poaceae). *Annals of Botany* **81**, 85-89

Linares S, Gonzalez N, Gomez E, Usubillaga A, Darghan E (2005) Effect of the fertilization, plant density and time of cutting on yield and quality of the essential oil of *Cymbopogon citratus* Stapf. Rev. Fac. *Agronomy Journal* **22**, 257-260

Luthra R, Srivastava AK, Ganjewala D (2007) Histochemical localization of citral accumulating cite in lemongrass (*Cymbopogon flexuosus* Nees ex. Steud) Wats cultivar GRL-1. *Asian Journal of Plant Science* **6**, 419-422

MSTATC (1991) *MSTATC package*, version 1. Michigan State University, Crop and Soil Science Department, USA

Pino JA, Rosado A (2000) Chemical composition of the essential oil of *Cymbopogon citratus* (DC.) Stapf. from Cuba. *Journal of Essential Oil Research* **12**, 301-302

Sarma PC, Baruah P, Pathak MG, Kanjilal PB (1998) Comparison of the major components of the oils of eight selections of *Cymbopogon martinii* (Roxb.) Wats. var. martinii. *Journal of Essential Oil Research* **10**, 673-674

Sangwan NS, Farooqi AHA, Shabih F, Sangwan RS (2001) Regulation of essential oil production in plants. *Plant Growth Regulation* **34**, 3-21

Srivastava HK, Satpute GK, Naqvi AA (2000) Induced mutants in m2 generation and selection for enhanced essential oil yield and quality in palmarosa (*Cymbopogon martinii*, Roxb.) Wats,. var. martinii. *Journal of Essential Oil*

Research **12**, 501-506

Virmani OP, Singh KK, Singh P (1979) *Java Citronella and its Cultivation in India*, Central Institute of Medicinal and Aromatic Plants Lucknow, India

Virmani OP, Srivastana R, Srivastava GN (1977) *Lemongrass and its Cultivation in India*. Central Indian Medicinal Plants Organization, National Botanic Gardens Campus Lucknow, India, 9 pp

Zheljazkov VD, Cantrell CL, Astatkies T (2010) Yield and composition of oil from Japanese cornmint fresh and dry material harvested successively. *Agronomy Journal* **102 (6)**, 1652-1656