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RESEARCH ARTICLE

ESSENTIAL OIL

Composition of Essential Oil of Indigenous and Exotic Species of Lemongrass Growing in Manipur

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Abstract

A comparative experiment was conducted between the indigenous (*Cymbopogon khasianus*) and exotic lemongrass (*Cymbopogon flexuosus*) species growing in Manipur on yield and quality of essential oil. The wild aromatic grass collected from the hill slopes of Manipur (Jalenbung, Kangpokpi District) at 24° 37' 38.5" N, 93° 46' 05.6" E reaching 1033 m were highly distributed in the area reaching 3m in length. The most commonly grown cultivar, Krishna of *C. flexuosus* was compared to the indigenous lemongrass. The essential oil of *Cymbopogon* species were analyzed through GCMS. The results showed that the essential oil contained citral (32.52%), neral (40.96%), geraniol (7.94%), carophyllene (3.14%), camphene (1.71%), as major constituents of *C. flexuosus* having oil yield of 1.87% (light yellow) and herbage yield of 32.0±1.60 tons/ha/year whereas, in *C. khasianus* methyl isoeugenol (51.44%), α –Pinene (19.28%), D-limonene (7.64%), Cubebol (4.20%), Tricyclo[3.2.1.0(2,4)]octane, 8-methylene-(2.11%) as the major constituent having essential oil yield of 0.09% (pale yellow) and herbage yield of 31.0±1.55 tons/ha/year respectively. Both the essential oil yield and productivity were found higher in *Cymbopogon* species growing in Manipur. The essential oil of exotic lemongrass species was found to be higher in oil percentage as compared to the indigenous lemongrass species showing difference in the oil compositions.

Keywords: *Cymbopogon khasianus , Cymbopogon flexuosus , Poaceae, Methyl isoeugenol, 6-octenal,3,7-Dimethyl-, Citral*

1 Introduction

The genus *Cymbopogon* belongs to one of the most important essential oils yielding monocot grass of family Poaceae, the major group of flowering plants native to warm temperate and tropical regions of the world (1). It is grown in different regions of the world due to its interaction with the specific environments comprising of 145 species, amongst them only 45 species are found in tropical Asia and India yielding aromatic essential oil which are used for cosmetics, pharmaceuticals, and perfumery applications (2; 3; 4). The commercial value and wide applications of lemongrass essential oil in various fields ranked in the top ten among the essential oil-bearing crops in the world (5). Among different species of *Cymbopogon*, the most commonly cultivated crops are *C. nardus*, *C. flexuosus* , *C. pendulus*, *C. citratus*, *C. khasianus* , *C. martini*, *C. winterianus*, and *C. jwarancusa* , yielding essential oils which are having commercial value in the world's market (6; 7; 8) *Cymbopogon*. East Indian Lemongrass (*C. flexuosus*) also known as Malabar or Cochin type is preferred by the industry for its superior oil quality. *C. khasianus* is among *Cymbopogon* species which grows by vegetative propagation as perennial crop for its high valued essential oil and various studies have been conducted on *C. khasianus* due to its high medicinal value (4). During the fast-growing season in warm and humid conditions, *C. khasianus* becomes taller than the other species (9). The major producers of Lemongrass oil are India and Guatemala (10). In Manipur, about 1200 plants are still used by Maibas-Maibis (priest-priestess) including the Maring tribes for traditional remedies where wild *Cymbopogon* species are found naturally (11). The most interesting characteristic of cultivating *Cymbopogon* species is that they can adapt in diverse agro-climatic conditions with different types of soils with less fertility. But for the proper growth of *Cymbopogon* species, environment

factors like warm humid condition with adequate sunshine, annual rainfall of 200-250 mm, temperature ranging from 9-35°C and well drained sandy loam-loamy soil favours the growth of the plants. The crop is sensitive to water logging conditions and the pH should ranged from 4.8-7.5 in order to increases the growth of the aromatic grass and its oil yields (10). Medicinal and Aromatic Plants (MAPs) has been used in various purposes to distinguishing the fragrant (aromatic, ethereal) ingredients containing group of chemical substances of different composition and activity. Their derivatives are used for prevention as well as curing of human health problems (diseases and disorders) since time immemorial. In different places of the world, the leaves of lemongrass plants are commonly used in the preparation of herbal teas and it is consumed in Manipur as CC Tea. MAPs are the source of various medicinal uses to chemotaxonomy or phytochemical plant systems. They have the ability to provide defenses against biotic and abiotic stress due to presence of secondary metabolites in plants (12). Plant based drugs become a global resurgence because modern drugs are either unavailable, unaffordable or unsatisfactory (13) and expectations to bring about changes in the already established phylogenetic systems by the recent trends to use cytological and molecular biological traits. In developing and under-developed countries food security issues has been raised due to its increasing population. The world population is increasing at a fast pace and it is estimated to reach 10 billion by 2050. The availability of food as well as their maintenance is an important pillar in food security and protection from insect pests and pathogens. The chemical constituent differs in quantity in wild populations during its developmental stages and they were significant in different environments for all the traits measured (3). Essential oils were used in various commodities for its non-toxic adhesive properties like in perfumery cosmetic products, soaps detergents, flavour agent, wide application in folk medicine as they have low mammalian toxicity and easily biodegradable in nature. Lemongrass oil is cytotoxic, which could be exploited for pesticidal or chemotherapeutic agents where the stimulant used as anti-inflammatory, anti-diabetic, antibacterial, antifungal, anti-inflammatory, antimalarial, antimicrobial, antinoceptive, antioxidant, antiplatelet and antiviral activities (14; 15; 16; 10; 17; 18; 1). Manipur is in the reign of biodiversity hotspot belonging to different climatic conditions varying from tropical, subtropical, and temperate zones which covers the major occurrence of aromatic and medicinal plants as they are very suitable to grow in these climatic conditions. The study of varietal evaluation in lemongrass is highly required as many areas are still unexplored to study the ecological interaction with plant in low, marginal average and high yielding environments. The commercial cultivation and extraction of *Cymbopogon* species has also been started in Manipur, North East India and potential addition to our country economy. The different ethnic groups living in remote areas of North-East India rely on various traditional medicines to treat different health related problems (19). Manipur has rich heritage and long history on use of medicinal and aromatic plants (MAP) as medicine, cosmetics, health hygiene, toiletries, fragrance and food supplements in improving the quality of life. However, increasing demand caused a great threatening in their indigenous habitation on plants and human exploitation becomes a major factor. Primitive people have used plants to cure a variety of ailments based on tradition and literature records but the records and the information is mainly passed on verbally from generation to generation(20). Conservation of natural bioresources become a major initiatives as the demand from both National and International markets on herbal medicine has been raised, medicinal plants in relation to their unutilized resource and its conservation practices have been conducted in different parts of the world(21; 22; 23; 24; 25).

2 Materials and Methods

2.1 Collection, Plantation and Preparation of Plant Materials

The different germplasms of *Cymbopogon* species were collected during the flowering season (December 2017-January 2018) from different locations of Manipur, North East India and planted (February 2019) in the experimental research area as selection trial located at Waithou Chiru, Thoubal District, Manipur having Lat: 24°42.00' N; Long: 93°59.06'E at 993 m. The indigenous wild lemongrass growing at the hill slopes of Manipur (Jalenbung, Kangpokpi District) at 24° 37' 38.5" N, 93° 46' 05.6" E reaching 1033 m and the known cultivar of *C. flexuosus* i.e. Krishna (collected from research farm of IBSD, Imphal) were used as a check species for comparative analysis growing in the same habitat. All the collected planting material were identified by the taxonomists of Botanical Survey of India, Shillong, Meghalaya vide letter number BSI/ ERC/Tech/2020-2021/75 having accession numbers and the sample were submitted to BSI, ERC, ASSAM Herbarium. Both exotic, *Cymbopogon flexuosus* (Nees ex Steud.) W. Watson and indigenous lemongrasses *Cymbopogon khasianus* (Hack.) Stapf ex Bor were planted at the same day in complete randomized block design at 4 × 3 sq. meter plot size. The line to line and plant to plant spacing was 60 × 60 cm with three replicas for experimental purposes. The plantation was adopted by following the cultural practices of the collected samples. The different physico-chemical characteristic of the soils and soil textural composition were analyzed. The soil textural composition of the experimental site Table1 has sandy loam soil type constituting sand (72.33 ± 3.616%), silt (24.66 ± 1.233%) and clay (3 ± 0.15%). The minimum and maximum soil moisture, soil temperature, soil pH and soil bulk density were in the ranged of 16.21 ± 0.810 to 37.78±1.889%, 14.98±0.749 to 27.72±1.386 °C, 5.53 ± 0.276 to 6.33 ± 0.316 and 1.28± 0.062 to 1.43 ± 0.071 gcm-3 Table2 respectively. The minimum and maximum available cations were recorded in the study site viz. sodium (25.22±1.260 to 86.65±4.33 ppm), potassium (3.66±0.183 to 18.79±0.939 ppm), calcium (1.47±0.073 to 9.20±0.456 ppm) and magnesium (4.39±0.20 to 26.51±1.324 ppm). Whereas, the minimum and maximum available anions like fluoride, chloride, nitrate and sulfate were also present in the range of 3.49±0.174 to 19.53±0.976 ppm, 6.13±0.306 to 6.51±0.325 ppm, 0.86±0.043 to 3.01±0.150 ppm and 2.85±0.142 to 14.45±0.722 ppm Table2.

2.2 Extraction and Isolation of EOs

The mature whole plant i.e. above ground parts of both the *Cymbopogon* species were harvested after completion of one year from the day of plantation. The EOs were isolated from the whole plant of *C. flexuosus* and *C. khasianus* by using Clevenger type apparatus through hydro-distillation method (14) for 4 h. Isolations were carried out in triplicates for both the species studied. The harvested plant materials were kept at normal temperature (25 °C–27 °C) for 2 days. After removing the extraneous material, the semidried whole plant was chopped into small pieces by using secateurs to get the higher essential oil yield . The whole plants were chopped into 2–3 cm in order to expose more cells to produce more yields by decreasing the particle size (26). The hydrodistillation flask was charged with 500 g each of *C. flexuosus* and *C.khasianus* whole plant. The oil content in percentage (v/w) was estimated on dry weight basis. The essential oil concentration (%) was calculated by the following formula:

$$\text{Essential oil (\%)} = \frac{\text{amount of essential oil extracted (g)}}{\text{amount of crop biomass distilled (g)}} \times 100 \quad (1)$$

The oil yield was 1.87% for *C. flexuosus* (light yellow) and 0.09% for *C. khasianus* (pale yellow) respectively. The oil percentage was calculated by oil yield of each isolate over w/w basis of semi-dried samples (27). The essential oils were dried by using anhydrous sodium sulphate (M. wt = 142.04) and stored at 4 °C in sealed amber vials for further analysis.

2.3 Analysis of Volatile Compound

Gas chromatography mass spectrometry (GC–MS) were used to analysed the chemical constituents of both the indigenous and exotic lemongrass species growing in Manipur with a Quadrapole detector (Thermo Fisher Scientific Pte Ltd, Blk 33 Marsiling Industrial Estate Road 307-06, Singapore-739256) of Trace 1300 GC TSQ 8000 DUO having TG-5MS fused with silica capillary column of 30 m × 0.25 mm i.d. and 0.25 μm film thickness. 70 eV of ionization energy was set at for GC–MS detection. While the injector was set at 250 °C and mass transfer line at 250 °C. The injection volume of each sample was 0.5 μl (1:100 essential oil in hexane) and helium was used as a carrier gas at a flow rate of 1 ml/min. The initial column temperature was programmed from 40 °C for 1 min to 250 °C at a rate of 5 °C/min heating ramp and then held at 250 °C for 20 min. The identification of the components was done by comparing mass spectra with those of the National Institute of Standards and Technology (NIST) GC–MS Libraries 2017, respectively.

3 Results and Discussion

Cymbopogon species are growing extensively in different geographical region of the world as the essential oils are easily available, non-toxic to mammals and environment friendly with pleasant aroma which attracts to pharmaceuticals and its alignment (28). In the present study, the essential oil of *C. flexuosus* and *C. khasianus* constitute nearly 30 compounds with amounts of up to 100% Table3. The major components in *C. flexuosus* oil was neral (40.96%), citral (32.52%) geraniol (7.94%), carophyllene (3.14%), ç-Muurolene (2.98%), Geranyl propionate (2.67%), camphene (1.71%), linalool (1.48%), as major constituents of *C. flexuosus* whereas, in *C. khasianus* methyl isoeugenol (51.44%), α –Pinene (19.28%), D-limonene (7.64%), Cubebol (4.20%), Tricyclo[3.2.1.0(2,4)]octane, 8-methylene-(2.11%), Caryophyllene (1.30%), α- Ocimene (1.27%), cis-Methyl isoeugenol (1.13%), 5,6-Decadien-3-yne, 5,7-diethyl (1.08%) respectively. Apart from their main compositions, the indigenous and exotic *Cymbopogon* species showed difference in the chemical constituents. Only six chemical constituents were present in both C.flexuosus and C.khasianus viz. camphene (1.71% 1.14%), D-limonene (0.24% 7.64%), α- Ocimene(0.24% 1.27%), linalool (1.48% 0.35%), endo-Bomeol (0.30% 0.46%), α-terpineol (0.21%-0.20%) respectively. The essential oil extracted from exotic C.flexuosus has 1.87% (light yellow) oil yield and herbage yield of 32.0±1.60 tons/ha/year. Whereas, the essential oil yield of 0.09% (pale yellow) and herbage yield of 31.0±1.55 tons/ha/year was recorded from indigenous *Cymbopogon* species i.e. *C. khasianus* growing in Manipur. According to the difference in the agro-climatic regions, the percentage and chemical constituents present in C.flexuosus and *C. khasianus* also showed difference on compositions and yield of the plants. Among the cultivars of *C. flexuosus* , the highest amount of citral was found in Krishna of 84.4% (neral 32.9 % and geranial 51.50%) as compare to Neema, Cauvery, Chirharit, OD-19 and Pragati (29). The developed geranial rich *C. flexuosus* (GRL 1) of about 91% has been released by CSIR-CIMAP, India but this genotype might not be suitable for cultivation in the North Indian rather need for developing a variety specific for NE India's soil and climate (4). The main chemical constituent responsible for chemical syntheses of lemongrass is citral (geranial and neral) with more than 70-80% (30). Through clonal selection and mutation breeding, *C. flexuosus* (Jor Lab L-8), C. flexousus (Jor Lab L-14) produced essential oil yield of 1 % and 1.35 % with herbage yield of 30.32 tons/ha/year and 29.57 tons/ha/year having wide range of applications in industrial sectors. Different varieties of *Cymbopogon* species constitute chemical components like methyl eugenol, methyl isoeugenol, myrcene, geraniol, geranyl acetate, elemicin, citral, linalool, β-myrcene, etc which can be converted into a highly valuable compound like elemicin or myristicin. Among the eight cultivars studied, CIM-Shikar of C.flexuosus was superior to other cultivars for essential oil yield and higher citarl content (302.40 kg/ha/year and 84.97 ± 4.08) From the NE India, it was reported from *C. khasianus* having the major components of geraniol (78.4 %), geranyl acetate (7.30 %) and linalool (2.20 %) in its fresh leaves (31). Elemicin (70.475%), Cis-Asarone (8.235%), β- ocimene (5.632%), Methyl eugenol (3.145%), Limonene (2.269%), Germacrene-D (1.569%), Neral acetate (1.241%), Unidentified (4.039%) as the major constituent found in the leaves of *C. khasianus* with average oil yield of all multi-location trial of 0.40%. Whereas the major compound identified in Jor Lab L-15 of C.khasianus were trans-β-Ocimene (3.70%), Geran-

Table 1: Soil Texture Composition of Lemongrass Experimental Site (Mean ± SE)

Soil Texture (%)	**January 2018-February 2019**
Sand	72.33 ± 3.616
Silt	24.66 ± 1.233
Clay	3 ± 0.15
Soil type	Sandy loam

Table 2: Physico - Chemical Characteristics of Soil in the Site Studied (Mean ± SE)

Soil Character	**January 2018-February 2019**	
	Min.	Max.
Moisture (%)	16.21 ± 0.810	37.78 ± 1.889
Temperature (°C)	14.98 ± 0.749	27.72 ± 1.386
pH	5.53 ± 0.276	6.33 ± 0.316
Bulk density (gcm-3)	1.28 ± 0.062	1.43 ± 0.071
Available sodium (ppm)	25.22±1.260	86.65±4.33
Available potassium (ppm)	3.66±0.183	18.79±0.939
Available calcium (ppm)	1.47±0.073	9.20±0.456
Available magnesium (ppm)	4.39±0.20	26.51±1.324
Available fluoride (ppm)	3.49±0.174	19.53±0.976
Available chloride (ppm)	6.13±0.306	6.51±0.325
Available nitrate (ppm)	0.86±0.043	3.01±0.150
Available sulfate (ppm)	2.85±0.142	14.45±0.722

iol (83.58%), β-myrcene (4.74%), 1,3,6-Octatriene (1.87%), Pseudolimonene (1.17%), Elemicin (1.0%) with average essential oil yield of 0.54 % and average herbage yield was 22.8 tons/ha/year which is much higher as compared to the check variety, IIMJ (CK) - 10 that showed geraniol content of 46.8 % and essential oil yield of 0.40 % with herbage yield of 16.80 tons/ha/year (4). Another genotype of *C. khasianus* , named Jor Lab L-9 showed highest chemical constituents of methyl eugenol (74.23%), followed by β-myrcene (14.28%), elemicin (1.65%), cis-α-bergamotene (1.19%), β-pinene (1.11%) with oil yield of 0.81 % and herbage yield of 29.50 tons/ha/year respectively (32). (31)also reported that the fresh leaves of *C. khasianus* have essential oil content of 0.70% through hydrodistillation. The GCMS analysis showed that the essential oils present in *Cymbopogon* species were the complex mixture of numerous compounds present in both major and minor constituents showing quite difference in compositions. On the other hand, comparisons of our *Cymbopogon* constituents with other oils composition from different places in the world showed that our oil is really different from others. Both the essential oil yield and herbage yield was found to be higher as compare to other geographical locations which may be due to the difference in agro-climatic conditions and physico-chemical characteristic of the soil that favors the proper growth of the plants. The main chemical constituents of C.khasianus growing in Manipur i.e. methyl eugenol is used for flavoring, non-alcoholic beverages, in processed food, perfumery, aromatherapy. In Taiwan and Okinawa, a mixture of methyl eugenol and cuelure at different concentrations against Bactocera dorsalis and Bactocera curcubitae has been used in Male Annihilation Techniques (MAT) to control pests. Methyl eugenol is used as a source of synthesizing an important hypertensive medication known as Methyl dopa. Different varieties of *Cymbopogon* species are extensively used in various purposes and significantly worked against different fungi and stored grain pest. The main constituents of these aromatic and medicinal plants are responsible for both the fragrance and biological activities (33).*Cymbopogon* species have different pharmacological benefits for its insecticidal activities for the control of stored grain pests or as mosquito repellents. The essential oils from *C. flexuosus* , *C. winterianus* and*C. martini* had shown very strong repellent activities against the adults of *T. castaneum* at 1.41μL/cm2 and the highest fumigant toxicity against with LC_{50} values of 27.1 and 4.23μL/L after 24 and 48 h exposure against *T. castaneum* was shown by essential oil of *C. flexuosus* (34). LD_{50} values of 2.1 and 1.5μg/L after 24 and 48 h exposures has shown high contact toxicity against *T. castaneum* by the essential oil of C. winterianus respectively. shown The most potent fumigant with LC_{50} values of 44.5 and 26.1 μl/L air after 24 and 48 h for contact toxicity by the essential oils of *C. flexuosus* , C. martini oil being the most effective against adults of S. oryzae with LC_{50} values of 2.6 and 1.8 μl/cm2 after 24 and 48 h exposure respectively (34; 1). The high anthelmintic activity displayed against C. elegans by the essential oils of *C. martini* at ED_{50} value of 125.4 μg/mL and C. citratus essential oils from Benin Republic in West Africa shown 100% mortality rate against adult of Anopheles gambiae (35). Culex quinquefasciatus with LC_{50} value of 0.9% showed dose dependent mortality by essential oil of C. winterianus (Makhaik et al. 2005). The chemo protective and used for the treatment of oral thrush in patients who tested positive to HIV/AIDS and proved effective by essential oil of *C. citratus* (36; 35). *Cymbopogon*

Table 3: Chemical Constituents of Essential Oils of *Cymbopogon Flexuosus* and *Cymbopogon Khasianus*

Peak no.	***Cymbopogon* flexuosus**				***Cymbopogon khasianus***			
	RT^a	Component	RSI^b	$\%RA^c$	RT^a	Component	RSI^b	$\%RA^c$
1.	8.4	Tricyclene	942	0.22	8.39	Tricyclo[3.2.1.0(2,4)]octane, 8-methylene-	948	0.32
2.	8.74	α-Pinene	925	0.27	8.73	3-Carene	927	0.62
3.	9.18	Camphene	957	1.71	9.16	Camphene	958	1.14
4.	10.28	Thujaketone	850	0.16	10.43	α-Pinene	914	19.28
5.	11.55	D-Limonene	893	0.24	11.55	D-Limonene	890	7.64
6.	11.8	α-Ocimene	900	0.24	11.8	Tricyclo[3.2.1.0(2,4)]octane, 8-methylene-	919	2.11
7.	12.83	4-Nonanone	884	0.59	12.11	α-Ocimene	937	1.27
8.	13.65	Linalool	913	1.48	13.34	p-Mentha-1,4(8)-diene	947	0.2
9.	13.82	photocitral B	986	0.24	13.63	Linalool	914	0.35
10.	15.16	photocitral A	984	0.73	13.69	Perillen	914	0.34
11.	15.54	trans-Verbenol	898	0.26	15.64	endo-Borneol	944	0.46
12.	15.65	endo-Borneol	919	0.3	16.33	à-Terpineol	925	0.2
13.	16.06	3-Heptyne, 5-methyl	911	0.27	18.07	cis-Geraniol	891	0.25
14.	16.35	α-Terpineol	929	0.21	21.24	α-Amorphene	938	0.37
15.	17.38	Geranyl propionate	903	2.67	21.87	Eremophila-1(10),11-diene	874	0.46
16.	17.52	4-Nonene, 2,3,3-trimethyl	895	0.22	22.17	Methyl isoeugenol	937	51.44
17.	17.77	Citral	875	32.52	22.65	Caryophyllene	949	1.3
18.	18.1	Geraniol	918	7.94	22.97	trans-à-Bergamotene	885	0.83
19.	18.59	Neral	878	40.96	24.17	Germacrene D	928	1.27
20.	21.29	α-Amorphene	915	0.43	24.35	Z,E)-à-Farnesene	916	0.71
21.	21.53	Geranyl propionate	877	0.33	24.4	cis-Methyl isoeugenol	927	1.13
22.	21.89	Eremophila-1(10),11-diene	887	0.26	24.48	Epicubebol	931	0.82
23.	22.65	Caryophyllene	935	3.14	24.77	Toluene, p-(1,2,2-trimethylcyclopentyl)-	869	0.36
24.	23.51	Humulene	892	0.26	24.99	Cubebol	921	4.2
25.	24.18	Germacrene D	925	0.34	25.15	Cadina-1(6),4-diene	917	0.75
26.	24.76	Rishitin	811	0.18	25.32	Methyl-4-(6-methylhept -5-en-2-ylidene)cyclohex-1-ene	901	0.41
27.	24.96	ç-Muurolene	910	2.98	26.42	5,6-Decadien-3-yne, 5,7-diethyl	907	1.08
28.	25.15	Cadina-1(10),4-diene	928	0.16	26.64	Caryophyllene oxide	911	0.24
29.	25.32	1-Chloro-5,10-pentadecadiyne	911	0.37	28.21	à-Cadinol	906	0.21
30.	26.64	Caryophyllene oxide	879	0.32	28.36	10-epi-ç-Eudesmol	921	0.24
		Total compound identified (%)		100		**Total compound identified** (%)		100

[a] Retention time
[b] Reverse similarity index on TG-5MS capillary column
[c] Relative area (peak area relative to the total peak area)

khasianus (Hack.)Stapf ex Bor reported to be found wild in some areas of the Himalayan foothills of North Eastern region of India. The essential oil of *Cymbopogon microstachys* contained (E)-methyl isoeugenol (56.4-60.7%) as the major constituent (37). Comparison between with an elite clone "Krishna" of a related species as "Check" the polyploid clone of C. khasaianus is superior by 237% in terms of the productivity of the economic product, i.e., citral rich essential oil(9). The study shows that the wild aromatic grass collected and cultivated in Manipur is a chemical variant of *Cymbopogon khasianus* showing different chemical composition of the essential oil having high medicinal properties as well. The easy availability of the plant in Manipur and presence of high oil yield and methyl isoeugenol as the major chemical constituents could be a potential essential oil for commercial cultivation. *Cymbopogon flexuosus* has adapted efficiently in Manipur's soil showing high value in oil yield and quality of the essential oil. The result showed that both the aromatic grasses could be a potential crop for vast commercial cultivation that would pave a great way for the enhancement of State's economy as well as for Nation's contributions.

4 Future Works

Cymbopogon species has been a hardy crop and offered vast biological, ecological and pharmaceutical properties but limited studies to acknowledge the maximum bioactive potential of these species. Various environment factors and soil properties played a major role on growth and development of these MAPs and influence in their bioactive compounds. Studies of MAPs including alkaloid extraction, isolation of compounds with few clinical trials are highly needed. Manipur being in biodiversity hotspot and rich in diversity, studies of various plant diverse in creating mass awareness as they are growing in different regions of Manipur and conservation of such plants is highly needed.

Conflict of Interest

The authors declare no conflict of interest in this reported communication.

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