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Lemongrass as a multipurpose aromatic crop: Agronomic management, bioactive compounds and industrial significance

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Abstract

Lemongrass (*Cymbopogon citratus* (DC) Stapf.) is a perennial herb native to the semi-tropical regions of Asia and is extensively cultivated across other semi-tropical areas of the world. In India, several species of lemongrass are cultivated successfully under warm, humid, and high rainfall conditions, particularly at elevations below 750 m. Optimal growth and superior performance of *Cymbopogon citratus* are observed in regions where the mean annual temperature ranges from 23 °C to 30 °C and the yearly precipitation varies between 2500 and 3000 mm. The use of bio-elicitors in the cultivation of medicinal and aromatic plants (MAP) has been advocated as an effective strategy to sustainably enhance both the yield and quality of essential oils (EOs). This review comprehensively presents the general characteristics and diverse applications of lemongrass. A distinctive and dominant feature of this plant is the intense lemon like aroma of its essential oil. The extracted oil is widely refined for incorporation into soaps, detergents, and perfumery products, and it also possesses considerable pharmaceutical significance. In addition, numerous ethnopharmacological applications of lemongrass have been documented. Beyond its nutritional constituents such as fats, proteins, fiber, and mineral elements, lemongrass contains a variety of bioactive compounds including terpenoids, tannins, saponins, flavonoids, and phenolic compounds. The essential oil of lemongrass is obtained from the dried leaves through steam distillation, resulting in an oil that is light in texture, pale to bright yellow in appearance, and characterized by a strong, fresh, lemony, and earthy aroma.

Keywords: Lemongrass, micropropagation, anti cancerous, anti-rheumatism

Introduction

The genus *Cymbopogon* belongs to the Poaceae family, is grown as perennial herb, known for their essential oil having pharmacological as well as therapeutic activities, and is widespread in its distribution throughout tropical and subtropical regions of world (Nambair and Mehta; Ekpenyong *et al.*). Lemongrass essential oil is a yellow coloured viscous liquid, volatile and chemically lipophilic mixture of secondary metabolites, mostly consisting of monoterpenes, sesquiterpenes and phenylpropanoids. Citral is the main constituent of oil and is made up of geranial and neral isomers; it acts as starting material for synthesis of alpha ionone, beta ionone and beta-carotene. The alpha ionone is used in cosmetics, perfumes, and flavours while beta ionone is used for synthesis of vitamin A. Lemongrass oil has promising antimicrobial, anti-inflammatory and analgesic, antioxidant activity, antispasmodic, antipyretic, diuretic and sedative values (Fokom *et al.*, 2019) [7]. It is used as spice due to its good taste appeal and not only used as flavouring agent but also utilized in food preservation and food processing, because of antioxidant, antibacterial, antimycotoxin and antibiofilm action (Boukhatem *et al.*). The oil also exhibits insecticidal, larvicidal, pesticidal and antifeedant properties (Barbosa *et al.*). The explosive demand of essential oil for industrial uses and therapeutic potential necessitates getting above average production.

Area

More than 60000 hectares area is under cultivation of aromatic grasses in India distributed in different states viz., Madhya Pradesh, Gujarat, Karnataka, Assam, Kerala, Maharashtra, Uttar Pradesh and Andhra Pradesh (Husain; Padalia *et al.*).

Species

There are more than 140 species in the genus *Cymbopogon* (Kumari *et al.*), out of which 45 are grown in India, and lemongrass is commercially important for the production of essential oil (Hassan *et al.*). The *Cymbopogon* spp. have a unique character, that they can be cultivated in different types of soils even with less fertile status of the land and have good adaptability to diverse agro-climatic conditions. The most commonly cultivated and economic species of *Cymbopogon* are *C. nardus*, *C. flexuosus*, *C. pendulus*, *C. citratus*, *C. khasianus*, *C. martini*, *C. winterianus*, and *C. jwarancusa*, yields essential oils which are having commercial value viz., lemongrass oil, citronella oil, palmarosa oil, ginger grass (Gupta and Jain, 1978; Rao 1997; Kumar *et al.*)^[35].

Economic importance

The essential oil is obtained through distillation of the leaves and flowering tops of lemongrass. Its intensely lemon like aroma is attributed to the high concentration of citral, which constitutes more than 75% of the oil. Owing to this distinctive fragrance, the oil is extensively utilized for imparting scent to soaps, detergents, and insect repellent formulations. Nevertheless, its principal commercial importance lies in serving as a primary source of citral, which is widely employed in perfumery, cosmetic formulations, and beverage industries, and also functions as a key precursor in the synthesis of ionones that are subsequently used in the production of vitamin A. The citral rich oil further exhibits notable germicidal, therapeutic, and flavour enhancing properties.

Botanical description

Lemongrass is a highly adaptable and multipurpose grass species that develops in thick, compact clumps arising from short rhizomes, attaining heights of up to 6 ft (1.8 m) and spreading approximately 4 ft (1.2 m) in width. The foliage consists of band shaped leaves measuring nearly 3 ft in length, gracefully arching with distinctly drooping tips. Individual leaves are about 0.5 to 1 inch in width. The bluish green, evergreen foliage releases a pronounced citrus fragrance when crushed (Alzawqari, M. H., *et al.*, 2016)^[1].

- **Leaf arrangement:** Most leaves arise directly from the soil surface without the presence of an evident stem.
- **Leaf type:** simple
- **Leaf margin:** entire Leaf shape: linear Leaf venation: parallel
- **Leaf type and persistence:** fragrant
- **Leaf blade length:** 18 to 36 inches
- **Leaf color: Green fall characteristic:** showy flowers Lemongrass is a cultivated variety and usually does not produce flowers or well developed flowering panicles (Ross, 2001)^[18].

Inflorescence The inflorescence attains a length of about 30 to 60 cm. The partial inflorescences are arranged in paired spikes that remain enclosed and partially covered by spathes.

Microscopy of leaf in transverse sections of lemongrass leaf blades and sheaths, only a small number of isolated cells show staining with Schiff's reagent. These cells become deeply red in color after staining, indicating

Climatic condition: At elevations below 750 m, *C. citratus* performs optimally under sunny, moderately warm, and humid environmental conditions, where the mean annual temperature ranges between 23 °C and 30 °C and the average annual rainfall lies between 2500 and 3000 mm. Although the plant adapts to diverse soil types, it shows a clear preference for well drained soils with a pH range of 5.5 to 7.5. Nevertheless, reports from Australia indicate that this species has also been observed growing in terrestrial soils with a pH as high as 9.6. *C. flexuosus* does not tolerate saline soils or frost conditions. In bright, humid, and wet tropical climates, *C. citratus* exhibits vigorous growth. In Kerala, lemongrass is cultivated successfully at elevations ranging from near sea level up to 900 and 1250 m. Both species yield the highest oil recovery per ton of herbage under conditions receiving an annual average precipitation of 2500 to 3000 mm. *C. citratus* demonstrates drought tolerance and can therefore be cultivated in regions experiencing comparatively low rainfall (Fokom *et al.*, 2019)^[7]. To achieve maximum oil yield, supplementary irrigation is recommended, with an ideal daytime temperature of 25 to 30°C and a nighttime temperature of 0 °C. Although plants can withstand temperatures exceeding 30 °C for short durations, a marked reduction in oil content is observed under such conditions. The species is hardy in nature and capable of resisting drought stress. Plant height during the rainy season was recorded as the lowest, and similar reductions were not observed during the second harvest.

Table 1: Climatic conditions required for lemongrass are depicted

S. No	Climate	Description
1	Tropical rainforest	60 mm precipitation per month
2	Tropical savanna climate with dry summer	60 mm precipitation driest month (in summer) and (100 - [total annual precipitation{mm}/25]
3	Tropical monsoon climate	60 mm precipitation driest month but (100 - [total annual precipitation(mm)/25])
4	Tropical wet and dry savanna climate	60 mm precipitation driest month (in winter) and (100 - [total annual precipitation{mm}/25])

Chemical composition

The essential oils derived from different *Cymbopogon* species exhibit considerable variation in their chemical composition, as do the distinct structural parts of the plant. Analytical investigations conducted specifically on *C. citratus* have demonstrated that citral represents the predominant constituent of its essential oil. Over time, refined methodologies have been developed to examine these components more precisely, enabling researchers to further advance and sophisticate their

analytical approaches. The principal constituents along with trace elements present in the essential oil of *C. citratus* have been documented by Viturro *et al.*, 1998 and Diop *et al.*, 2017^[38, 23]. The detailed chemical composition of lemongrass is presented in Table 2.

Traces - Minor constituents identified include alloaromadendrenes, α -bisaboles, β -bisabolens, borneoli, d-cadinens, calamins, campheses, camphires, β -caryophyllene oxides, α -chamigrenes, and β -caryophyllene oxides; α -cubebene,

cuprene, o-cymen, 1,8-cineole, citronellol, and 5,6-dimethyl-5-norborne-2-ol. Additional trace elements comprise β -element, delement, elemi, d-element, d-element, carvone in the European Union, eudemon, fennone, geranyl, geranyl acetate, geranyl formate, geranyl propionate, germacrene, α -farnesene, β -farnesene, fenchone, and geranyl acetate. Iso-borneol, α -humulene, spirit cassock, lavender, and linalool are also present. Further compounds detected include cis and α -p-mentha-2, pmentha-2, 8-dien-1-ol, methyl thymol ether, α -murolen, myrtenal, phellandrene, myrtenal, alpha-pineol, apineol, β -thuj-, 2-en-4-ol, verbenone, β -ylangen, α -pineol, and cis-peperitol.

The primary constituents identified in the leaves of *C. citratus* reveal notable variation in the proportions of geraniol and geranyl acetate during different stages of leaf development. In essential oil extracted on the tenth day following leaf emergence, geraniol and geranyl acetate were recorded at approximately 59% and 33%, respectively. In addition, two dominant components, Piperidone at 54.36% and Phellandrene at 30.86%, have been reported as key constituents of the essential oil. The base oil of *C. citratus* also contains saponins, tannins, anthraquinones, alcohols, phenols, and flavonoids. The major chemical groups detected in the essential oil include terpenes, alcohols, ketones, aldehydes, and esters. Significant individual compounds comprise citral α , citral β , geraniol, nerol, citronellal, geranyl acetate, terpinolene, myrcene, and terpinole, while flavonoid constituents such as luteolin, orientin 2-O-rhamnoside, quercetin, kaempferol, and apigenin have also been identified (Majewska *et al.*, 2019)^[9].

Table 2: The chemical composition of lemongrass is shown.

S. No	Components	Percent of Oil	
1	Terpene	20-70	
2	Tetaraniol	20-24	
3	Cihronellular	30-40	
4	Ci-Malic	0.0-3.5	
5	Geraniol	0.0-22.5	
6	β -pinene	3.5	
7	Jwarankusa	20-6	
8	Nerol	40.8	
9	Methylheptenone	0.2-14	
10	Borneol	0.1-0.4	
11	Geraniol	3.04	
12	Citronellal	2.10	
13	Geranyl acetate	0.83	
14	Myrcene	0.72	
15	Terpinol	0.45	
16	Gel-terpine	7.5	
17	Terpine-piperitone	20-6	
18	Linaly acetate	0.1	
19	Citral α	40.8	
20	Citral β	32	
21	Myrcene	0.72	

Langan *et al.*, 2017, Diop *et al.*, 2017, TA Tran *et al.*, 2018, Olayemi *et al.*, 2017, Premathilake *et al.*, 2018, Boeira *et al.*, 2020, Bhatt *et al.*, 2019, Markovic *et al.*, 2018, Bonferroni *et al.*, 2017 [22, 23, 24, 25, 26, 5, 27, 28, 29]

Propagation

By seeds

In Kerala State, the most popular technique is based on seeds. November to December is when the crop flowers, and January to February is when the seeds are gathered. The plants are not harvested in order to collect the seeds since plants that are regularly harvested produce fewer seeds. A healthy plant often yields 100-200 g of seeds. The entire inflorescence is clipped and spread out in the sun to dry for two to three days at the time of seed collecting. The seeds are then dried in the kiln once more after being beaten. Ultimately, these are kept in gunny sacks. Longer storage times cause the seeds to lose their viability.

Raising of seedlings in nursery

It is advantageous to transplant seedlings to expand the plantation anytime a steady supply of water is available. Direct seeding has been found to be less effective than transplanting seedlings grown in nurseries. The seeds are manually sown on a thin layer of soil on constructed raised beds that are one to one and a half meters wide at the beginning of the monsoon. 3-4 kilogram of seed per hectare is recommended. It is recommended that the bed be watered as soon as possible after seeding, and that the soil be kept adequately moist. After 5-6 days of germination, the seedlings are prepared for transplantation 60 days later.

By rooted slip

To obtain superior oil quality and higher yield, cultivation of lemongrass is recommended through vegetative propagation using slips prepared from healthy, well established clumps. The upper portions of the clumps are trimmed to a height of 20 to 25 cm above the root level. Subsequently, the clumps are carefully separated into individual slips, and the lower brown sheath is removed in order to expose the young and actively growing roots prior to planting.

Irrigation

The recently developed varieties of lemongrass possess specific water requirements to achieve optimum yield. Under the climatic conditions of northern India, approximately 4 to 6 irrigations are provided during the summer period extending from February to June. In situations where rainfall distribution is irregular, irrigation is applied at intervals of 3 days during the initial month following planting, and thereafter at intervals of 7 to 10 days. Once the crop becomes well established, the irrigation schedule is modified in accordance with the soil's water holding capacity and the prevailing weather conditions.

Intercultural operation

The crop field is maintained free from weeds during the first 3 to 4 months after planting to ensure proper establishment and growth. In addition, weeding combined with hoeing operations are carried out up to one month after each harvest. Typically, 2 to 3 weedings are required annually to sustain effective weed management. In crops planted in rows, intercultural operations may be performed using a tractor drawn cultivator or by manual hoeing. The residual waste obtained after distillation is utilized as an organic mulch at the rate of 3 tonnes/ha, which has been observed to effectively suppress weed growth in the field. Regarding chemical control measures, the application of Diuron at 1.5 kg ai/ha and Oxyfluorfen at 0.5 kg ai/ha has proven effective in managing weeds. Once fully established, lemongrass itself contributes to suppressing weed growth by providing ground cover.

Manure and fertilizers

Nitrogen, phosphorus and potassium @150:60:40 is required per ha per year.

Entire amount of phosphorus and potassium is applied at the time of last ploughing in 1st year and in subsequent year after the summer harvesting. Nitrogen is applied in splits thrice per harvest, under non-irrigated condition quantity of fertilizer will be reduced.

Harvesting yield

Lemongrass undergoes flowering during the winter season. The initial harvest is typically secured 4 to 6 months after the

transplantation of seedlings. Thereafter, successive harvests are carried out at intervals of 60 to 70 days, with the exact timing influenced by soil fertility status and prevailing seasonal conditions. Under standard cultivation practices, three harvests can be achieved in the first year, while 3 to 4 harvests are feasible in the following years depending upon the management strategies adopted. Harvesting is performed manually using sickles, cutting the plants approximately 10 cm above the ground level, after which the harvested material is left in the field to wilt prior to its transport to the distillation unit.

Yield

The economic lifespan of a lemongrass plantation generally extends for about 3 to 4 years, depending on prevailing soil characteristics and climatic conditions. Oil production remains relatively low during the first year of cultivation, increases noticeably in the second year, and reaches its peak in the third year, after which a gradual decline in yield is observed. On average, 25 to 30 tonnes of fresh herbage per hectare per year are obtained from 4 to 6 harvests, resulting in an approximate oil recovery of 80 kg. When cultivated under irrigated conditions

using newly developed varieties, oil yields ranging from 100 to 150 kg/ha have been reported. The freshly harvested herb contains about 0.3% essential oil on average, and the thicker stems are separated prior to distillation because they do not contain oil.

Distillation method

Distillation techniques involves introducing the desired part of the plant to steam or boiling water and the vapour is made to flow along the network of tubes which forms the condenser from which the oil drops are collected. There are three different systems viz., hydro-distillation, hydrosteam distillation and steam distillation.

Crop Economics: On the basis of 5 years

S. No	Particulars	Irrigated (₹)	Rainfed (₹)
1	Expenditure (₹ ha ⁻¹)	40,000	23000
2	Gross Income (ha/year)	1,60,000	60000
3	Net Income (ha/year)	1,20,000	35000

Table 3: Improved Varieties of Lemongrass

Cultivars	Plant species	Variety	Development Adaptability	Cultivar details references
Krishna	<i>Cymbopogon flexuosus</i>	Clonal selection	Indian Plains and hills	Anonymous (1997) ^[30]
Cauvery	<i>Cymbopogon flexuosus</i>	Phenotypic recurrent selection	Requires high soil moisture and is evolved for river valley tracts of Indian Plains	Patra <i>et al</i> (2005) ^[31]
Nima	<i>Cymbopogon flexuosus</i>	Half sib seed followed by clonal selection	Indian Plains Anonymous (2003)	Anonymous (2003) ^[32]
OD-19	<i>Cymbopogon flexuosus</i>	Clonal selection	Adapted to a wide range of soil and climatic condition. much suited for rainfed cultivation	Kumar <i>et al</i> (2000)
CIM-Suwarna	<i>Cymbopogon khasianus</i>	Clonal selection	Drought prone areas and marginal lands	Lal <i>et al</i> (2010) ^[33]
CIM-Shikar	<i>Cymbopogon flexuosus</i>	Recurrent selection	High yielding cultivar (>20% Krishna)	Anonymous, (2016) ^[34]
CKP-25	<i>Cymbopogon flexuosus</i>		Hybridization Grows well in northern plains	Rao and Sobti, (1991) ^[35]
CIM-Atal	<i>Cymbopogon flexuosus</i>	Selection	Geraniol rich (80-85%) grows well in tropical and subtropical region	Kulkarni <i>et al</i> (2020) ^[36]

Potential for biofuel production

The southeastern United States holds potential for ethanol production from lemongrass owing to its substantial biomass yield. Compared with other lignocellulosic crops currently under investigation in the United States, lemongrass presents a distinct advantage because, in addition to biomass, it yields essential oil, a high value natural product that may help compensate for production expenses. Crops cultivated exclusively for biomass may therefore offer fewer economic benefits than those capable of serving dual purposes such as biofuel and essential oil production. In the present investigation, lemongrass biomass yields ranged from 7,500 to 25,900 kg/ha at Verona and from 8,036 to 12,593 kg/ha at Poplarville. In contrast, an evaluation of 39 experiments assessing the production potential of switch grass (*Panicum virgatum* L.) in the United States reported mean yields of 8,700 ± 4,200 kg/ha for upland ecotypes and 12,900 ± 5,900 kg/ha for lowland ecotypes (Wulfschleger *et al*). While switch grass intended for ethanol production has largely been examined under rain fed conditions, the lemongrass evaluated in this study was cultivated under irrigation. Although switch grass is generally regarded as more tolerant to diverse environmental conditions than lemongrass, the latter offers specific advantages for the southeastern United States, including the generation of a valuable natural product and the extraction of essential oil through a process that effectively subjects the biomass to thermal treatment.

Steam distillation of lemongrass essential oil, which essentially involves exposing the biomass to hot steam for approximately 2 hours, may help reduce biomass recalcitrance as described by Himmel *et al.* (2007)^[37]. As a result of this pretreatment, lemongrass biomass may be more amenable to ethanol conversion compared with biomass from other species that have not undergone hot steam processing. The production of essential oil from lemongrass may also contribute to ongoing discussions concerning the economic, agronomic, and environmental implications of large-scale biofuel crop cultivation. Lemongrass biomass exhibits structural uniformity because the plants develop as rosettes bearing elongated leaves. In the southeastern United States, lemongrass did not produce stems or inflorescences, resulting in a homogeneous biomass composed entirely of leaves, a characteristic that may further facilitate bioethanol production.

Currently, essential oil of lemongrass is imported from India to satisfy domestic demand, as commercial production is not established within the United States. Cultivating lemongrass in the Southeast United States for both biofuel and essential oil purposes could provide farmers with an additional income source. Moreover, the production of lemongrass oil may encourage regional value-added processing industries centered on essential oil extraction, thereby strengthening the overall economic sustainability of the region.

Conclusion

The aromatic grass *Cymbopogon* sp. contains numerous bioactive constituents that exhibit extensive medicinal potential. Its utility has already been established in the fragrance and cosmetic industries. Looking ahead, the therapeutic attributes and essential oil of lemongrass may find broader applications within herbal medicine. The plant is capable of assisting in the management of infectious conditions affecting the respiratory tract and contributes to the prevention of gum disease and periodontitis through the elimination of pathogenic bacteria from the oral cavity. The antibacterial efficacy of *Cymbopogon citratus* is well documented. Moreover, *C. citratus* demonstrates strong antioxidant activity through effective free radical scavenging and possesses high total flavonoid and total phenolic contents. The species exhibits antifungal, antibacterial, antinociceptive, and cardioprotective activities. In addition, *C. citratus* is reported to have sedative, antithetical, and vasorelaxant properties. Medicinal plants play an essential role in sustaining human health, and there has been increasing scientific attention toward the pharmacological assessment of plants used in traditional Indian systems of medicine. Owing to their extensive use in traditional healing practices and culinary applications, along with their economic significance, lemongrass essential oils have attracted considerable interest.

A comprehensive phytochemical and pharmacological investigation is essential to further explore the therapeutic potential of this remarkable plant. The renewed focus on natural products derived from lemongrass may pave the way for expanded pharmacological applications, thereby supporting clinical research initiatives and facilitating the development of novel therapeutic agents.

Future scope

Numerous species of lemongrass are cultivated all over the world; the molecular diversity analysis of lemongrass will be the focus of future research. To guarantee that all of the oil's components are available, the methods currently used for extracting essential oils can be enhanced. Lemongrass oil has a number of uses that should be investigated

References

- Alzawqari MH, Al-Baddany AA, Al-Baadani HH, Alhidary IA, Khan RU, Aqil GM, *et al.* Effect of feeding dried sweet orange (*Citrus sinensis*) peel and lemon grass (*Cymbopogon citratus*) leaves on growth performance, carcass traits, serum metabolites and antioxidant status in broiler during the finisher phase. *Environ Sci Pollut Res.* 2016;23(17):17077-17082.
- Arhoghro EM, Kpomah DE, Uwakwe AA. Curative potential of aqueous extract of lemon grass (*Cymbopogon citratus*) on cisplatin induced hepatotoxicity in albino Wistar rats. *J Phys Pharm Adv.* 2012;2(8):282-294.
- Asaolu MF, Oyeyemi OA, Olanlokun JO. Chemical compositions, phytochemical constituents and *in vitro* biological activity of various extracts of *Cymbopogon citratus*. *Pak J Nutr.* 2009;8(12):1920-1922.
- Battaglia S. Lemongrass. 2019.
- Boeira CP, Piovesan N, Flores DCB, Soquetta MB, Lucas BN, Heck RT, *et al.* Phytochemical characterization and antimicrobial activity of *Cymbopogon citratus* extract for application as a natural antioxidant in fresh sausage. *Food Chem.* 2020;319:126553.
- Costa G, Ferreira JP, Vitorino C, Pina ME, Sousa JJ, Figueiredo IV, *et al.* Polyphenols from *Cymbopogon citratus* leaves as topical anti-inflammatory agents. *J Ethnopharmacol.* 2016;178:222-228.
- Fokom R, Adamou S, Essono D, Ngwasiri DP, Eke P, Mofor CT, *et al.* Growth, essential oil content, chemical composition, and antioxidant properties of lemongrass as affected by harvest period and arbuscular mycorrhizal fungi in field conditions. *Ind Crops Prod.* 2019;138:111477.
- Gautam M, Agrawal M. Influence of metals on essential oil content and composition of lemongrass (*Cymbopogon citratus* (DC) Stapf.) grown under different levels of red mud in sewage sludge amended soil. *Chemosphere.* 2017;175:315-322.
- Majewska E, Kozłowska M, Gruszczynska-Sekowska E, Kowalska D, Tarnowska K. Lemongrass (*Cymbopogon citratus*) essential oil: Extraction, composition, bioactivity and uses for food preservation - a review. *Pol J Food Nutr Sci.* 2019;69(4):295-307.
- Manvitha K, Bidya B. Review on the pharmacological activity of *Cymbopogon citratus*. *Int J Herb Med.* 2014;1(6):07-07.
- Med J Ayu Herb. Antibacterial activity profile and quality standards of *Cymbopogon citratus* Stapf - an aromatic grass used in Indian system of medicine. *J Ayu Herb Med.* 2016;2(3):63-66.
- Meenapriya M, Jothi Priya. Effect of lemongrass oil on rheumatoid arthritis. *J Pharm Sci Res.* 2017;9(2):237-237.
- Okémy NA, Moussoungou AS, Koloungous BC, Abena A. Topical anti-inflammatory effect of aqueous extract ointment of *Ageratum conyzoides* L. in Wistar rat. *Int J Phytopharm.* 2015;5:37-41.
- Pandey J, Verma RK, Singh S. Screening of most potential candidates among different lemongrass varieties for phytoremediation of tannery sludge contaminated sites. *Int J Phytoremediation.* 2019;21(6):600-609.
- Patra DK, Pradhan C, Patra HK. Chelate based phytoremediation study for attenuation of chromium toxicity stress using lemongrass: *Cymbopogon flexuosus* (Nees ex Steud.) W Watson. *Int J Phytoremediation.* 2018;20(13):1324-1329.
- Pontes ECU, Melo HM, Nogueira JWA, Firmino NCS, de Carvalho MG, Júnior FEAC, *et al.* Antibiofilm activity of the essential oil of citronella (*Cymbopogon nardus*) and its major component, geraniol, on the bacterial biofilms of *Staphylococcus aureus*. *Food Sci Biotechnol.* 2019;28(3):633-639.
- Rabe AM, Aliero BL, Galadima A, Baqi AS. Thermal decomposition of camel grass and lemon grass. *J Sci Res Rep.* 2017;1-4.
- Ross IA. Chemical constituents, traditional, and modern medicinal use. Totowa (NJ): Humana Press; 2001.
- Silvestre WP, Livinalli NF, Baldasso C, Tessaro IC. Pervaporation in the separation of essential oil components: A review. *Trends Food Sci Technol.* 2019;93:42-52.
- Sisay B, Debebe E, Meresa A. Phytochemistry and method preparation of some medicinal plants used to treat asthma - review. *J Anal Pharm Res.* 2020;9(3):107-115.
- Thiagamani SMK, Rajini N, Siengchin S, Rajulu AV, Hariram N, Ayrilmis N. Influence of silver nanoparticles on the mechanical, thermal, and antimicrobial properties of cellulose-based hybrid nanocomposites. *Compos Part B Eng.* 2019;165:516-525.
- Langan M. Virtuous Power Turkey in Sub-Saharan Africa: The 'Neo-Ottoman' Challenge to the European Union. *Third World Quarterly.* 2017 Jun 3;38(6):1399-414.

23. Diop MT. *Entwicklungspolitik und Partizipation in Senegal*. Springer Fachmedien Wiesbaden; 2017.
24. Tran TA, James H, Pittock J. Social learning through rural communities of practice: Empirical evidence from farming households in the Vietnamese Mekong Delta. *Learning, culture and social interaction*. 2018 Mar 1;16:31-44.
25. Olayemi OM. Awareness and Perception of National Health Insurance Scheme (NHIS) among Librarians' in Nigeria. *International Journal of Perceptions in Public Health*. 2017;2(1):56-63.
26. Premathilake D, Outlaw RA, Quinlan RA, Parler SG, Butler SM, Miller JR. Fast response, carbon-black-coated, vertically-oriented graphene electric double layer capacitors. *Journal of The Electrochemical Society*. 2018 Jan 1;165(5):A924-31.
27. Bhatt DL, Steg PG, Miller M, Brinton EA, Jacobson TA, Ketchum SB, *et al*. Cardiovascular risk reduction with icosapent ethyl for hypertriglyceridemia. *New England Journal of Medicine*. 2019 Jan 3;380(1):11-22.
28. Markovic S, Iglesias O, Singh JJ, Sierra V. How does the perceived ethicality of corporate services brands influence loyalty and positive word-of-mouth? Analyzing the roles of empathy, affective commitment, and perceived quality. *Journal of business ethics*. 2018 Apr;148(4):721-40.
29. Mesiarová-Zemánková A, Kelly S, Ahmad K. Bonferroni mean with weighted interaction. *IEEE Transactions on Fuzzy Systems*. 2018 Jan 12;26(5):3085-96.
30. Syverson PF, Goldschlag DM, Reed MG. Anonymous connections and onion routing. In *Proceedings. 1997 IEEE Symposium on Security and Privacy (Cat. No. 97CB36097)* 1997 May 4 (pp. 44-54). IEEE.
31. Patra AK, Abbadie L, Clays-Josserand A, Degrange V, Grayston SJ, Loiseau P, *et al*. Effects of grazing on microbial functional groups involved in soil N dynamics. *Ecological monographs*. 2005 Feb;75(1):65-80.
32. Brown HM. Peer review should not be anonymous. *BMJ: British Medical Journal*. 2003 Apr 12;326(7393):824.
33. Lal R. Managing soils and ecosystems for mitigating anthropogenic carbon emissions and advancing global food security. *BioScience*. 2010 Oct;60(9):708-21.
34. Black EW, Mezzina K, Thompson LA. Anonymous social media-Understanding the content and context of Yik Yak. *Computers in Human Behavior*. 2016 Apr 1;57:17-22.
35. Rao BL, Sobti SN. CKP/25, a hybrid lemongrass. *Indian Perfumer*. 1991;35(3):148-9.
36. Kulkarni BN, Anantharama V. Repercussions of COVID-19 pandemic on municipal solid waste management: Challenges and opportunities. *Science of the Total Environment*. 2020 Nov 15;743:140693.
37. Himmel ME, Ding SY, Johnson DK, Adney WS, Nimlos MR, Brady JW, *et al*. Biomass recalcitrance: engineering plants and enzymes for biofuels production. *science*. 2007 Feb 9;315(5813):804-7.
38. Chang S, Till H, Viturro E, Watson K, Pérez AT, González A, Castellanos A. Measurement of toner cohesion in liquid inks using a visualization cell. In *NIP & Digital Fabrication Conference 1998 Jan 1 (Vol. 14, pp. 218-221)*. Society of Imaging Science and Technology.