

a heritage of whole humankind, a heritage to delight in. Those who would 'cola-nize' the world, and make it uniform, do not understand this.

Just look at some of the conflicts in the world today – Ireland, Albania, Serbia, Kosovo, many in Africa, the Middle East, India, Pakistan, Sri Lanka, East Asia, also Americas. Most of these have arisen because intimacies feel threatened. Much like living organisms, they respond with unduly strong immunological responses. This often exacerbates the situation even further. And the cycle continues.

We have to realize that globalizing efforts to rub out the intimacies will make the situation even worse. We have to learn to place them on a global canvas, a cosmic canvas, with space vision.

Who would bring in the world of space vision? You can, but on one condition. Do not become mere experts. Design and build your space systems,

go to the moon or Mars, build solar power satellites, bring in ever new and cunning devices to improve communications, and many more things. But do not become mere experts. Such people can be rather dangerous. This is not to say that those who are not experts in anything cannot be dangerous, besides being redundant. Many academics, politicians and diplomats also belong in that category. There are moments when I wonder whether I am also a member of the same fraternity.

Your vision comes through your expertise and your passion, only if you are not imprisoned by your expertise. Do not be seduced into believing that the well-being of this earth, including the spiritual and ethical climate of the planet, is a concern that belongs in another department.

This is not just an evangelical sermon. I have observed your enthusiasm, your striving spirit, your capacity to

dream and your capabilities. There are innovations waiting to be discovered, science to be done and technologies invented. Engage in all this, but do not let go of your space vision and a deep respect for specificities. If you do let go you may still have a successful future, but your success will be limiting and not up to your real potential. I urge you to seek your potential.

You belong in a group that could begin the task. There is a possibility of unprecedented personal fulfilment in this venture. I commend it to you.

Remember. The space vision implies that from now on the whole earth is the responsibility of the whole earth.

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SCIENTIFIC CORRESPONDENCE

Comparative antifungal activity of essential oils and constituents from three distinct genotypes of *Cymbopogon* spp.

Essential oil distilled from field population of three distinct genotypes of *Cymbopogon* spp., namely *C. martini*; *C. flexuosus* and *C. winterianus* was evaluated for antifungal activity. Also four oil components, namely geraniol, citronellol, citronellal and citral were simultaneously assayed for comparative activity. The comparison indicated specific activity profiles. Invariably *Microsporum gypseum* was found to be most sensitive to these oils/components. Activity-wise, lemon grass oil was most active followed by palmarosa oil and then citronella oil. This study on oils distilled from stable genetic populations provides dependable criteria for selection of high value oil combination(s). The possibility of using these oils/components in combination to obtain antifungal formulation is also obvious.

Essential oils from various aromatic plants are known to show a wide spectrum of anti-microbial activity against both plant and human pathogenic mi-

croorganisms. The essential oils have been evaluated for antifungal activities from palmarosa^{1,2}, citronella³ and lemon grass^{4,5} and also for constituents like geraniol and citral^{2,6}. *Cymbopogon* species represent a wide diversity in phylogenetic relationships⁷ and hence the chemotypic variation in their essential oil composition is genetically traceable. We utilized essential oils from well-established genetically stable and uniform genotypes of three species, namely *C. martini*, *C. flexuosus* and *C. winterianus* for comparative bioactivity evaluation. In addition, based on their chemotypic constitution, four of their constituents were taken for comparative bioactivity testing. These included citral, geraniol, citronellol (rascemic of d and l-citronellol) and citronellal (aldehyde) isolated from the essential oils of lemon grass (*C. flexuosus*), palmarosa (*C. martini*) and citronella (*C. winterianus*). Four human pathogenic fungal strains were used as the biologi-

cal screen to compare the levels of activity in these oils and some of their constituents with the objective of identifying plant substances for future antifungal formulation(s).

The elite genotypes used in the oil extraction were variety Pragati of *C. flexuosus*⁸, variety CIMAP/PRC-1 of *C. martini*⁹ and variety BIO-13 of *C. winterianus*¹⁰.

The per cent purity of the isolates was determined by GLC analysis showing citral (94%), geraniol (95%), citronellol (rascemic, 90%) and citronellal (aldehyde, 90% pure). Four human pathogenic fungi, namely, *M. gypseum*, *Aspergillus niger*, *Candida albicans* and *Sporothrix schenckii* were used as screen. These four clinical isolates were procured from Uma Banerjee, All India Institute of Medical Sciences, New Delhi. Sabouraud dextrose agar/broth invariably was the medium used for culture maintenance and the bioassays. Antifungal activity testing was done

Table 1. Comparative bioactivity profiles of essential oils/components tested against four fungal isolates

Essential oil/ components	MG			CA			AN			SS		
	ZOI	MID	MFC	ZOI	MID	MFC	ZOI	MID	MFC	ZOI	MID	MFC
Lemon grass oil	40	1/6400	1/3200	25	1/3200	1/1600	21	1/800	1/800	35	1/1600	1/1600
Palmarosa oil	38	1/3200	1/3200	15	1/1600	1/800	19	1/6400	1/100	19	1/1600	1/800
Citronella oil	34	1/1600	1/1600	7	1/800	1/800	8	1/400	>1/100	12	1/800	>1/100
Citral	32	1/6400	1/3200	6	1/800	1/800	7	1/400	1/400	20	1/800	1/400
Geraniol	40	1/3200	1/1600	20	1/1600	1/800	15	1/6400	1/400	25	1/3200	1/800
Citronellol	36	1/3200	1/1600	20	1/1600	1/1600	15	1/6400	1/400	23	1/3200	1/400
Citronellal	33	1/1600	1/800	5	1/400	1/400	4	ND	ND	8	1/400	1/400

MG, *Microsporum gypseum*; CA, *Candida albicans*; AN, *Aspergillus niger*; SS, *Sporothrix schenckii*; ND, not determined; ZOI, Net zone of inhibition (mm) as determined by disc diffusion assay; MID, Minimal inhibitory dilution; MFC, Minimal fungicidal concentration.

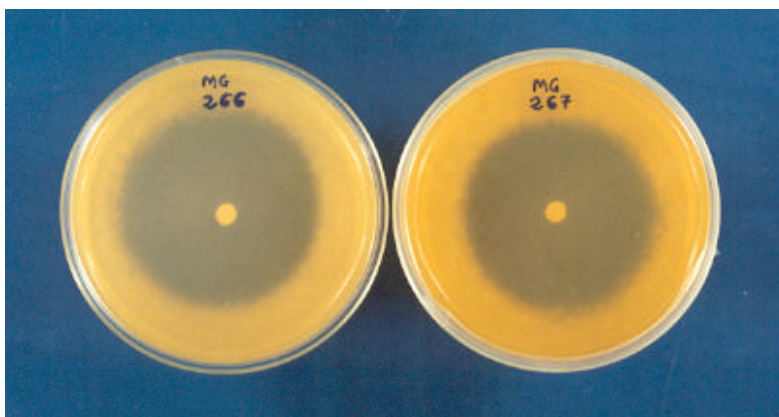
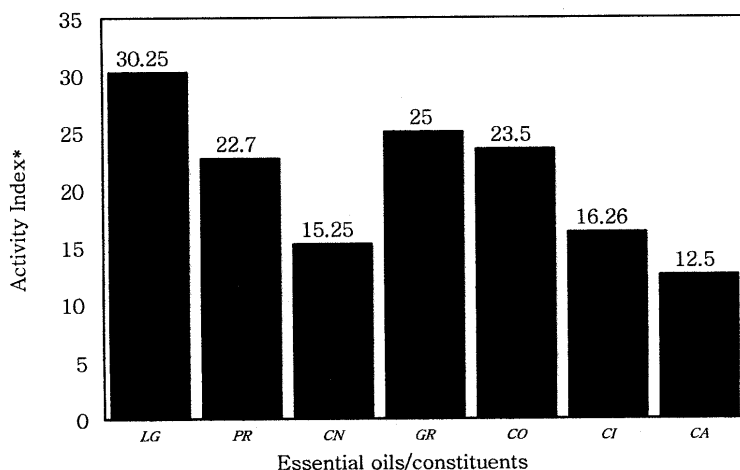
a**b**

Figure 1. *a*, Typical zone of inhibition of essential oil components, (left) geraniol and (right) citronellol against *M. gypseum*; *b*, Comparative antifungal activity of three essential oils and four constituents. LG, Lemon grass oil; PR, Palmarosa oil; CN, Citronella oil; GR, Geraniol; CO, Citronellol; CI, Citral; CA, Citronellal. *Activity index was calculated as the mean value of net zones of inhibition (mm) against all four fungal test strains.

using standard disc-diffusion assays¹¹. For preparing the test discs, 5 µl of the essential oil or the constituent was pipetted onto 5 mm filter paper discs made from Whatman No. 3, which were

carefully transferred onto the surface of seeded agar plate. The plates were incubated at 28°C for 7–10 days following which the diameter of the inhibition zone was measured. The net zone of

inhibition was determined by subtracting the disc diameter (i.e. 5 mm) from the total zone of inhibition shown by the test disc in terms of clear halo fungal lawn around the disc. MID (minimal inhibitory dilution) was estimated using macro dilution broth assays. For this purpose, two-fold serial dilution series was employed to assess the MID of a given compound. In each assay, 20 µl of fungal culture (ca. 0.7×10^5 spores) prepared as before was added to the medium and incubated at $28 \pm 2^\circ\text{C}$ in a shaker bath and the killing or inhibition was examined by visible turbidity. MFC (minimal fungicidal concentration) was determined by plating 100 µl from each tube used for determining MID and observed for any growth after 5 days of incubation.

The comparative evaluation of essential oils from three distinct species of *Cymbopogon* showed variation in the level of activity against four human pathogenic fungi. This variation was evident from zones of inhibition as well as in MID and MFC values (Table 1). Similar observations were made when some of the known major components of these oils were also tested, namely citral, geraniol, citronellol and citronellal. Invariably, *M. gypseum* was found to be highly sensitive to all these essential oils and tested components. The inhibition zones on this fungus in the disc-diffusion assays were 1.5- to 2-fold larger (Figure 1*a*) compared to others and accordingly the MID values were also low. This observation differing from an earlier report⁵, probably indicates strain differences in sensitivity to lemon grass oil.

The most active oil was lemon grass oil followed by palmarosa and then

citronella. Among the oil constituents, geraniol from palmarosa oil was the most active followed by citronellol (ex. citronella) and citral from the lemon grass oil. Minimum activity was shown by citronellal from citronella (Figure 1 b).

Interestingly, difference in activity of whole oil and citral has been reported⁵, with lemon grass oil showing higher activity than this pure isolate. In our study citral, which had a low activity index producing smallest inhibition zones against *M. gypseum*, demonstrated the highest activity in terms of MID as well as MFC values comparable to the lemon grass oil. *M. gypseum* is known to cause hair and scalp infections in humans and thus lemon grass oil in general and citral in particular can be good candidates for medicated formulations like shampoos, hair oil, etc. In fact the combination of these with other active components like geraniol and citronellol can be tested for synergism, if any. Against *C. albicans* also lemon grass was most effective, but not citral. Against *A. niger*, however, palmarosa oil was the most effective in terms of inhibitory activity (MID), but that did not translate into fungicidal activity (MFC). MFC again was highest in lemon grass oil. Hence this combination might be useful in case of growth inhibition of *A. niger* and then its elimination. Against *S. schenckii*, geraniol showed the best inhibition, but for fun-

gicidal activity (MFC) again lemon grass oil was the best. Hence lemon grass oil enriched with geraniol might be a good approach for its control.

This study being on genotype-specific oils distilled from field plants where chemotypic constituent is well stabilized and defined opens up new avenues for developing new oil compositions through genetic selections/hybridization to yield value-added oils with such effective combinations, so that these oils can be directly used as formulations. On the other hand, it will be important to study synergistic/antagonistic effects in combination (work in progress), so that these oils and their components could be converted into therapeutic or skin and hair care formulations.

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Significance of sequential opening of flowers in *Gloriosa superba* L.

Gloriosa superba (family Liliaceae), a perennial herb and an important medicinal plant as a source of colchicine used in gout, etc.¹, is characterized by very low seed set in nature². Both its tuber and seed have similar medicinal properties³, but because of low seed set only tubers are being harvested. Economical tuber harvest is after 3–4 years which leads to destructive harvesting resulting in the species coming under the threatened category⁴. Investigations to study the causes of low seed set in this species have revealed that the species is (i) both self- and cross-

pollinated, and (ii) seed set is dependent upon both pollinator activity and the time of pollination^{5,6}. Although there are no self- or cross-incompatibility barriers, the herkogamous and attractively-coloured flowers favour cross-pollination. Its flowers change colour and a particular colour pattern can be identified with a particular stage. The perianth lobes at the bud-opening stage are light-greenish in colour. This is followed by the stigma-receptive stage which is characterized by perianth lobes that are crimson-coloured at the tip, yellow in the middle and greenish to-

wards the base. Post-pollination stage is characterized by the upper half of perianth lobes being crimson coloured and the lower portion being yellow coloured. Lastly, the perianth lobes turn entirely crimson coloured. The peculiar structure of the large flowers with six perianth lobes bent backwards, six radiating anthers and the style bent almost 90° at the point of attachment to the ovary, does not make them suitable for pollination by small insects. Only large insects like bumble bees and birds like *Nectarinia zeylonica* and *Nectarinia asiatica* with long beaks⁷ have been