Allelopathic impact of \textit{Cymbopogon}

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\textbf{ABSTRACT:} Food security is a major issue worldwide. As steady we are advancing towards development of synthetic pesticides so steady is the development of resistance among microorganisms. Developing nations are witnessing crop loss to microbes at a more frequent rate as compared to developed nations. Human beings are shifting their concerns to find eco-friendly means to deal with food crises as the results of excessive use of synthetic herbicides are already proving hazardous and drawing criticism from vast populations. Plant essential oils are natural plant secondary products that have allelopathic aspects and are completely environment friendly and can have potential use in agriculture. Citral is one such essential oil derived from lemongrass (\textit{Cymbopogon citratus}) and has various benefits both for plants as well as humans. This review is based on comprehensive study of lemongrass and its possible application in improving crop production including that of tomato in order to deal with global issue of food production and security.

\textbf{INTRODUCTION}

Allelopathy (Gk, \textit{allelon} meaning ‘one another’, \textit{pathos} meaning ‘suffering’) is basically a plant interference mechanism which is carried out by inducing rhizosphere of soil with secondary products which are produced by plants themselves. The adverse effects exerted by plants influencing one another’s growth are denoted by the term interference. Term allelopathy was first coined by Molisch who however defined it as all biochemical reactions between plants including microorganisms. Although this definition is quite broad but is most relevant as recent researches reveal the implication of microorganisms for possible involvement in producing phytotochemically active compounds or allelochemicals (Inderjit and Weiner, 2001; Putnam, 1986). Allelochemicals are found in almost all the plants, at hand available in their tissues like leaves, roots, stem, flowers, bark, seeds etc. When the environmental conditions are favourable these allelochemicals are released into the rhizosphere in appropriate quantities in order to influence the growth and development of nearby plants (Weston, 1996). Allelochemicals propose a future prospective of being developed into herbicides. This can help in escalation of weed management and protection of flora biodiversity.

The increased use of pesticides have been drawing flak lately, concerning human health and environment welfare due to tremendous hazards they pose towards it (Paster and Bullerman, 1988). Mankind is now looking for safer alternatives against synthetic pesticides. Plant secondary products which possess pesticidal activity can be considered good alternative due to their least environmental effects (Ravid and Juven, 1995; Hamilton-Kemp et al., 2000;
Paranagama et al., 2003). Essential oils which can be derived from various plant parts are complex secondary plant products having vital functions like protection against pest and diseases (Goubran and Holmes, 1993). Lemongrass (Cymbopogon citratus L.) belongs to genus Cymbopogon which is a tropical grass family having characteristic dense leaves. It possesses 1 - 2% of essential oil which is commonly known as west Indian lemongrass oil. The main component of this essential oil is citral (3,7-dimethyl-2,6-octadien-1-al) from which vitamin A, betacarotene and ionone can be produced (Paviani et. al., 2006). According to researches, lemongrass oil has been found to possess antimicrobial properties which even include disease causing fungi in humans (Appendini and Hotchkiss, 2002; Daferera et. al., 2003; Serrano et. al., 2005). Lemongrass is popularly known for a tea which is prepared from its leaves which is known to possess antispasmodic properties (Devi et al., 2011). Apart from this Liete et al., in 1986 and Saddiq and Khayat, in 2010 have reported its anti-inflammatory, pain relieving, diuretic, antifever and sedative properties. Numerous other properties of this include apetite promotion, antiseptic, tranquiliser, antipyretic, antihypertensive and carminative effects (Borreli and Izzo, 2000). Previous studies reveal its neurobehavioral, anti-inflammatory, fungistatic and antimicrobial activities (Carlini et al., 1986; Carbajal et al., 1989; Francisco et al., 2011). Many countries are using C. citratus as a sedative of which Mexico is an important example (Tortoriello and Romero, 1992). Brazil too reports of using cold juice derived from its leaves as sedative as well as an analgesic (Hiruma-Lima et al., 2002). Its medicinal use is not restricted to these countries only but have been identified worldwide for example Fook in 1980 reported its use against gastric problems, pneumonia, common cold and fever in Malay peninsula and Mauritius Island. Similarly in Nigeria it is used as an antipyretic (Olaniyi et al., 1975). Indonesian people use it to aide digestion and also as diuretic and sudorific (Hirschhorn, 1983). Its antiseptic and antirheumatic properties are considered in India and Angola (Alves et al., 1960). Lemongrass essential oil is used in India to treat gastrointestinal problems (Alves et al., 1960) while another of the component of essential oil called geraniol is used in china as an asthmolytic (Peigen, 1983). Research reveals antioxidant parameters of leaves of lemongrass (Cheel et al., 2005). Stem of lemongrass when tested against profuse mesenteric arteries exhibited a slight effect of relaxation (Runnie et al., 2004). Therefore from the enormous number of health benefits in humans we could probably make analysis of potential uses of lemongrass in plants as well. Several researches have already been done in this regard with many positive results. Currently food security and crop production are global issues. To deal with these crises, there need to be devised certain ways. Natural plant products can be a good alternative over synthetic herbicides because not only these are eco-friendly but are very effective as well. Lemongrass is effective against several pathogens indicating its possibility of being developed into biopesticide to be probably used in crop plants including tomato which faces huge loss every year due to pathogen infections.

Tomato plant (Lycopersicon esculentum) belongs to the family Solanaceae. It is the second most grown vegetable crop worldwide after potato. It is an important vegetable cum fruit crop and is used both as raw material as well as supplement to other products. Tomato plant is susceptible to various diseases caused by numerous pathogens such as bacteria, fungi, nematodes and viruses. Identified pathogens and diseases are nearly about 200 in number.
which lead to crop damage and decrease in yield (Nowicki et al. 2013). Fungal pathogens cause the diseases such as Sclerotinia rot, Fusarium wilt, late blight, Fusarium crown, and root rot. The most damage causing fungal disease is late blight causative agent of which is Phytophthora infestans. 20-70% is the total estimated economic loss attributed to this disease (Foolad et al., 2008; Nowicki et al., 2012, 2013). Among the bacterial diseases, bacterial leaf spot is quite common causative agent of which is Xanthomonas campestris. About 10-80% of total productivity loss in India is attributed to this disease (Sharma and Sharma 2005), while there are numerous viral diseases in tomato among which tomato spotted wilt virus is most prevalent (Rossello et al. 1993). Post-harvest pathogens pose yet another threat to tomato yield so in order to deal with these problems allelopathy can be prove effective. C. citratus effect should be analysed so as to check the possible solutions for these various problems.

Cymbopogon and its potential impact

Enormous research has been done on lemongrass analysing its various pharmacological benefits and research has also been done on allelopathic effects of its essential oil. An experiment was carried by Plotto et al. in 2002 analysing the effect of various essential oils that included lemongrass as well on postharvest disease control in tomato. Results revealed that lemongrass vapours resulted in complete inhibition of growth of Alternaria arborescens and Botrytis cinereal. Citral was found sensitive to pathogen Geotrichum candidum. Lemongrass oil failed to suppress growth of Rhizopus. A study was conducted by Pradhanang et al in 2003 in which greenhouse experiment was performed to check efficacy of essential oils against the population density of pathogen Ralstonia solanacearum and the occurrence of bacterial wilt in tomato results led to conclusion that lemongrass oil does have the potential to inhibit the in soil growth of R. solanacearum populations and reduce the occurrence of bacterial wilt in tomato and therefore this essential oil can be employed to manage various soilborne diseases in tomato plant.

Lucas et al. in 2012 conducted an experiment to study essential oils antibacterial efficacy that included lemongrass essential oil as well against Xanthomonas vesicatoria and for control of severity of bacterial spot in tomato. Results showed that when the essential oil concentration in vitro was kept above 10% which included oils like clove, cinnamon, lemongrass etc lead to inhibition of growth of Xanthomonas vesicatoria and at concentration of 0.1% all essential oils were able to reduce tomato bacterial spot disease indicating possible other factors contribution towards essential oil action in vivo. Lemongrass essential oil also lead to disintegration of bacterial cell wall in vitro. Hammer et al. in 1999 conducted an experiment to study Antimicrobial activity of about 52 plant essential oils which included lemongrass against pathogens namely Serratia marcescens, Aeromonas veronii biogroup sobria, Klebsiella pneumoniae, Candida albicans, Escherichia coli, Enterococcus faecalis, Acinetobacter baumanii, Salmonella enterica, Pseudomonas aeruginosa, subsp. and Staphylococcus aureus with the help of agar dilution method results revealed that Lemongrass as well as oregano and bay essential oils were able to inhibited all these organisms at concentrations of ≤2·0% (v/v). Velluti et al. in 2003 evaluated the contribution of Fusarium proliferatum in the growth and production of fumonis in B1 in maize plant and analysed various aspects of its inhibition using essential oils of lemongrass, clove, cinnamon,
oregano and palmrose. Result suggested that only lemongrass showed inhibitory effect against FB1 production at 30 °C and only essential oils of oregano and cinnamon could control FB1 production in maize under preharvest conditions.

In an experiment by Somda et al. in 2007 Antifungal Effect of essential oils of lemongrass C. citratus, (Neem) Azadirachta indica and camaldulensis were evaluated against seed-borne fungi in sorghum i.e Phoma sorghina, Colletotrichum graminicola and Fusarium moniliforme results indicated that C. citratus essential oil resulted in 76.2% in vitro inhibition of C.graminicola as compared to Dithane M-45 fungicide it was also observed that C. citratus essential oil was effective at about 6% concentration in controlling C. graminicola transmission to seeds. Therefore it was concluded that lemongrass essential oil is effective for sorghum seed treatment as it helps in controlling of F. moniliforme, C. graminicola and P. sorghina. A research was done by Satthanakul et al in 2015 in which lemongrass oil’s antimicrobial effect towards oral malodour microbes was checked. The results obtained showed that mouthrinse from lemongrass was found to be effective against microbes such as Porphyromonas gingivalis W50 and Aggregatibacter actinomycetemcomitans ATCC43718 but ineffective against Streptococcus mutans ATCC 25175. The study concluded that lemongrass is effective and safe for use as mouthrinse against prevention of malodour, plaque and even gingivitis.

A study was conducted by Balakrishnan et al in 2014 to check the potential of lemongrass as antioxidant and antibacterial agents against disease causing pathogens in humans results revealed that human pathogens like pseudomonas aeruginosa, Bacillus subtilis and Proteus vulgaris were completely inhibited. It was also observed that leaf extracts of C. citratus showed a sound antibacterial activity against gram negative as well as gram positive microbes leading to conclusion that lemongrass can offer sound healthy benefits. In another study, conducted by Soonwera et al. in 2015 to check efficacy of thai essential oils as mosquito repellent. The selected mosquito vectore were Culex quinquefasciatus and Aedes aegypti respectively results showed that lemongrass oil mixed in olive oil exhibited efficacy to about 98.9% in repelling C. quinquefasciatus for nearly about 170 minutes. Hence it was concluded that C. citratus oil can be regarded as green repellent for the control of mosquito menace and is ecofriendly and safe for both animals and humans. Vazirian et al conducted a study in 2012 to check the antimicrobial efficacy of C. citratus against food borne pathogens that included E.coli, Bacillus cereus, Staphylococcus aureus, Candida albicans and Salmonella typhimurium that were added to creamy cakes and pastries results showed that lemongrass was able to show its potential antimicrobial activity against these food borne pathogens and hence can be considered as good preventive measure against food spoilage and can also act as natural preservative. It can also prevent diseases which can develop after contaminated food consumption. Paret et al. in 2010 analysed the effect of essential oils which included lemongrass on the inbition of Ralstonia solanacearum race 4 and control of bacterial wilt in ginger. Results revealed that lemongrass oil in culture assay with palmarosa at 0.014% inhibited the growth of the bacterium indicating their possible use as biofungicide for reduction of bacterial wilt in edible ginger. Goes et al. in 2015 conducted an experiment to determine the effect of aroma of C. citratus on anxiety in humans the results revealed that the
volunteers that were exposed to 3-6 drops test aroma immediately showed a decrease in their state of anxiety and tensions after the administration of treatment. This experiment showed desired anxiolytic results although the time exposure to aroma was quiet brief. Therefore more study and research might lead to its clearance in clinical relevance. Paranagama et al. in 2003 conducted a study to evaluate the fungicidal activity of lemongrass oil against the fungus Aspergillus flavus that was isolated from stored rice. Results showed that fungicidal constituents of lemongrass are citral a and b. results also revealed that at a concentration of 2-80 and 3-46 mg ml⁻¹ respectively complete inhibition of sporulation and mycelial growth was observed. Hence lemongrass can be used to prevent the growth of Aspergillus flavus in stored rice.

**Conclusion:** From the vast study of literature it can be concluded that lemongrass (Cymbopogon citratus) has diverse benefits for both humans and plants. In terms of health benefits in humans it has shown anticancer, anti-inflammatory diuretic, pain relieving, antipyretic and sedative properties. It even works well as a mosquito repellent and has shown significant antimicrobial activities. In terms of plants it has significantly reduced various plant diseases and has proved fruitful in dealing with different kinds of disease causing microorganisms. Lemongrass is completely natural and environmental friendly with no side effects. The excessive use of pesticides and fungicides has led to evolving of pesticides resistant microbes. Due to tremendous health hazards of synthetic herbicides/pesticides mankind has shifted its concerns towards something that could be effective as well as eco-friendly. Food security which is major concern nowadays also needs implementation of effective and less harmful measures for dealing with crop problems and various diseases causing pathogen in crop plants. Plant essential oils are natural plant products that can prove beneficial and lead to crop enhancement Lemongrass enormous uses in pharmacology as well as agriculture has already been discussed but more research is yet to be done especially in the field of agriculture so as improve crops and to deal with various plant diseases including tomato which is a very important food crop, so as to address the global issue of food security.

**References**


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