



## VETIVERIA ZIZANIOIDES L. NASH-A WONDER PLANT:AN INDUSTRIAL PERSPECTIVE

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### ABSTRACT

In many parts of South Asia, Southeast Asia and West Africa the medicinal uses of *Vetiveria zizanioides* L. Nash are well known. In India it is widely used for the preparation of many household articles. Especially in some parts of Karnataka vetiver roots have been used to prepare refreshing herbal drinks to beat tiredness. *Vetiveria zizanioides* essential oil shows very important properties against fungal and microbial growth. Vetiver oil is a nice mixture of hydrocarbons and sesquiterpene alcohols with remarkably low evaporation rate. Its extracts are utilized as an important ingredient of a body cleanser, powder and as an exfoliating agent and is equally beneficial for the body massage. It also shows potent anti-inflammatory, antioxidant, anti-pest, bioremediation properties. So, with such enormous properties *Vetiveria zizanioides* becomes a brilliant choice for the industrial usage.

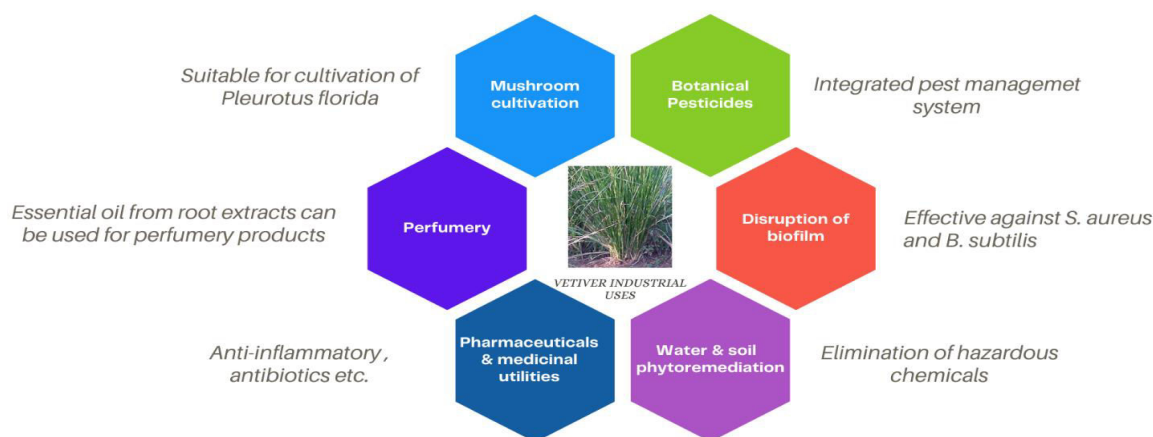
**Keywords:** *Vetiveria zizanioides*, essential oil, anti-inflammatory, antioxidant, root extracts, vetiver grass.

### 1. INTRODUCTION

In some parts of Karnataka vetiver roots are used to prepare refreshing herbal drinks. In some rural parts of India its roots are entwined to make window coverings. It is also used as a flavoring agent in ice-cream, syrups, milkshakes, yogurt, soft drinks, chewing tobacco, paan masala etc [1]. It is extensively used in perfumes, shampoo, and liquid soaps. Various tribes from among the world use the different parts of this plant for multiple complications like headache, mouth ulcer, fever, boil, burn, snakebite, etc. Vetiver plant can be exploited in dried, semi dried form or even its freshly harvested leaves and roots are utilized for many different purposes either in processed or non-processed forms [2]. Few of the non-processed production includes e.g., animal fodder, thatch for roofs, mulch for soil to retain moisture, mushroom medium bouquet, compost; likewise the semi-processed products from vetiver plant includes e.g. handicraft, pots, low-cost silo, furniture; and amongst the fully-processed products are primarily the essential oil and the derivatives and also includes herbal medicine along with pulp and paper, ash as cement replacement material, and industrial products [1].

*Vetiveria zizanioides* essential oil has very important properties like antifungal and antimicrobial activities. It also shows potent anti-inflammatory and antioxidant

properties. Vetiver oil exhibits impressive free radical scavenging activity (~ 93%) when dissolved in methanol. The presence of Malondialdehyde is reported which is a marker for oxidative stress. Since years, traditional use of Vetiver as a medicine in some parts of South Asia, Southeast Asia and West Africa is well known. Vetiver oil is consumed in China and the edible oil extracted from the plant is sold there in higher prices [1]. Its use as an additive in other foods is a permissible act. Its extracts are utilized as an important ingredient of a body cleanser, powder and as an exfoliating agent and is equally beneficial for the body massage. The soft powders of vetiver are prepared and then mixed with chickpea flour which is said to encourage the circulation and helps liquefaction/liquefaction of fat which in turn improves the health of the skin. The oils are often used for the stress relieving body massage and for removing the excess oil from the skin. The powder is known to regulate/balance the activity of oil glands and helps in maintaining moisture in the dehydrated skin. Vetiver oil is a great mixture of hydrocarbons and sesquiterpene alcohols with low evaporation rate. It also shows high solubility in alcohol [2]. *Vetiveria zizanioides* oil extracts is found to contain three major components, 18.48% of valerenol 10.21% of valerenal and 6.23% of  $\beta$ -cadinene.



**Fig. 1: Industrial uses of *Vetiveria zizanioides* L. Nash in various streams**

## 2. *VETIVERIA ZIZANIOIDES* PLANT EXTRACTS APPLICATIONS

### 2.1. Vetiver grass for the cultivation of oyster mushroom

Extremely beneficial role of vetiver that has been studied is in mushroom cultivation (Fig. 1). The production of edible mushroom by using shoot biomass of vetiver grass as a straw have been made possible. Keeping this in view, Gurudevan et al. conducted an experiment, to cultivate oyster mushroom *Pleurotus florida* [3]. They utilized vetiver grass straw alone and in combination of paddy straw (1:1) as substrates. Use of Paddy straw substrate alone was done for comparison. The results revealed that vetiver straw yielded 360 g/350 g dry straw weight with bioefficiency of 108.6% of *P. florida* mushrooms. The substrate combination with paddy straw and vetiver yielded 398.3g/350 g dry straw weight with B:C of 3.2 with bio- efficiency of 113.7%. However, paddy straw yielded 423.3 g/350 g dry straw weight with B:C of 3.2 with bio-efficiency of 120.9% [3]. In another similar experiment the utilization of vetiver straw alone gave the production of 355 to 405 g of mushroom per bed with the bio-efficiency ranges from 70 to 80 per cent. However, the combination of paddy straw and vetiver grass in 1:1 (w/w) concentration gave significantly higher yields of about 434.7 g per bed [4].

These results are suggestive of the fact that vetiver straw either alone or in combination with paddy straw can be best utilized for cultivation of oyster mushroom. The cultivation on commercial basis can thus be done effectively that will earn some additional income to farmers and will encourage the vetiver integrated farming system.

### 2.2. Disruption of biofilm maturation by vetiver root extracts

*Vetiveria zizanioides* root extracts found to have effective against the biofilm formation in concentration dependent manner (Fig. 1). According to some studies vetiver root extracts have been found effective against *Staphylococcus aureus* and *Bacillus subtilis*. Significant antimicrobial activity is shown by Vetiver root extracts against the biofilm formation in concentration dependent manner. It restricts the production of certain exopolysaccharides along with slime and  $\alpha$ -hemolysin toxin. Vetiver root extracts downregulates the genes which are responsible for the initial adherence such as *clfA*, *fnbA* and *fnbB*. The downregulation of these genes ultimately causes the disruption of biofilm maturation [5].

### 2.3. Beneficial in decontamination of Soil, water bodies and Phytoremediation

*V. Zizanioides* can be a good and cost-effective choice for Wastewater treatment and water purification strategies. Traditional Industrial Wastewater Treatment Methods (WWTM) are money draining (Fig. 1). However, phytoremediation techniques implemented for the purification of various types of wastewater bodies with the pollutants from industries are found cost effective as well as highly efficient [6,7]. Impressive results were obtained on the application of phytoremediation techniques utilizing vetiver grass. The observed results establish the ability of the vetiver grass in rising wastewater quality and thereby diminishing or eliminating the hazardous effects of the polluted water on the environment during wastewater discharge [8, 9]. Grass of *V. zizanioides* has been used for waste water

treatment activities in the polluted water bodies. *V. zizanioides* a plant with higher resistance and is enduring in adverse climatic conditions. It has a huge, fibrous and long roots that gives a plant the unique ability to absorb much more pollutants and create a promising condition for aerobic bacteria to develop naturally. Thus, the process of decomposition of chemical, organic pollutants occurs more effectively than many other plants. Some studies are reported where *V. zizanioides* has been used effectively for the improvement of wastewater quality of organic wastewater from tapioca factory [10]. Vetiver plant is equally effective for phytoremediation of heavy metals [10]. *Vetiveria zizanioides* because of its long hairy roots is well known for its natural part in preventing soil erosion and rehabilitation of the metal polluted land. 2,4,6 trinitrotoluene (TNT) is a common pollutant of soil. Another interesting application of vetiver is associated with the degradative treatment of 2,4,6 trinitrotoluene (TNT). TNT has been identified as a cancer causing substance and has a role as an explosive and is commonly found in explosive contaminated areas. TNT as an explosive is used in military tank shells, for making bombs and grenades, for underwater blastings and in industrial uses. Studies carried out in this regard concluded that *Vetiveria zizanioides* grass is capable of removing Trinitrotoluene from contaminated soils. The pretreatment with urea chaotropic agent is recommended [11]. Additionally, investigation that how the effectiveness of TNT removal of vetiver-urea system alters in concentration dependent manner, and what are its recommended concentration range for agricultural purposes [12]. According to the results of further studies, TNT and few of its derived byproducts were observed in vetiver grass root and shoot system, that indicates the capability of vetiver to translocate TNT from the root to shoot system and its good potential to degrade TNT.

#### 2.4. Utilities of vetiver essential oil in pharmaceutical industries and medicinal utilities

Till date, around 25 distinct compounds in *V. zizanioides* essential oil (VZ-EO) have been studied. The major components observed were cedr-8-en-13-ol, found at the concentration of 12.4% another component was  $\alpha$ -amorphene found at the concentration of 7.80%. The other two compounds e.g.  $\beta$ -vatiene and  $\alpha$ -gurjunene are found at the concentration of 5.94% and 5.91% respectively [13]. *Vetiveria zizanioides*

essential oils may be effective in suppressing the inflammatory responses of LPS-stimulated RAW 264.7 macrophages. It may be useful in suppressing nitric oxide production and cell apoptosis. It is found to regulate the expression of the enzymes such as heme oxygenase-1, inducible nitric oxide synthase and cyclooxygenase-2 that are related to the inflammation. The expression of inflammatory cytokines tumour necrosis factor- $\alpha$ , interleukin 1 $\beta$  and interferon- $\beta$  are also regulated [13]. The anti-inflammatory activity of VZ-EO thus can be beneficial for the synthesis of some plant based drugs and the side effects caused by the heavy doses of conventional medicines can be minimized.

Since ancient times, vetiver oil is used as a medicine for the treatment of ailments like skin diseases, piles, rheumatism, fever and fungal growth control [14-16]. In recent years, the interesting results obtained by several research findings have proved the valuable applications of *Vetiveria zizanioides* in medicine and is supported by the findings of Porras and Francisco who also received a patent for the helpful invention of associating the vetiver grass extract for increasing growth of hair and restoring or preventing excessive loss of hair [14]. The research observations and data collected on vetiver essential oil through bioactivity tests indicates that the oil shows therapeutic properties for both cosmetic and metabolic health care products in a human skin disease model. Vetiver oil reported significant properties like anti-proliferative and anti-inflammatory activity. It shows the inhibition of collagen III production. Vetiver essential oil strongly modulated global gene expression and impacted signaling pathways of several critical physiological processes that are related to tissue remodeling and cholesterol metabolism [17]. The vetiver oil is effective against tuberculosis (TB) and reported the remarkable activity against the virulent as well as avirulent strains of *M. tuberculosis* [18]. The vetiver root extract could be considered as potential antituberculosis agent. Moreover, vetiver oil extracted from roots has been tested and shown to possess mosquito repellent activity along with some other plant oils such as extracts of catnip plant, citronella, and hairy basil. The experimental results collected further confirmed that vetiver oil could serve as potential mosquito repellent against *C. quinquefasciatus* and *A. minimus* mosquitos. Various elaborative work and studies reported the essential properties like anti-inflammatory, anti-oxidant and antifungal activities of

vetiver oil along with its role against Malaria vector *A. stephensi* [19-21]. Vetiver oil is extensively utilized in aromatherapy and care for cancer patients since it can relieve pains caused in cancer condition and decrease symptoms like prolonged fatigue, anxiety, severe pain, and insomnia [22].

## 2.5. Perfume and Cosmetic Industries

Vetiver oil has woody, earthy, and grapefruit like aroma (Fig. 1). It is greatly appreciated for the production of high brand perfumes due to its pleasant odor. Vetiver oils are extracted by distillation of vetiver using distilled water and other suitable methods involving suitable solvents. Vetiver oil (VO) contains hundreds of the essential compounds such as alcohol, bicyclic and tricyclic sesquiterpenes, carboxylic acids, hydrocarbons and found to contain certain components with outstanding fixative properties because of which it is widely employed in perfume industries. Since ancient times in few parts of south India, the typical aromatic properties of vetiver roots are utilized on routine basis by soaking the vetiver roots in coconut oil overnight and the next day the coconut oil with pleasant fragrance is applied in hair. It is good starting material for fragrance constituents such as vetivene, vetiverol, vetivone, benzoic acid, and furfural [23]. Vetiver oil is used on large scale in perfume industries, primarily for its earthy and woody odor. Approximately 250 kg of *Vetiveria zizanioides* root is required for the production of 1 kg VO extract [23]. Certain chemical processes are applied and good percentage of the *Vetiveria zizanioides* oil is traditionally transformed into vetiveryl acetate. The environment friendly process is reported by Notar et al. (2017) for vetiveryl acetate using acetylation of alcohols catalyzed by lipase [23]. Apart from its humongous applications in perfumery industry, vetiver oil is also used since ages in cosmetics. The making of several cosmetic products of daily uses such as shampoos, soaps, skin bleach along with deodorants and lotions utilize vetiver oil extracted from vetiver roots. Vetiver essential oil is used worldwide for aromatherapy and is suitably incorporated in cosmetics production owing to its great aroma. The presence of low volatile component characteristics and safety specifications with negligible side effects makes vetiver an immensely profitable plant choice for farmers [24-28]. Nowadays the consumers are becoming aware about the hazardous effects of artificial cosmetic products and are demanding more enduring cosmetics. The cosmetics with natural ingredients is a preferred choice of people from all over

the world, hence the utility of vetiver essential oil in cosmetic industries is expected to rise in near future [29]. According to the recent studies conducted by the group of researchers from different countries, the vetiver oil market share is expected to reach \$ 169.5 million globally by the year 2022, according to Grand View Research [29]. Since the ancient times local people have the knowledge about the utility of vetiver oil in perfumes and as medicinal applications. However, its large-scale application in industries and markets are being known to people only in the recent decades. *Vetiveria zizanioides* is increasingly becoming a promising choice for farmers across the world owing to the large benefits of each part of the plant e.g., leaves, grass and roots. Its fibrous roots contain, approximately 3 % of oil on dry weight basis. The vetiver essential oil is easily extracted by applying simple techniques like steam distillation. In recent times, the vetiver essential oil is largely manufactured worldwide and noticeably come mostly from Asian countries like Indonesia where java is the leading producer, India (South India) and Haiti is a producer of one of the best quality vetiver oils, with an estimated capacity of 300-350 tons/year [30]. The vetiver crop oil recovery yield as reported recently is about 10-30 kg of oil/hectare [31].

## 2.6. An important agricultural application as botanical pesticides

Integrated Pest Management (IPM) systems now a days is the effective way to curb hazardous insects (Fig 1). Vetiver can be used as a biopesticides for IPM. IPM consists of trap crops and is ecofriendly. Trap crop for specific pests and natural enemy insects of harmful pest are important aspects of IPM. Integrated Pest Management has been defined as the system which reduces the harm keeping pest population in check by using minimal techniques keeping the economic, social and environmental needs of human beings. Main motto of this approach is effective management of pest and not its eradication. *Vetiveria zizanioides*, can be used as a trap crop in IPM as recommended in the pest management of stem bores of East Africa [32, 33]. This effective strategy of trap cropping as pest management has been studied widely in recent days [34-35]. Intensive research has been carried out regarding the characteristics of vetiver grass as a trap crop. The plantation of trap crop is done in close proximity to the main crop, aiming to attract the target pests from the main crop. Vetiver is known for low larval survival capability [35], thus, it can be termed as a dead-end

crop [36] for harmful pests in different environments. Different methods for vetiver as a trap crop have been cited in the literature [37]. Repellent compounds from vetiver roots are used to head lice, bed bugs, clothe moths, cockroaches and flies [37]. Essential oil of vetiver consists of various biological compounds [38] among which, six have insect repellent properties [38]. One of the natural organic compounds in vetiver roots is nootkatone. Nootkatone is a strong repellent and toxicant for Formosan subterranean termites known as *Coptotermes formosanus* in the United States of America. The regular planting of a barrier plant that manufacture a termite repellent and toxicant could provide the potential and effective repellence to this pest [38].

### 2.7. Miscellaneous uses of vetiver

Vetiver grass board manufactured broadly, consists of large amount of cellulose, high content of fiber, as well as lignin. Its properties are quite similar to natural wood. High strength of Vetiver grass board, its endurance and water resistance capacity is greatly advantageous. Vetiver grass board has a mild pleasant fragrance and possesses beautiful ornament pattern. The chemical odor of other boards containing synthetic material could be injurious to nose and eyes but Vetiver grass boards avoid this risk. It can be used to produce durable furniture, and also utilized for the production of interior design material for wall, ceiling or floor [39].

### 2.8. Future recommendation for vetiver grass utilization

In present time commercialization of only vetiver oil has been done and few applications for e.g. production of vetiver drink have been implemented in large scale so far. Many other applications of *V. Zizanioides* are still under research and are yet to be declared full proof. Therefore, there is a need to frame farmer friendly policies and should introduce several country level projects for farmers to encourage them for large scale cultivation of *Vetiveria zizanioides*. Regular and adequate funding is needed to promote the quality research in vetiver cultivation and its successful utilization in various industries. The coordinated approach among academia, government organizations and private industries should be promoted. A long-term, cost effective, stable, effective and implementable policy must be formed and suitable actions must be taken for its success [40].

The governments should organize the conferences, workshops and camps for farmers, academicians, research scholars to spread knowledge on various industrial applications of vetiver and to convince the need for increased vetiver cultivation. It should provide funding and subsidies to attract more farmers towards *Vetiveria zizanioides* cultivation; provide latest technology to support farmers and facilitate their work [41]; encouraging the groups for knowledge sharing; make available the adequate vetiver saplings and seeds [41]; government should implement supportive measures for the use of vetiver grass for energy and plant extracts containing essential oils for biochemical production. To make it more profitable for farmers and to generate rural employment there is a need for the initiation of new research projects to improve vetiver cultivation techniques for obtaining higher crop oil yields. Improvisation of vetiver cultivation techniques and application of conservation strategies for higher crop oil yields for perfumery application, e.g., by adding microbes to soil is another important aspect that should be taken care of [42].

### 3. CONCLUSION

The vast research studies conducted throughout the world, prove that, *Vetiveria zizanioides* is a potential plant and has great economic as well as environmental benefits in several rural parts of the world. Its long, fiber like, deep root system along with moist shoot provides this plant with the nice ability to endure the extreme climatic conditions along with minimal maintenance. Its effective and potentially vast applications make this plant supreme choice for conservation and cultivation purposes and also for the rural development projects. Therefore, owing to its vast application and demand as natural soil erosion remedy, phyto-remediation capability, utility as energy and bio-products, pharmaceutical and medicinal, perfumery and household applications several vetiver conservation projects must be introduced in rural as well as urban areas. This could be best achieved when developed and developing countries go hand in hand. In addition to the above mentioned points, development of modern cultivation techniques, machineries and mindful research inputs are necessary to enhance the quality and applicability of vetiver plant at industrial levels.

### Conflict of interest

Authors declare that there is no conflict of interest.

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