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Cultivation of Vetiver (*Chrysopogon zizanioides* (L.) Roberty)- A Versatile Medicinal and Aromatic Plant

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

Vetiver (*Chrysopogon zizanioides*) is a versatile medicinal and aromatic plant mainly used for soil and conservation purposes. It is a perennial grass species with a densely tufted enormous root system that grows up to two meters long. The fibrous roots are highly aromatic and used for extraction of essential oils used in high-grade perfumes as a base or fixative for their long-lasting characteristic odor. The fragrant dry roots are traditionally used for water purification in south India. Besides, the consumption of vetiver-treated water has cooling properties and refreshes the body and mind. It also acts as a deodorant and stimulant, aids digestion, and has carminative, colic, anthelmintic, and antioxidant properties. It is a very hard grass, suitable for growing in wastelands, arid regions, and hill slopes with the least maintenance. The worldwide demand for vetiver oil was estimated at around 408.8 t/year in 2019, and the growth was reported to increase at a CAGR of

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7.8 % from 2020-2027. India consumes 100 tons of vetiver oil annually; the domestic production is only 20 tons, and the remaining 80 % of the oil is imported. Hence, there is a lot of scope for increasing the vetiver area in India and globally. Looking at its vast utilization and demand, an attempt has been made to present the improved cultivation practices of vetiver based on the literature survey and experience.

Keywords: Vetiver; medicinal plant; essential oil-yield; medicinal crops.

1. INTRODUCTION

Vetiver is one of the most important essential oil-yielding medicinal crops, known as *Khus* grass, belonging to the family Poaceae (2n=20). It is a densely tufted perennial grass found growing on various soils. Roots contain a viscous, high-density essential oil with an earthy and persistent odor. The root oil will be obtained from a long distillation process, and the oil color varies from orange to red. The oil is primarily used in high-grade perfumes as a base or fixative for its long-lasting characteristic odor. Globally, Indonesia, China, and Haiti are major vetiver oil producers. Overall, around 250 tons of vetiver oil are produced every year from Haiti, Indonesia, China, Japan, India, and Brazil [1-5]. Among them, Indonesia alone produces about 75 tons of vetiver oil annually, contributing a significant share in world trade. The USA, Europe, Japan, and India are the major consumers of vetiver oil in the fragrance and pharmaceutical industries. The worldwide demand for vetiver oil was estimated at around 408.8 t/year in 2019, and the growth was reported to increase by a CAGR of 7.8 % from 2020 to 2027 [6]. India consumes 100 tons of vetiver oil annually; the domestic production is only 20 tons, and the rest 80 % oil is imported [7,8].

2. CHEMISTRY AND USE

South Indian vetiver root oil was found to be rich in sesquiterpenes and oxygenated sesquiterpenes with cedrane, bisabolane, eudesmane, eremophilane, and zizaane [9]. The major oil components were δ-selinene, β-vetispirene, β-vetivenene, vetiselinenol, nootkatol, khusimol, isonootkatol, germacrene-D and isovalencenol. The important compounds that impart the characteristic vetiver odor are: khusimene, delta-selinene, beta-vetivenene, cyclocopacamphan-12-ol (epimers A and B), vetiselinenol, khusimol, isovalencenol, khusimone, α and β-vetivone [10-12]. Vetiver oil extracted from the North Indian variety was reported to have a typical earthy aroma, higher specific gravity, free alcohols, and ester value after acetylation. In contrast, the South Indian variety has the dominant spicy character, higher refractive index, acid value, and ester value [13,11].

The highly fragrant fibrous roots are traditionally used for water purification in South India. It has a cooling property; hence, in summer, floor mats and curtains from vetiver are used to keep the surroundings cool and refreshing. Drinking vetiver water by soaking vetiver roots in cold or hot water -slowly releasing its aroma and chemical constituents into the water will help to keep the body fresh in summer. It also acts as a deodorant, stimulant, aids digestion, carminative, colic, anthelmintic, and antioxidant properties [10,14]. Vetiver oil possesses medicinal properties used to treat paralysis, rheumatic arthritis, and joint pains. Dried roots are employed to scent clothes either by themselves or in the form of sachets. A lot of handicrafts are prepared from vetiver roots as well as from leaves and inflorescence, such as doormats, curtains, baskets, hats, hand fans, brooms, *etc.* Leaves are used for the thatching of huts, bedding for cattle, and mulching [15,13].

Above all these, the vetiver plant has wide recognition as a soil conservator since the extensive rooting system preserves the soil from erosion. The grass is used in the border of coffee, tea, and rubber estates to plant against sloppy terrains to reduce soil erosion. Vetiver is selected to grow extensively in arid and semi-arid regions, even in waste and barren lands, to conserve soil and reduce runoff. Commercially, vetiver oil is one of the most expensive and valuable perfumer's raw materials, and it is extensively used as a base in perfumery, cosmetics, and soap scents. The oil of vetiver blends well with other oils, particularly with sandalwood, patchouli, and rose.

2.1 Origin and Distribution

Khus grass originated from the Indian subcontinent and is widely grown in tropical and subtropical regions of Asia, Africa, and Australia.

It is naturally distributed throughout India, in the Himalayas, Srilanka, and Malaysia and extensively cultivated in Indonesia, Cambodia, Myanmar, Java, Haiti, China, Brazil, Vietnam, Thailand, and Java. It is introduced to almost all continents and cultivated in South America, Mexico, Costa Rica, the Philippines, Japan, etc.

In India, it was found to be an invasive species in Rajasthan, Uttar Pradesh, Assam, and Meghalaya. Vetiver is systematically cultivated for its oil extraction in Kerala, Karnataka, and parts of Andhra Pradesh, Tamilnadu, Madhya Pradesh, Orissa, and Haryana. It is also grown in Andaman and Nicobar Islands, Bihar, and West Bengal states on a small scale [16].

2.2 Botany

Vetiver is a perennial hardy grass that grows to about 3-5 feet in an erect fashion. It forms many dense clumps at the base, producing enormous hairy rootlets 10-50 cm long and 1-3 mm diameter, tightly binding to the soil all around the clump. Under favorable conditions, roots can grow up to 3 m depth, distributed in 1.0 -1.5 m radius around the plant. The roots are incredibly tolerant to drought and flood. The aerial shoots or leaves are smooth, narrow, erect, and pale green. The inflorescence is a terminal panicle; flowers are arranged in many whorls in simple racemes. Spikelet-bearing flowers will be 5 cm in length and contain male and hermaphrodite flowers. Vetiver is an obligatory cross-pollinated crop where selfing is not common [13].

2.3 Varieties

There are two different types of vetiver in India. The one that grows in North India is mainly wild, and it tends to produce flowers and seeds profusely. In south India, improved varieties have been cultivated, and they are primarily non-flowering types and do not plant viable seeds. The North India type produces superior quality oil even though the oil content in roots is less. South Indian types yield more than 1.5 -2.0% oil in roots, and the oil quality was found to be inferior compared to wild types [17].

Initially, during 1982, the Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow has developed two superior clones, KS-1 and KS-2, from a collection from Bharatpur (North Indian type). These are reported to have a high oil yield and the best quality oil at that time.

Sugandha: It is a superior tetraploid genotype over its diploid parents with marked higher root biomass and oil percentage developed by CIMAP Lucknow. The variety has the potential to produce 1.4 % oil in the fresh root (46% free moisture) and 21.2 q roots /ha.

In 1998, CIMAP Lucknow released three high-yielding varieties of vetiver, namely, Kesari, Gulabi, and Dharini [18].

Kesari: The variety is suitable for dry regions and marginal land. The plant grows to medium height with light green thin leaves producing greenish/white inflorescence**.** It produces Saffron note essential oil**,** which has a dry root yield of 29 q/ha and yields 30 kg/ha of essential oil.

Gulabi: The variety is adaptable to wide soil types – alkaline and waterlogged areas- and is suitable for dry and poor soils. It is a late flowering type that produces purple inflorescence. It has long fibrous roots containing the essential oil of rose notes. Potential dry root yield: 28 q/ha and oil yield: 34 kg/ha.

Dharini: Dense, tall variety (2.5m ht) producing very broad, lush green leaves and light brown inflorescence. Long, thick roots produce a high dry root yield- of 31 q/ha and an oil yield of 39 kg/ha.

CIM Samriddhi and **CIM Vridhi** were released from CIMAP in 2007. Among them, CIM Vridhi is a short-duration crop suitable for one-year cultivation in drought conditions, producing a dry root yield of 27 q/ha and an oil yield of 33 kg/ha [3].

Two high-yielding vetiver varieties with robust and erect growing habits were released in 2012 from CIMAP Lucknow for cultivation across India, *viz*.,

CIMAP Khus 22: Dry root yield: 18-20 q/ha; oil yield: 28-30 kg/ha and oil content: 1.8%.

CIMAP-Khus 15: Dry root yield: 9-22 q/ha; oil yield: 35-40 kg/ha and oil content: 2.1%.

CIMAP- Khusinolika- khusinol rich essential oil-producing clone of vetiver, capable of producing >1% (v/w) essential oil containing 45-50% Khusinol (v/v) obtained after hydro distillation from fresh roots harvested from 06-month-old plantations - a short duration crop.

CIMAP-KHUS 40 (2n= 4x=40) is a tetraploid with leaves having larger stomata and fast-growing deep penetrating roots. It has seed infertility, which prevents it from spreading as a weed.

Other varieties of vetiver: NBPGR, New Delhi, has been involved in developing vetiver hybrids. Among them, hybrids 26, 7, and 16 perform better in saline and alkaline soils with high root and oil yield.

Hybrid-8: Grows to a height of 2 m with long medium roots having a large number of rootlets per plant containing high essential oil. It possesses 70-85% vetiverol content. This variety produces profuse tillering under light soil texture, is suitable for south Indian conditions, and gives a high root yield of 12-15 q/ha.

Hybrid-26: The variety gives a higher yield of roots (14.58q/ha) with an oil content of 1.5%.

Nilambore: It is a popular South Indian variety that produces 3.8 t/ha of fresh roots and 15-22 kg. oil in well-managed fields.

A vetiver clone **ODV-3** developed at the Lemon Grass Research Station, Odakkali, is reported to have a good root and oil yield in Kerala.

2.4 Soil

Vetiver can be grown on a wide variety of soils, from heavy clay to light sandy soils, even in barren or wastelands with poor soil fertility. It can be grown even in saline and alkaline soils with a pH range of 8.5 to 10.0. However, well-drained sandy loam and red lateritic soils rich in organic matter are considered to be ideal for its cultivation. It also grows in acidic soil and is tolerant to frost, drought, and waterlogging. But not suitable for shade conditions. The plants are used to recline mined areas and heavy metal-affected soils and wastelands. Roots grown in light soils are reported to contain less oil than heavy or fertile soils [16].

2.5 Climate

Khus grass prefers warm and humid climates for better growth and development. It grows luxuriantly in places with a mean annual rainfall of 1000 - 2000 mm, an average temperature ranging from 21-44°C, with a moderately humid climate. It can also be grown in low rainfall areas, which receive 200-500 mm. However, irrigation and humidity enhance the essential oil content in the roots.

2.6 Cultivation

2.6.1 Plant propagation

Vetiver is mainly propagated by rooted slips in South India as well as from seeds in North India. Wild types of vetiver are mostly shown to be distributed by self-sown seeds. But for commercial cultivation in the South, dense clumps around the plants are uprooted, and individual tillers are separated along with roots and, known as rooted slips. Only the lower 15-20 cm leaf portion is retained with the slip, and the top portion of the shoot is pruned off.

3. LAND PREPARATION

The land is prepared by deep plowing to a depth of 20-25 cm for 2-3 times, and the soil is mixed with the recommended dose of manure and fertilizers for commercial planting.

3.1 Planting

Rooted slips can be directly planted during the rainy season (June-August), or they can be planted in nursery bags and transplanted from March to April if the irrigation facility is available. Vetiver is planted at 45 x 30 cm distance in moderately fertile soils; where are in irrigated condition, it has to be planted at a row spacing of 60 cm with a plant-to-plant distance of 45 cm. Two to three slips are planted in each pit of 5-8 cm depth, and the soil is pressed around the hole. In high-density planting, 60 x 25 cm spacing is recommended to accommodate 60,000 plants/ ha [17].

3.2 Manures and Fertilizers

Even though vetiver comes up very well in poor and moderate soils, the application of manures and fertilizers helps to increase root yield and oil content. Application of 10t farmyard manure (FYM) and 25:25:25 kg nitrogen, phosphorous, and potash fertilizers per hectare is recommended in vetiver. The entire dose of recommended FYM, phosphorous, and potash is applied during planting. Half of the nitrogen (12.5 kg) is used as a basal dose, and the remaining half of the nitrogen fertilizer is top-dressed six months after planting [13,17]

3.3 Irrigation and Interculture

Vetiver does not need supplemental irrigation for its growth in coastal and high rainfall areas with high humidity. However, about 8-10 irrigations will be required in drier areas to get the optimum yield. One or two inter-cultivation or hand weeding helps to keep the plantation weed-free in fertile soils.

3.4 Pests and Diseases

There are no serious pests noticed in vetiver; in fact, vetiver repels termites. Sometimes, in high rainfall areas, the plant is attacked by *Fusarium* sp. It can be controlled by drenching the roots with carbendazim @ 2g/l. Leaf blight caused by *Curvularia trifolii* is controlled by spraying copper oxychloride @ 3g/l [13].

3.5 Harvesting and yield

Generally, vetiver roots will be ready for harvesting in 18 months after planting, depending on the variety. The grass planted in July will be ready for harvesting in February of next year to get maximum oil content. The harvesting time is crucial as the root yield and oil content vary from winter to rainy season. Cool, dry winter or summer season crops yield better quality oil than rainy season crops [13]. The major expenditure in vetiver cultivation is the harvesting process. It is not easy to harvest the densely tufted roots manually. Hence, the harvesting is done by pulling out the plants by excavation using JCB. After harvesting, the roots are separated from the stem, cleaned, and dried under shade for a couple of days before distillation. Root yield in vetiver varies from 30-40 q/ha and contains around 1% essential oil in south India. In north India, the yield of roots was much lesser (14-18 q/ha) due to collection from the wild [16].

3.6 Essential Oil Extraction

Conventionally, the essential oil from the vetiver was extracted using steam or hydro distillation process from both fresh and dry roots. Generally, it takes 12-14 hours for hydro distillation of dry roots of north Indian types, whereas steam distillation takes a bit less time. Even though fresh roots yield maximum essential oil in less time, fine-quality oil was reported to be obtained from dry roots only. South Indian types take more extraction time (72h) for maximum oil extraction [13]. The average yield of the North Indian variety is between 0.15 to 0.2 percent, whereas the average yield of the South Indian variety is 1 percent. The aging of extracted essential oil for six months improves the odor of the oil substantially. The characteristic harsh and green odor disappears gradually on storage of essential oil and develops a sweeter, heavier, and earthy aroma. Now a days Supercritical fluid extraction (SFE) is followed to extract vetiver essential oil [19,20]. SFE has been demonstrated to be a rapid extraction method compared to steam or hydro distillation, and it takes around 2 hours for the complete extraction of vetiver essential oil.

4. CONCLUSION

Vetiver grass is a hardy tufted perennial grass used in soil and water conservation besides medicinal and aromatic properties. However, the area under vetiver cultivation is reducing drastically due to its long duration, dependency on mechanical harvesting, and difficulty in traditional distillation processes. Hence, using short-duration varieties, improved oil extraction techniques, such as the supercritical fluid extraction method, and high demand for vetiver essential oil make its cultivation more viable and necessary for the hour.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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