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**ORIGINAL RESEARCH ARTICLE**

# Validation of harvesting time in vetiver crop for enhancing root and oil yield in Tsunami affected coastal regions of Tamil Nadu

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## ABSTRACT

*The metabolism of plants is influenced by climatic factors both quantitatively and qualitatively. The influence of climatic conditions on harvesting, oil recovery, and yield of vetiver grown in farmer's field during 2017-2019 at Nochikadu, Cuddalore district, Tamil Nadu was examined. The results suggest that essential oil production in vetiver is closely correlated with plant metabolism, influenced by changes in the environment, mainly temperature, rainfall, relative humidity, and sunshine hours. The oil recovery was found to vary in different harvesting months, ranging from 0.65-1.45%, and the root yield vary between 5.13-8.0t/ha. The maximum oil recovery and root yield were noticed in April and September. This study provides information for timely agro-technological operations during the planting and harvesting seasons for maximum root yield and oil recovery of vetiver crop in Tsunami affected coastal regions of Nochikadu, Cuddalore, District, Tamil Nadu.*



## INTRODUCTION

Vetiver (*Vetiver ia zizanioides* (L.) Nash, syn. *Chrysopogon zizanioides* (L.) Roberty is an important perennial aromatic grass that belongs to the Poaceae family. The plant is well known for its perfumery and flavour values. Vetiver originates in India and is cultivated throughout tropical countries. Roots and essential oil of vetiver have high industrial demand mainly due to its fixative property. Vetiver can be grown under adverse climatic conditions ranging from dry to submerged soil conditions with a pH range from 4-11, and it can withstand a wide range of temperature conditions (4-50$^0$C). The growth and development of its root are mainly influenced by the physicochemical properties of soil, such as temperature, texture, moisture, pH, salinity, and heavy metals concentration (Troung and Baker,1998). Vetiver oil is a complex mixture of terpene, sesquiterpene, alcohols, hydrocarbons, etc., having more than 150 compounds. The oil is viscous with enormously less volatility. The vetiver essential oil has unique demand in the world market mainly due to its aroma, and it cannot be replaced with reconstituted/synthetic oil.

Composition and concentration of secondary metabolites (SMs) in plants are mainly influenced by various factors such as (i) ecological habitat conditions, including climatic and edaphic factors which controls physiological and metabolic activities of the plant, inter and intraspecific biological

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interactions, (ii) geographic and genetic variations (Figueiredo *et al.*, 2008). The essential oil content and its composition of active molecules are dependent on intrinsic and extrinsic factors, including soil and climatic conditions, plant ontogenesis, and season of harvest (Verma *et al.*, 2010; Verma *et al.*, 2012). Several studies have been carried out in different regions and in different agro-climatic situations to understand variation in vetiver oil content with respect to time and space (Lemberg and Hallley, 1978; Ghani, 2003). Knowledge of the optimal time of harvesting is essential to assure the quality of essential oil and yield.

The farmers of coastal regions of Tamil Nadu cultivate vetiver and sell the roots for handicrafts and oil production to different commercial companies. Vetiver being cultivated in coastal regions of Tamil Nadu *viz.*,Cuddalore district throughout the year, no specific month for planting and harvesting has been identified. Oil recovery and yield therefore vary over different seasons. The present study was undertaken for evaluation/ validation of harvesting time of vetiver for maximum oil recovery in Tsunami affected coastal regions of Cuddalore district, Tamil Nadu. The objective of this study was to examine the effect of environmental factors and management conditions on vetiver root yield, oil content, and essential oil yield and identify a suitable month of harvest for better oil yield.

## MATERIALS AND METHODS

### Experimental site

Cuddalore is located at 11.75°N 79.75°E with an average mean sea level elevation of 6m(20ft). The flat land has large deposits of alluvial soil inland, coarse, and very fine sand near the seashore areas. Summer rains are sparse; the South-West monsoon sets in June and continues till September. North-East monsoon sets in October and continues till January. The South-West monsoon rainfall is much lower than that of the North-East monsoon. The average annual rainfall is 1400mm, most of which is contributed by the North-East monsoon. Most of the villages are in cyclone-prone regions and were also affected by Tsunami in 2004.

### Weather parameters

Data on average sunshine hours and sunny days, average cloud and humidity, average pressure (mb), average rainfall, average and maximum wind speed, maximum, minimum and average temperatures of Cuddalore, Tamil Nadu were collected from worldweatheronline.com (https://www.worldweatheronline.com/cuddalore-weather-history/tamil-nadu/in.aspx). The data on the weather parameters are briefly summarized below.

***Temperature*:** The average temperature ranges between 21-35$^0$C (Fig. 1). The maximum temperature was noticed from April to July of 2017-18. A decline

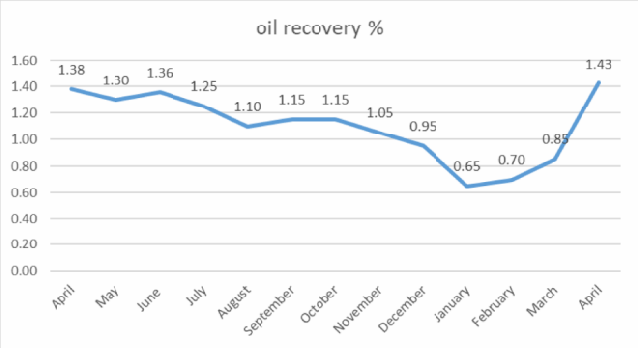


**Fig. 1: Oil recovery of vetiver as influenced by the different months of harvest.**

in the temperature was noticed from July to January. The temperature during the winter season (December-February) dropped to 3°C, and in summer (June-October), extremely harsh temperature (50°C) was observed.

***Rain fall (mm)* :** The rainfall during 2017-18 lies in the range 0-124mm. The highest rainfall and more rainy days were observed from August to January (Fig. 2). Very scanty rainfall and less rainy days were noticed during January to April.

***Average sunshine hours and sunny days*:** The average sunshine hours and sunny days are presented in Fig. 3. The maximum sun hours were noticed in May (380hr), which was declined up to 180 hours in the month of September. Less numbers of sunny days were noticed from August to January (<10hr).

***Average atmospheric pressure (mb)*:** The atmospheric pressure showed a decrease from February to August (1014mb to 1005mb). The highest

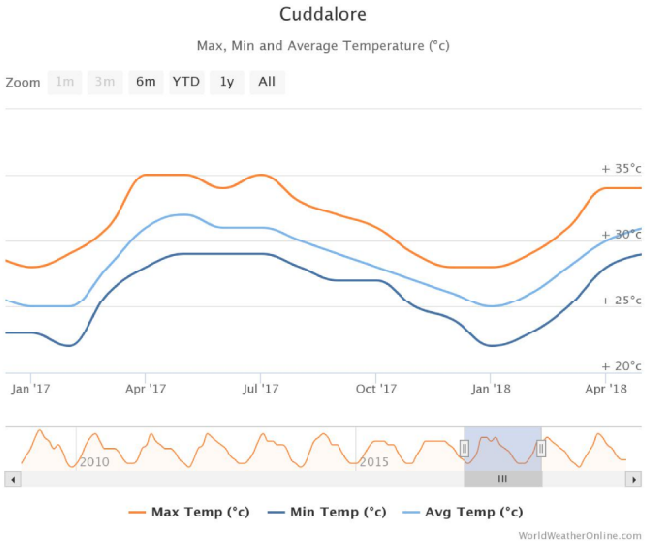


**Fig. 2: Minimum, Maximum and Average temperature ($^0$C) of Cuddalore during 2017-2018**

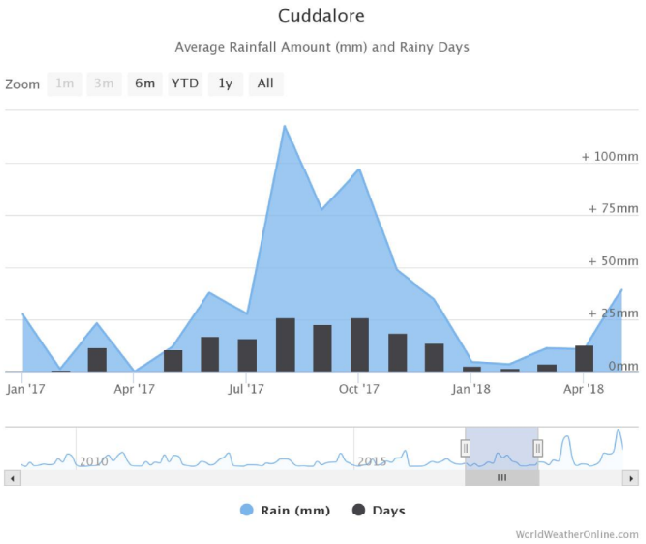


**Fig. 3: Average rainfall (mm) and Rainy Days at Cuddalore during 2017-2018.**

atmospheric pressure was noticed in the month of February (Fig. 4). A steady raising pattern of atmospheric pressure was recorded from August to February, after which the reversed trend was noticed.

***Average cloud and humidity (%)*:** The average cloud and humidity (%) were in the range of 3.5-48% and 55-75%, respectively. The lowest cloud (3.5%) was observed during April, and the highest cloudy weather was noticed in November (48%). Humidity followed a similar trend, with the highest humidity recorded in November (75%) and the

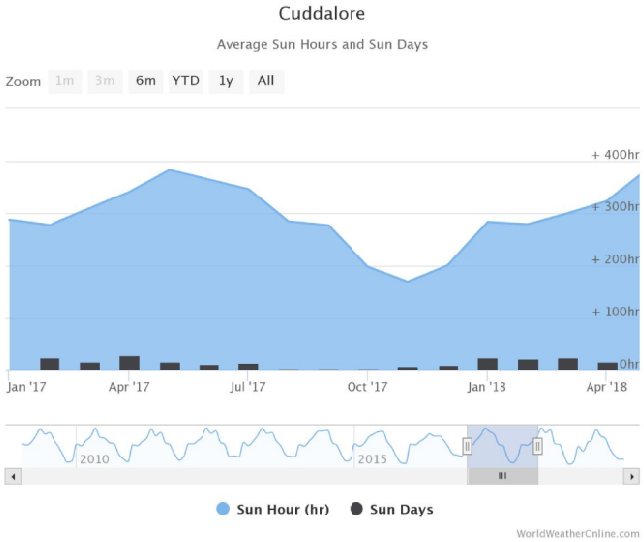


**Fig. 4: Average sun hours and sun days at Cuddalore during 2017-2018**

lowest in the month of July(60%) (Fig. 5, 6) (source: worldweatheronline. com).

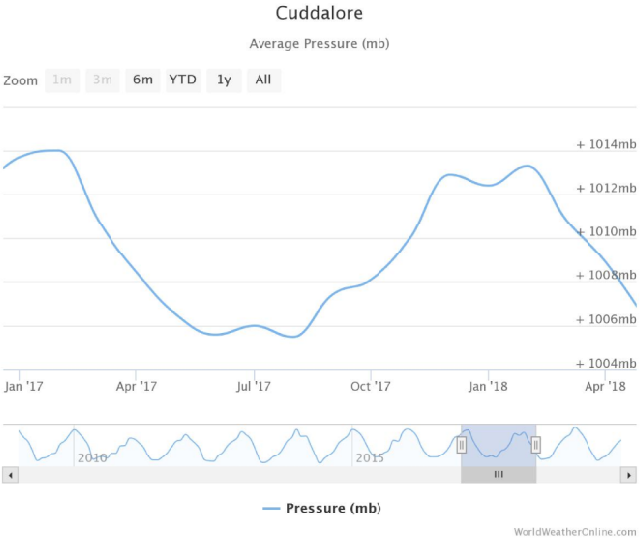


**Fig. 5: Average atmospheric pressure (mb) at Cuddalore during 2017-2018**

## Agronomical experiment

The field experiment was conducted in the farmer's field (Late Shri. Danaraj) located at the Tsunami affected areas of Nochikadu, Cuddalore district, Tamil Nadu for a period of two years, 2017-2019. The study involves the planting of vetiver slips and root collection every month from January to December in the farmer's field. The area adopted for the planting of vetiver slips is >1000m$^2$. CIM-Virddhi, an improved vetiver variety released from

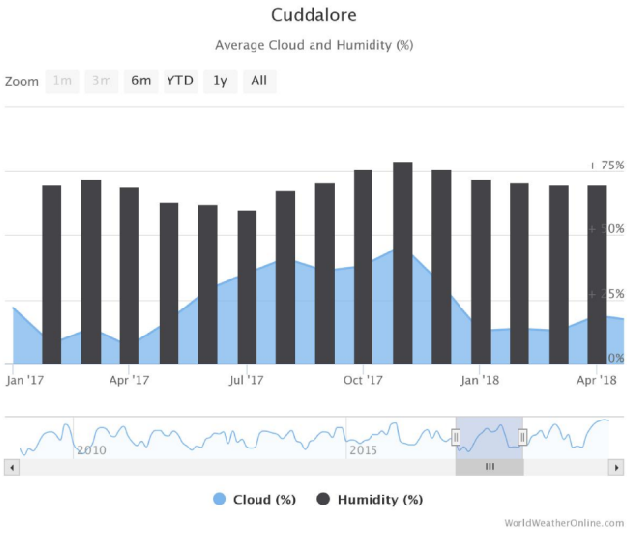


**Fig. 6: Average cloud and humidity (%) at Cuddalore during 2017-2018**

CSIR-CIMAP, was used in the study. The crop was raised by following the standard package of practices. Vetiver was planted in a spacing of 30cmx30cm. The experimental soil was sandy in nature, and soil reactions ranged from 6.5-8.0. Soil organic carbon (0.40%) was low, and the available NPK content of the soil was low. The recommended dose of fertilizer 150-60-60 kg NPK $ha^{-1}$ was applied. N was supplied in 3 splits through urea. The crop was irrigated once in three days at the early stages; irrigation was provided once a week in later stages. Roots were harvested every month at proper maturity (10-12 months old). At each harvest, the roots were washed and air-dried in the shade for distillation.

## Triturating of the roots

Starting from the transplantation, root samples (about 200g) from five independent vetiver clonal plants were dug up, harvested, and pooled periodically every month to extract and analyze the essential oil. Sampling was performed at the maturity stage (10-12 months after planting) when the soil was not too moist to avoid collecting excessive soil residues with the roots. The roots were then de-earthed, washed, and dried (25-30°C) in the shade for about 3-5days. The roots, cleaned and dried, were cut up into small pieces of a few centimeters in length by a blade for the distillation.

## Extraction of essential oil

The essential oil from air-dried and minced roots was isolated by hydrodistillation for 24-30 hours through Clevenger-type apparatus using n-hexane as a solvent. Vetiver roots were pre-soaked in water for about 4-6 hours prior to distillation. The oil was dried over anhydrous sodium sulphate and stored in the dark amber colour bottle.

**Table 1: Root and essential oil yield of vetiver according different months of harvest**

| Harvesting month | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Root yield (t/ha)** | | | | | | | | | | | | |
| **Range** | 5.53 - 6.55 | 5.25 - 6.50 | 6.50 - 7.10 | 5.25 - 6.55 | 5.13 - 6.0 | 6.55 - 7.38 | 6.05 - 7.63 | 6.05 - 7.35 | 6.55 - 8.00 | 6.55 - 7.75 | 6.75 - 7.75 | 6.5 - 7.5 |
| **Mean** | 6.04 ± 0.72 | 5.88 ± 0.88 | 6.8 ± 0.42 | 5.9 ± 0.92 | 5.57 ± 0.62 | 6.96 ± 0.59 | 6.84 ± 1.12 | 6.7 ± 0.92 | 7.28 ± 1.03 | 7.15 ± 0.85 | 7.25 ± 0.71 | 7 ± 0.71 |
| **SD** | | | | | | **0.60** | | | | | | |
| **Sem±** | | | | | | **0.17** | | | | | | |
| **CD (5%)** | | | | | | **0.52** | | | | | | |
| **Oil recovery (%)** | | | | | | | | | | | | |
| **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** | |
| 0.65 | 0.75 | 0.85 | 1.45 | 1.30 | 1.36 | 1.25 | 1.10 | 1.15 | 1.15 | 1.05 | 0.95 | |
| **Oil yield (L/ha)** | | | | | | | | | | | | |
| | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| Range | 35.94 - 42.57 | 36.75 -45.50 | 55.25 - 60.35 | 73.50-91.0 | 66.69 - 78.00 | 89.08 - 100.36 | 75.62-95.37 | 66.55 - 80.85 | 75.32 - 92.00 | 75.32 -89.12 | 70.87 - 81.37 | 61.75 - 71.25 |
| Mean | 39.26 ± 4.69 | 41.13 ± 6.19 | 57.8 ± 3.61 | 82.25 ± 12.37 | 72.35 ± 8.0 | 94.72 ± 7.98 | 85.5 ± 13.97 | 73.7 ± 10.11 | 83.66 ± 11.79 | 82.22 ± 9.76 | 76.12 ± 7.42 | 66.5 ± 6.72 |
| **SD** | | | | | | **17.36** | | | | | | |
| **Sem±** | | | | | | **5.01** | | | | | | |
| **CD (5%)** | | | | | | **15.41** | | | | | | |

## RESULTS AND DISCUSSION

The influence of harvesting time (month) on root and oil yield is summarized in Table 1. The average root yield of vetiver is found to vary between 5.13- 8.0 t/ha, and the mean root yield ranged from 5.57-7.28 t/ha during different months of harvesting schedule. The lowest and highest root yield were recorded in May and September, respectively. It was observed that mean root yield was not much influenced by the harvesting time.

The oil recovery as influenced by different months of the harvest is presented in Fig 6. The oil recovery ranged from 0.65 to 1.45% over different months of vetiver harvest. The best oil recovery was observed in the month of April, followed by June (1.36%) and July (1.25%). Meanwhile, oil yield reflects the oil recovery and root yield of vetiver crops. The oil yield ranges from 35.94 to 100.36L/ ha.

The influence of various environmental factors on the yields of essential oils is witnessed in several crop species. Vetiver is a dominant crop in the selected location, viz. Nochikadu village of the coastal district Cuddalore, (TN) for more than ten years. However, no systematic investigation of the optimum planting/harvesting time for vetiver in this location has been done previously. The precipitation pattern is inversely proportional to the temperature profile, and minimum rainfall is observed between the months of January–July. The results of our study show that the highest root yield can be obtained in the month of September. The total rainfall received in the month of April-July during 2017-2018 was comparatively lower than the rainfall received during July-December 2017-2018. The vetiver root samples harvested in November, December, January, February, and March showed lower oil recovery mainly due to the onset of rainfall and temperature. These results are in accordance with the study conducted by Kotoky *et al*. (2011), reporting higher essential oil yield (0.7%) and valerenol percentage (28%) in the month of March, for the crop grown in Jorhat, Assam, India. However, oil recovery (%) was higher in the month of July, with a comparatively lower concentration of valerenol. This may be attributed to higher rainfall which played a significant role in affecting the concentration of the specific component. Khusimol is one of the most important components of vetiver oil. The khusimaol content was found to be 14.52-31.42% among thirteen accessions from Florida, Nepal, and Portugal (Adams *et al*., 2003).In the present work, GC analysis of vetiver root oil showed khusimol content was ranging from 12.5-14.75% (Fig. 7). Gobbo-Netoand lopes (2007) reported that the secondary metabolites production in plants is influenced by many environmental factors, and these factors vary with seasonality, bringing changes in the yield and chemical composition of essential oils. The average sunshine hours and sunny days were more during April-July; later it tends to reduce, resulting in lower recovery of essential oil between August-March. Hussain (2010) reported that the variation in the yield and chemical composition of different *Mentha* spp. The essential oil yield *of Mentha* spp. was high during summer, whereas isomethane was found to be high in the winter season. The regulation and biosynthesis of essential oil with respect to the season might have been due to the influence of phonological status and environmental conditions (Massoti *et al.,* 2003).

## CONCLUSION

The results of the study confirmed that harvesting vetiver crops in the coastal areas of Nochikaddu, Cuddalore, Tamil Nadu was very closely associated to environmental factors. Thus, harvesting vetiver roots during the less rainy period of April and planting in August-September are for higher root yield and oil recovery.

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**Declaration of Competing Interest:** None.

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