

C. S. I. R. MONOGRAPH

SURVEY
OF
INDIAN VETIVER (KHUS)
AND
ITS OIL

BY

RAO SAHEB A. K. MENON

AND

C. T. ITTYACHAN

ESSENTIAL OIL ADVISORY COMMITTEE

(BOARD OF SCIENTIFIC & INDUSTRIAL RESEARCH)



Council of Scientific and Industrial Research

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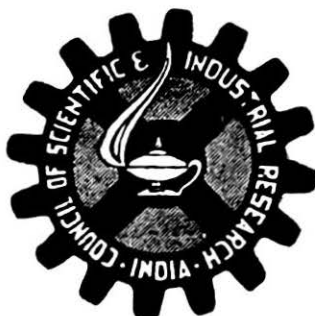
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FOREWORD

The Essential Oil Exploratory Committee in their report of 1941 laid stress on the importance of *Khus* oil as an ingredient in the perfumery industry and recommended a systematic study of the *Khus* roots growing in India with a view to the cultivation of the best type of grass for obtaining not only the highest yield of oil but in addition an oil of fine aroma.

2. No development of essential oil industry in India is possible unless and until, as a first step, a systematic and patient search is carried out on the available resources of the country in aromatic raw materials. The preparation of a comprehensive list of aromatic plants growing in the country, whether cultivated or growing wild, is already on hand, but its compilation being a work of major and fundamental importance will take some time for completion. When it is ready it will enable a detailed economic survey being made of such of those plants that are of commercial importance and which are already being utilised or the exploitation of which would lead to the development of new essential oils.

3. From the available literature, it was noticed that no survey or investigation had been carried out on the *Khus* grass or its root or oil. In view of the importance of *Khus* oil in the perfumery and allied industries in India and all over the world and since it is known to have been distilled in India on a commercial scale for hundreds of years, the Essential Oil Advisory Committee at its first meeting in July 1942 recommended to the Council of Scientific & Industrial Research that a survey be made of the existing position in India of the cultivation of *Khus* roots and of the oil distilled from them. The object of this study was twofold *viz*, in the first instance the collection of factual data and secondly to devise ways and means of encouraging and developing the cultivation of *Khus* roots on a regular and scientific basis to obtain the best quality of *Khus* oil of an intense and sweet odour.

4. The Council of Scientific & Industrial Research were pleased to approve the recommendations of the Essential Oil Advisory Committee in March, 1943 and sanctioned a grant to meet the expenditure of the investigation.

5. A special investigator was appointed for the survey, and Rao Sahib A.K. Menon, who is a member of the Essential Oil Advisory Committee, was requested to supervise the work of the investigation and to prepare and present a report of his findings to the Council through the Essential Oil Advisory Committee.

The investigation was to be conducted along well specified lines and they consisted of:—

- (i) making an economic survey of *Khus* roots grown wild or as a cultivated crop in different parts of India and
- (ii) collecting specimens of roots from different parts of the country for their botanical and chemical investigation
- (iii) collecting information of the distillation of the oil as carried out at present.

The botanical examination of the roots was to be conducted at the Institute of Plant Industry at Indore whilst Rao Sahib A.K. Menon who was the Superintendent of the Kerala Soap Institute, Calicut, offered to carry out the chemical examination of the roots at his Institute at Calicut.

6. The services of Mr. C.T. Ittyachan of the Agricultural Department of the Government of Madras were lent to the Committee by the Government of Madras for the purpose of this survey and he started the work towards the end of October 1943. The investigations continued over a period of several months and the results are embodied in this report. Before the survey could begin Rao Sahib Menon had retired as the Superintendent of the Kerala Soap Institute Calicut, and he was unable to carry out the chemical investigation of the roots. The Committee was, however, able to secure the ready assistance of the Tata Oil Mills Co. Ltd., Bombay, who undertook this work at their laboratory in Bombay. The Committee is thankful to the Director, Institute of Plant Industry, Indore, and the Tata Oil Mills Co. Ltd., for the examinations they have carried out without any remuneration and giving thereby, an impetus to the development of this important essential oil.

7. The results of many months' hard work of Rao Sahib A.K. Menon and Mr. C.T. Ittyachan are presented in this report. It is the first attempt to be made to collect in a single monograph the present position of the *Khus* root and oil industry in India. A serious attempt has been made to survey the distribution of the *Khus* root and oil industry in India and their present state of development and though there are several lacunae, it is nevertheless an useful contribution to our knowledge of *Khus* roots and *Khus* oil, the uses to which they are put, the possibilities that they offer for systematic development on a commercial scale. The *Khus* oil industry, though ancient, has, due to ignorance and lack of scientific outlook, deteriorated considerably and if urgent steps are not taken to keep pace with the modern trend in scientific development it may soon die out. It therefore behoves all those who are interested in the development of the industry to help in its revival and set it up on a sound footing and progressive outlook.

8. As the report indicates, *Khus* roots are rarely cultivated in this country and in the three important centres where they are available so abundantly, namely, in the United Provinces, the Punjab and the Bharatpur State, they grow in a wild state. The botanical study of the roots, unfortunately, could not be carried out more exhaustively as most of the samples of roots collected by Mr. Ittyachan and sent to Indore, arrived there in a half-dead condition and could not therefore be propagated. Had all the samples of the roots been successfully raised it would have given an opportunity for a more detailed study of the root system of each individual specimen and to observe the differences, if any, in the root system as also the leaves and stems of the different samples.

9. A systematic study of the *Khus* grass and its roots and oil is therefore distinctly called for.

10. Apart from a study of the root system, it would be interesting to observe the effects on the yield of oil and its aroma from various aspects. For instance, what are the factors which influence a higher yield of oil? Would manuring and irrigation of the roots help the growth of the roots as well as increase the yield of oil? Similarly, is the fragrance or aroma of the oil, which is the most important factor for the perfumery industry, influenced in any way when the roots are manured and irrigated? A comparative study of the fragrance of oil from roots found wild and those cultivated is likely to yield interesting information. It is mentioned in the report that due to the present high price of *Khus* oil there is a tendency on the part of the distillers to have the roots pulled out before they are matured. A study of the yield and quality of oil and their relationship to each other from mature roots and immature roots will help to further our knowledge. It has also been suggested that the yield of oil and its fragrance is less during the rainy months and that roots from places where water stagnates are poor in odour. All these are important factors and need scientific investigation to come to any conclusion. A study is also indicated in finding out uses for the *Khus* grass. There appear to be interesting possibilities in utilising it as cattle fodder, for paper making and for starting new cottage industries like hat-making.

11. These are the reflections that arise from the report, which although contains a considerable amount of useful information must be considered in some respects, as only the first stage in our investigation.

12. The Essential Oil Advisory Committee at its meeting of January 1945 considered this useful report and recommended to the Council of Scientific & Industrial Research that in view of the findings of the report, a systematic inves-

tigation of *Khus* root should now be instituted, both in North and South India, in order to study the effect on the growth of the roots, of climatic conditions irrigation and manuring and also carry out further investigations on the root system and the oil content of the roots at different stages of growth. Along with this should also be undertaken a series of experiments on the method of distillation of the roots to determine if the process of distillation and the use of matured and unmatured roots have any influences on the fragrance of the oil. These recommendations were considered by the Board of Scientific and Industrial Research on the 17th March 1945. The Board recommended that the Indian Council of Agricultural Research be requested to make the necessary grants for work to be done in the United Provinces and Madras and that in case the I.C.A.R. do not sanction the work, the matter be brought before the B.S.I.R. again. The I. C. A. R. have been accordingly requested to take necessary action, and it is understood that this question has been referred to the Miscellaneous Crops Committee of the I.C.A.R.

13. Cordial thanks of the Essential Oil Advisory are due to Rao Sahib Mr. A. K. Menon and Mr. C.T. Ittyachan for the labour and time they have given to the preparation of the report. To Rao Sahib Menon it has been a labour of love and he has not spared himself throughout the inquiry.

14. The thanks of the Committee are also due to all persons who gave Mr. Ittyachan directions and help in the course of his investigation. It is not possible to give a list of every person who helped him, but an acknowledgment of gratitude is due to the Director of Scientific & Industrial Research, the President, Forest Research Institute, Dehra Dun, the Peripatic Oil Distillation Party organised by the Industries Department of the Government of Punjab, the H.B. Technical Institute, Cawnpore, the Director of Agriculture, U.P., the Agricultural College and Research Institute at Coimbatore and the Kerala Soap Institute, Calicut. Without their guidance and assistance a good deal of work of Mr. Ittyachan would have been delayed for months. The Committee's thanks are also due to all persons and institutions whom Mr. Ittyachan interviewed in the course of his investigations. Finally the Committee's thanks are due to Mr. Ittyachan for all the labour that he has put in this work, as during the course of his investigation he has travelled nearly 4500 miles and has had to travel in the interior parts of several places where conditions and facilities were far from satisfactory, especially for approaching out of the way places for the collection of samples of *Khus* roots.

Bombay,
July 21, 1945.

P. A. NARIELWALA
Chairman,
ESSENTIAL OIL ADVISORY COMMITTEE

CHAPTER I

Khus

Khus, *Vetiveria zizanioides* (Stapf) (N.O.Gramineae) was originally classed under *Andropogon* species and named *Andropogon muricatus* (Retz) and *Andropogon squarrosus* (Linnf). It belongs to the natural order Gramineae, commonly known as the grass family. It is called *Vala* (Marathi), *Khus* (Hindi and Bengali), *Velamachamver* or *Vetiver* (Tamil and Telugu) and *Ramacham* (Malayalam). It is popularly known in India as *Khus Khus* but this word rightly refers to poppy seed. Unfortunately, this expression has in some manner crept into literature. In order to avoid confusion it is advisable to call it only as *Khus*. The earliest record in India of *Khus* root, classed as an article of commerce, was found on 12th century copper plates in Etawah, south-east of Agra. They showed that as early as the 12th century the Kings of Kanauj levied a tax on *Khus* root because of its commercial utility.

2. Habitat: *Khus* is found throughout the plains and lower hills of India, Burma and Ceylon up to 4000 feet. It grows particularly on the banks of the rivers and in rich marshy soil; it thrives well in a warm damp climate with an average temperature of about 30°C and on firm sandy and clayey soil. Throughout the Punjab, the United Provinces, Bharatpur State and parts of Ajmer it grows wild and very little of it is cultivated. Hissar, Guargaon, Rohtak and Karnal are important districts for *Khus* in the Punjab. It is found throughout the Bharatpur State, while in the Ajmer Merwara Agency tract, it is confined to a few localities. In the United Provinces it grows in a wild state in jungle tracts and on the banks of the rivers and lakes in almost all the districts particularly Etawah, Agra, Dehra Dun, Farukhabad, Bareilly, Pilibhit, Nainital, Cawnpore, Sitapur, Gonda, Kheri, Gorakhpur and Bhabraich. In the Central Provinces it is met with, partly wild and partly cultivated, in several places particularly in the forest region of Yeotmal and near about Katni and Bilaspur. It is also found in Chota Nagpur, Behar, Assam and near Khoorda and Jamsale (Mayurbhanj) in Orissa Province. In the States of Baroda, Hyderabad, Mysore, *Khus* grows more or less wild. In South India, it is found as a cultivated crop, especially in Malabar (Ponnani Taluk), Tuticorin and South Travancore and in some parts of East Godavari and Kurnool districts. It is probable that it grows wild elsewhere also in the Madras Presidency.

3. Description: *Khus* is a densely tufted perennial grass often growing gregariously on heavy, rich, marshy soils and attaining a height of 3 to 6 feet,

with the root stock branching into spongy, aromatic, fine rootlets. It grows in stout clumps. The central shoot is tall, smooth, glabrous, covered by the sheaths which are strongly compressed, especially at the lower portion and very smooth and polished. The leaves are 1 foot to 3 feet long, narrow, erect, rigid, firm or slightly spongy, usually glabrous, but some times hairy on the upper surface towards the base and with a rough margin. The leaf blades are linear, acute and pale green in colour with slender midrib and close lateral nerves. The inflorescence is from 4" to 12" long and is an erect, conical, oblong racemose panicle at the tip of the central stout rachis, having oblique, filiform branches, bearing sessile spikelets. The seeds are shed when they get matured before the leaves become completely brown. No perceptible external morphological differences were observed between the plants met with at various places except in points of height and sturdiness of the grass and in the size as well as the branching habit of the roots. The grass from young sprouts is readily eaten by cattle. The upper portion called "Seenk" is cut just after flowering and used for thatching purposes. It is sold at As. 5 to As. 6 per seer of 2 lbs in Northern India. In the Reunion Islands the grass is used for making hats. It is said that the grass is suitable for paper making, but no definite information on this point is available.

4. Soil and Climate: Khus grass grows in any soil but the best suited is a rich loamy cum sandy soil. The grass grows profusely in places with annual rainfall of about 40 to 80 inches and temperature ranging between 70° to 110°F and a somewhat humid climate. The propagation of the grass is by means of root divisions. The grass met with in jungle tracts in a wild state is more sturdy and the roots more clustery than those found in the plains, river, banks and canal bunds. Perhaps the high fertility of the jungle soil might be the stimulating factor, although it is sometimes opined that the shade in jungles is unfavourable to root development. Since the grass attains sturdy growth with fine root formation in rich soils, it should respond to timely manuring whereby the quality and yield of the root would be considerably improved. The creeping habit of the grass renders it valuable for binding the soil when landslips occur; hence it is planted on field bunds. There are apparently two varieties of grass—one flowering and the other non-flowering. In North India the Khus that grows wild is more of the flowering variety; in South India both varieties are found. These habits will have to be further observed and studied.

CHAPTER II

Roots

5. Though the roots are mature enough to be lifted by November, the actual lifting is started only towards the end of December or the beginning of January, as most of the labourers are busily engaged in the harvest of food crops till then. Only the perfumery dealers interested in extracting the oil start plucking the roots in December and January. Where the roots are required by the contractors for making into screens (tattis) for the hot season, lifting of the roots is postponed till February. It is easy to lift the roots in sandy tracts; whereas in clayey and hard soil of North Indian centres, this is a difficult process. The roots collected from sandy areas are generally of poor aroma whilst the roots growing in clayey soil are said to possess a better aroma. During the rainy season, the oil content of the roots is also reported to be less than during the dry months. Another interesting observation is that the roots lifted from places where water stagnates for long periods are lacking in odour. This deterioration in the quality is attributed to the action of the stagnant water, which washes away a portion of the aromatic components of the roots. The length of the root varies from 4" to 14" according to the conditions of growth, soil, climate etc. of the locality. The root development is said to be stimulated by frequent cutting of the grass. Digging forks and spades are used for lifting these roots and the quantity that can be lifted by one man varies from 8 seers (1 seer = 2 lbs) to 12 seers per day depending upon the nature of the soil and the character of the root formation. The grassy portion is removed immediately and the roots are tied into small bundles of 6 to 8 oz. in weight. The poor villagers belonging to the caste of "Chumars" in the Punjab and "Kanjars" in the U.P. gather the roots and sell their daily collection to petty dealers, who supply them to merchants in big cities. There are also contractors, who engage daily labour for collecting the roots in jungle tracts required for making fans, screens etc. In the Punjab a labourer is paid Re. 1/- to Rs.2/- per day, but the labour charges are cheaper in the U.P. and Bharatpur State, the rate varying from As.12/- to Rs. 1/4/- per day. The total quantity of roots lifted per year in Northern India can be roughly estimated at 62,500 maunds (=2380 tons) but this can be more than doubled if all the available quantity is collected. The yield from one acre is about 1/2 to 1 ton of roots.

6. Occurrence of Roots.

(a) *North India:* Khus grows wild and is seldom cultivated in North India; probably it was cultivated in olden times but remnants only now remain, due to

neglect. As a result it is not met with in extensive or compact blocks but scattered in small stray patches. The tillering habit of the grass has resulted in its natural propagation. New shoots come up in the months of May and June in Northern India soon after a few showers. The number of tillers in a clump varies from 10 to 40, depending upon the nature and the fertility of the soil. The grass is said to flower during September and October. Good sturdy plants are met with in centres like Sirsa and Kaithal in the Punjab, in Bharatpur and in Musanagar, Utripura, Sitapur, Gonda and Kheri in the United Provinces. A rough estimate of the total area under Khus grass in the Punjab, U.P. and Bharatpur State will be about 10,000 acres spread within a space of 7100 sq. miles. As the grass is not systematically cultivated but grows wild in scattered areas, the actual output of root in an acre is considerably less than what it would be in a properly laid out plantation.

(b) *South India:* In South India, Khus is cultivated in some parts of the Madras Presidency particularly in South Malabar (Kaipamangalam and adjoining villages in Ponnani Taluk), in Tuticorin (Tinnevely District) and near about Neyyatinkarai in the Travancore State. The soil in some parts of the Ponnani Taluk, adjoining the sea shore is mostly sandy whereas in South Travancore, it is light red loam with an admixture of fine gravel. The propagation is by slips, previously sprouted by keeping them in moist soil for a few days. The sprouted slips and culms capable of sprouting are planted 8" to 10" apart on ridges in loosely prepared plots 3' to 4' broad and 30' to 40' long. Four to five thousand slips can be set out on a cent of land, but the actual number that survive and come up will be about 25% less. If the planting is done in March and April, just before the rains, the crop can be harvested in November and December. After planting the roots in March or April, the plots have to be watered now and then between the summer showers and prior to the south-west monsoon. Just after a few showers i.e. 3 or 4 months after planting, weeding and earthing up is done and in some places manure such as ash, compost, fish guano and sweepings from the fish curing yards on the coast is applied. Manuring is said definitely to improve the quality of the roots and the yield and aroma of the oil. A second crop will be ready for harvesting in March or April, if the slips were planted in August. In any case, the roots reach to maturity only after 9 or 10 months; if plucked earlier they will be devoid of aroma. Now-a-days, the lifting of the roots is done before they are mature owing to their great demand, but such immature roots are useless for oil extraction purposes. The planting, lifting and export of Khus form a regular village agricultural industry and nearly 750 acres are covered by this crop.

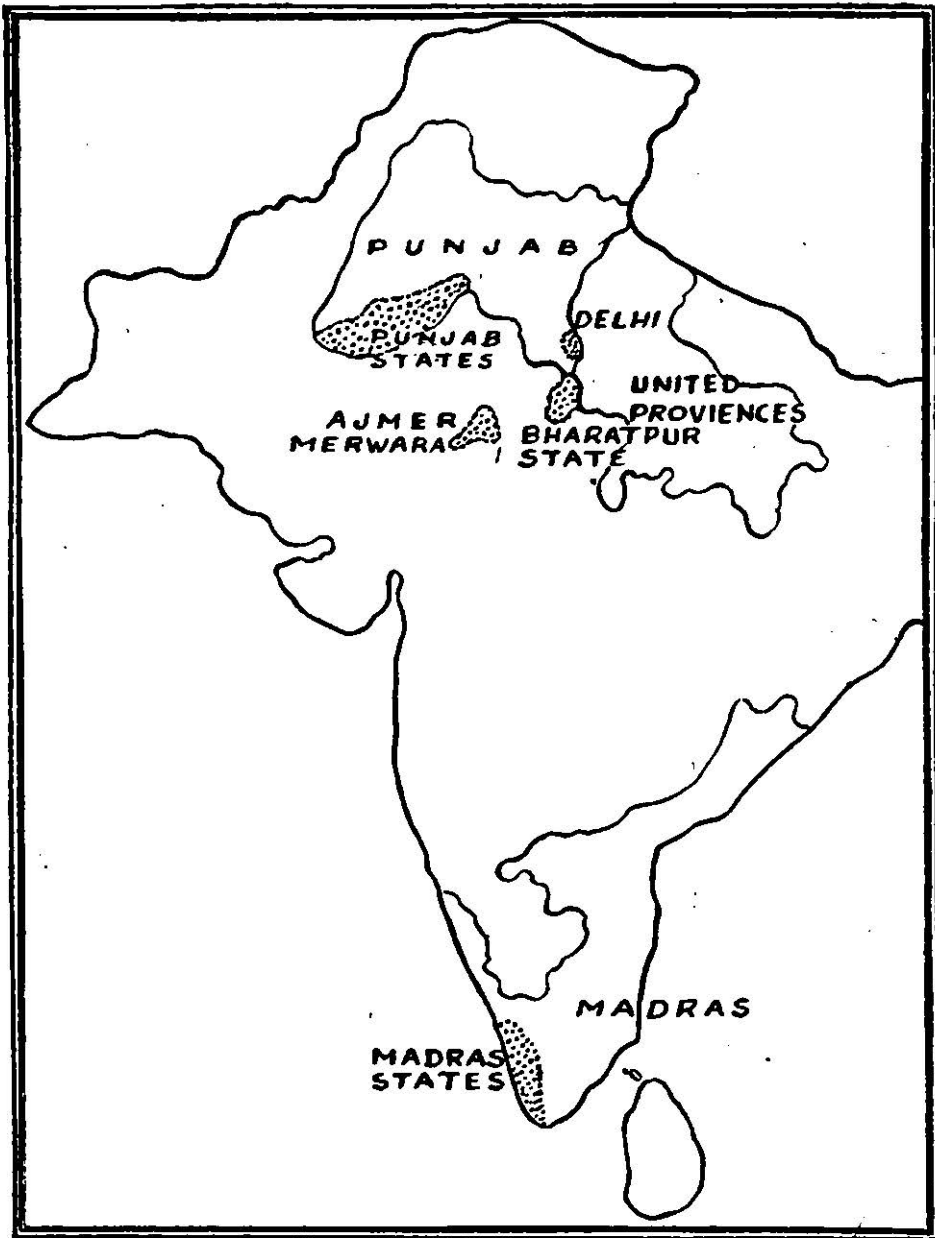


Fig. 1 MAP OF INDIA
showing the important centres of cultivation

(c) *Other Countries:* Khus is also said to grow in Java, Malaya, Reunion Islands, Uganda, Gold Coast, Fiji, Phillipines and Jamaica. In Java, the cultivation of Khus is carried on a systematic basis with proper attention paid to weeding, watering, manuring etc. Two crops are harvested every year. The slips are transplanted in the rainy season in rows of $1\frac{1}{2}$ metres apart, 65 rows to a hectre. A total of 6500 metres representing about 43,000 slips is under cultivation and they are reported to yield after about 2 years about $2\frac{1}{2}$ tons of clean dry roots i.e. about one ton per acre from which 14 lbs of oil are obtained, representing an yield of about 0.62%. In some instances the roots are said to yield 2 to 3% of oil whereas the Indian roots, except in very exceptional cases in South Malabar (where selected batches yield 0.5 to 1.2% oil) yield barely 0.3%. The importance of watering and manuring of the roots at the required time cannot be over emphasised. In the Phillipines it is stated that the oil content of the root continues to increase up to the flowering period which is within 3 to 4 months from the time of cultivation.

7. Cultivation of roots: Firsthand information regarding the cultivation, production, consumption and trade in Khus roots was gathered by Mr.C.T. Ittyachan by visiting a number of centres in India. A map of India showing the important centres of cultivation is shown in figure 1. The results of his investigations are summarised below:—

(i) *Delhi:* Delhi is not a Khus growing centre but a few wild plants are met with in the low lying waste lands in the suburbs of the city. These plants are seldom lifted and used. The total quantity of Khus root coming into the Delhi market is estimated to be about 550 tons per annum. It is brought from places like Gurumukhteswar, about 58 miles from Delhi in U.P., Farukhnagar, Kaithal, Ellananad, Gurgaon, all in the Punjab and Bharatpur State. Bombay and Madras also supply some of the requirements. The price of the roots at the time of the investigation i.e. during November 1943 was Rs 20/- to Rs.40/- per maund of 82 lbs. (= Rs.546/- to Rs.1092/- per ton) depending upon the quality of the root and it was estimated to go up to Rs.30/- to Rs 50/- per maund (=Rs.820/- to Rs.1365/- per ton) during the summer. Different qualities of roots are available in the market and the grades are fixed according to the aroma and the amount of foreign matter such as clay etc. mixed with the roots. The bulk of the roots consumed in Delhi is for making "tattis" and it is not an uncommon practice amongst the dealers to purchase used tattis in auction, and after adding some fresh roots, to resell them as good stuff. The leading firm dealing in Khus root in Delhi is Messrs. Surajbhan Sultanchand, Iswar Bhawan, Delhi, and according to them they sell about 100 tons of Khus root every year.

(ii) The Punjab :

(a) *Lahore:* Lahore is not a Khus producing centre, the roots consumed locally for "tatti" making being obtained from the Hissar District of the Province.

(b) *Multan:* In Multan only stray patches of Khus grass were noticed and the quantity available at the time was negligible.

(c) Hissar District:

(i) The most important area for Khus in the Punjab is the district of Hissar situated in the Southern Punjab. The Khus growing area of the district covers nearly 150 square miles and about 220 tons of roots can be collected every year. There is no actual cultivation and the growth is entirely wild. The Tahsils and villages of this district where Khus grows are Sirsa, Ellanabsd, Talwara, Hensi and Hissar. On the route from Sirsa to Ellanabad, 27 miles by katcha road through jungle area, one meets with luxuriant crops of Khus grass, on the canal bunds and also in the interior of the jungle. Along the banks of the river Ghaggar, a branch of the river Jumna, and round about the lake Talwara, there is a plentiful growth of Khus. Talwara is an important village for the collection of Khus root and is 7 miles from Ellanabad. The only mode of transport to this place, on account of the distance and ruggedness of the path, is by camel. The grass grows to a height of 4 to 6 feet and the roots are fairly good and fragrant. The soil in this place is sandy. The poor people of the locality collect the roots and sell them to small contractors, who in turn undertake the supply to the dealers in principal cities, like Lahore, Delhi and Bikaner. The roots are transported in bullock carts, on camel back and by rail. The entire available crop of roots is not lifted every year but could be done if some care and trouble were taken. The price quoted for fresh roots was Rs.8/- to Rs.15/- per maund of 82 lbs. (=Rs.218/- to Rs.410/- per ton). One of the big contractors at Ellanabad is Nathuram and Badri Prasad. At Ellanabad, also two firms, Lakshmi Narayan Vaid & Co. and Manmohan Perfumery Works used to distil the roots on a small scale; the former conduct the operations nowadays only rarely, while the latter have completely stopped the work. Samples of roots from Talwara were collected and sent for chemical and botanical examination.

(ii) At Sirsa a Technical Demonstrator in charge of the peripatetic Essential Oil Demonstration Party, organised since 1938 by the Industries Department of the Punjab Government, was found giving a practical demonstration to the villagers of the different processes of extracting the oil from Khus roots and explaining the uses of Khus oil, in order to induce and encourage them to take

up the distillation of Khus roots on a cottage industry basis. The Demonstration party had already completed the work in three Khus producing districts of the Province, namely, Hissar, Gurgaon and Rohtak, and was expected to move shortly to the Karnal District. The Demonstration Party carried with it an ordinary still unit, consisting of a copper container, tinned inside to which was attached the condenser with a copper receiver. The heating was done by open fire. The roots are cleaned, chopped and steeped in water for 16 to 24 hours prior to distillation. The distillate is passed into the receiver, containing an oil base like bloomless white mineral oil so that the oil from the roots could be completely absorbed by it. The water vapour is condensed and removed and put back into the still. No pure oil, however, is extracted. The roots are said to yield a maximum of about 0.6% of pure oil. A sample of Khus oil was obtained from the Demonstration Party; its price was said to vary from Rs. 16 to Rs. 20 per oz. A factory at Sirsa, known as Durga factory, owned by Mr. Suraj Bhan, is extracting oil from Khus root on a small scale by the above method. They send this oil to Lahore. No large scale production of the oil is carried duu to the non-availability and high cost of labour in this locality.

(d) *Rohtak and Gurgaon District:* The important Khus producing villages of these two districts are Buddedu, Jaraom, Farukhnagar, Siwari and Jhajjar. Mr. Gujar Mal Manchand Jain at Farukhnagar is a big dealer of Khus roots and maintains a store at Delhi. The quality of the root grown in these districts is on a par with that of the Hissar District. The annual output of roots in this area is about 300 tons and is sent mostly to Delhi. Nobody extracts Khus oil in this locality.

(e) *Karnal District:* Karnal is another important Khus producing district in the Punjab. The villages of Siwan, Kaithal and Pahewa in this district were visited. On the roadside and jungles skirting these villages, thick wild growth of Khus were noticed. At Dhaneshwar, on the banks of the river Saraswati, Khus is found to grow well. The roots are long, thick, fleshy and of good aroma. The present output of roots in Kaithal is about 80 tons, but it can be considerably increased if the entire quantity of root is lifted. The local price for one maund of root was Rs. 20 to Rs. 25 (=Rs. 546 to Rs. 687 per ton). This high rate is attributed to scarcity of labour. Most of the roots are sent to Delhi and Lahore as no extraction of the oil is done in this locality. Mr. Lala Mothiram, Banker and Landlord, and Mr. Doudi Khan, Zamindar, both residing in Siwan can supply large quantities of Khus root if required. Samples of root from Siwan were collected for botanical and chemical examination.

(iii). *Ajmer*: Ajmer, an Agency tract of British India, though not an important centre for Khus root, possesses a few Khus growing localities in the villages of Kaleswara, Tabji, Ramsan, Sarwan, Burna and Bansendri. The total crop of root in this area is estimated at 12 tons, but not much attention is paid in the matter of collecting the roots. For the manufacture of "rattis" for use in summer about 4000 to 5000 rupees worth of Khus root is consumed every year in Ajmer. This is obtained from Bharatpur through contractors, one of whom is Mr. Nanduram of Anasagar Gate, Ganj, Ajmer.

(iv). *Bharatpur State*: Of all the centres in India, Bharatpur State is said to be the biggest supplier of Khus roots. From the Forest records, it was gathered that the annual output of Khus root was about 750 tons but this figure could be doubled if attention was paid to collect all the available roots from the villages, some of which were reported to be highly malarial. The important Khus producing Tahsils in the State are Kumehar, Bharatpur and Rupbas. The roots are long, fleshy and fragrant. The roots are distilled in the State as well as exported to places like Delhi, Ajmer and Agra. The following table shows the quantity of roots distilled and exported from the Bharatpur State:—

TABLE I.

Year.	Quantity distilled (maunds)	Estimated quantity of oil produced	Quantity of root exported (maunds.)	Octroi duty rate per (maund.)		
				Rs.	As.	P.
		lbs.				
1938-39	10,263	1925	339	1	8	0
1939-40	7,847	1470	815	1	8	0
1940-41	11,880	2100	585	1	8	0
1941-42	870	160	1242	1	8	0
1942-43	6,837	1280	811	4	0	0
1943-44	15,000	2800	5000	4	0	0

(N.B. 1 Maund=82 lbs.)

On every Bengal maund of root, the State at present collects an octroi duty of Rs. 4/- per maund and a royalty of Rs. 2¼/-. The octroi duty used to be Rs. 1/8/- per maund until 1942-43 when it was raised to Rs. 4/- per maund. The octroi acts as a heavy impost and considerably increases the cost of the oil and the State would be well advised to remove it or atleast reduce it substantially. In 1943 Lala Bansari Das Kathri of Kanauj had entered into a contract with the State to distil 500 tons of root and 140 still units were commissioned for the purpose. The yield of oil was reported to be about 3 oz. per maund of root. Including the cost of the root and State duty, the cost of production of oil from

1 maund of root was estimated to be about Rs. 15/- to Rs. 18/- or about Rs. 80/- to Rs. 96/- per lb. The selling price of the oil was said to be about Rs. 120/- to Rs. 160/- per lb. Samples of roots were collected from the villages of Mala and Bhrapura for chemical and botanical examinations. An ounce of pure freshly distilled oil was also obtained from Mr. Lala Benarsi Das Khathri at Bharatpur for analytical test.

(v) *United Provinces*

(a) *General* : From references available in the Imperial Agricultural Institute as also the Indian Forest Records, Vol. 11 (Khus Grass by N. L. Bor) it was found that Dehra Dun, Ramnagar, Gorakhpur, Gonda, Etawah, Pilibhit, Bahraich, Cawnpore and Kheri are places in the United Provinces where Khus is grown. To facilitate the conduct of the survey in the United Provinces, the Director of Agriculture at Lucknow, in consultation with some of the Agricultural Officers and the Provincial Marketing Officer, made the necessary arrangements for the visits of Mr. Ittyachan to important centres. Information on the various aspects of the Khus root industry in U.P. was also obtained from Rai Saheb D.Y. Athawale and Dr. Mulay of the H.B. Institute, Cawnpore.

(b) *Lucknow* : Though Lucknow is not a Khus producing centre, it is considered important as a perfumery market. Amongst the various firms dealing in perfumery articles there, the firm of Ashgar Ali Mohamad Ali holds a high place. They have about 30 distillation units operating for them in various centres and they prepare both pure oil, called "Ruh" and also "attar" prepared on bases like Sandalwood oil and white mineral oil. The price of 1 tola of "Ruh" was Rs. 12/- (= Rs. 480/- per lb.) whilst a tola of "attar" cost from Rs. 1,8/- to Rs. 4/- (=Rs. 60/- to Rs. 160/- per lb.) (N.B. 40 tolas = 1 lb.) The genuine oil or "Ruh" is of green colour, viscous and possesses a fine aromatic smell. There are several varieties of "Ruh" the quality depending on the nature of the roots distilled and the locality where they grow. The best oil is reported to be that distilled from the roots grown in Musanagar and Bharatpore State. The distillation of the roots is conducted wherever the roots are found and the stills are moved from place to place. The still consists of one copper container, to the neck of which is attached a bent bamboo tube, which serves as a condenser and the end of which is let into a copper receiver. A small wooden barrel or iron drum is used for keeping the cooling water, which is provided by any pond or stream nearby. The average yield of oil is said to be 2 oz. from a maund of roots, the price of which was Rs. 15/- per maund of 82 lbs. The oil is packed in leather bottles or tins and sent to different places such as Delhi, Lahore, Calcutta, Cawnpore, Madras and some times also to places outside India. In the

city of Lucknow, the annual consumption of Khus root for "tatti" making is reported to be about 50 tons.

(c) *Cawnpore* : In Cawnpore about 40 tons of Khus root are consumed annually for "tatti" making and the supply is obtained from Utripura and Kasganj area. the price ranging from Rs. 15/- to Rs. 20/- per maund of 82 lbs. The tattis are sold at 5 to 10 annas per sq. ft.

(d) *Dehra Dun* : At Dehra Dun with the assistance of the Forest Research Institute a few neighbouring villages, about 6 to 7 miles from the town, where Khus grows wild, were visited. Clumps of grass were met with in scattered areas, but the soil being hard, difficulty was experienced in lifting the roots. The plants are sturdy and grow to a height of 4 to 5 feet. The roots are fairly long and of medium thickness with a few branches. No regular lifting of the roots was noticed probably due to the labour involved. A sample of the entire plant was sent to the Director, Institute of Plant Industry, Indore, for botanical study.

(e) *Kanauj* : Kanauj is famous from time immemorial as the centre of the perfumery trade and industry in India. There are a number of firms carrying on the business—most of them, family concerns of long standing—who distil various oils, blend them into perfumes and prepare scents, agarbattis and several other perfumery articles, much favoured by well-to-do people. The methods in vogue are somewhat antiquated, but the art of perfumery is still kept up. Synthetic chemicals and raw materials imported from abroad are also being used for blending purposes. The following are the leading perfumery firms in Kanauj :—

1. Messrs. Lala Benarsi Das Khathri.
2. „ Budh Sen Sidh Nath.
3. „ Beniram Mulchand.
4. „ Makulal Ayodhya Prasad.
5. „ Debi Prasad Sunderlall.

Oil extraction parties are sent by these firms during the season, i.e. from December to February to various Khus growing centres such as Musanagar, Bharatpur, Biswan, Utripura and Nawabganj where they carry on distillation operations for a period of 2 to 3 months. In all there are about 400 distilling units (degs) owned and employed by these firms. The equipment is of the usual type met with in Lucknow and elsewhere in Northern India. The prewar cost of a complete distilling unit was about Rs. 300/- but the current prices would

be more in view of the increased cost of materials and labour. According to Kanauj distillers the yield of oil from Bharatpur roots was $3\frac{1}{2}$ oz. per maund. The root considered next best in quality is the Musanagar variety which yields 3 ozs. of oil per maund and is said to have the maximum vetiverol content. The total output of Khus oil extracted by the Kanauj perfumers is reported to be about 5000 lbs per annum. The oil is packed and sent in bottles, tins as well as in thin leather containers called "kuppees" which are credited with the property of preserving and improving the smell and appearance of the oil; non-leakability is another advantage of these leather containers which cost about 12 annas for holding 1 lb of oil. The principal markets for the oil are Lucknow, Cawnpore, Delhi, Lahore, Calcutta, Bombay and Madras. The oil is consumed by soap makers throughout India for blending soap perfumes but some of the oil is also used in pharmaceutical preparations. A sample of the oil extracted at Utripura was purchased from Messrs. Lala Benarsi Das Khathri.

(f) *Pilibhit*: Pilibhit is another important Khus area in the United Provinces. About 40 tons of roots are available in this locality and the grass grows in the villages of Mala and on the sides of the rivers Gomthi and Kharant. The soil is loamy and clayey. The root is known locally as "Gandar" whilst the grass is called "Seenk" which is used for making brooms. The roots are used for making "tattis", fans and brushes (for cleaning ornaments). Khus roots are also found in the 'tarai' (low lying lands, bordering on the foot of the Himalayas) especially in and around Naini Tal, but no oil is extracted in this locality. Samples of roots from Pilibhit were collected and sent for chemical and botanical examination.

(g) *Biswan*: Biswan is an important centre in the district of Sitapur for the production of Khus root. The villages of Patini and Saanda, each ten miles away from Biswan were visited for collecting samples. Khus root is offered for sale in these villages in fairly appreciable quantities. The land, where Khus grows, belongs to Zamindars, who collect 6 annas for every maund of root lifted. The soil is of a loamy nature and the rainfall is about 30 to 40 inches per annum. The villagers are not interested in the collection of the roots, but Kanauj firms like Messrs. Beniram Mulchand, Debi Prasad Sunderlall and Hiraji Mangalji are carrying on distilling operations in these villages. The distilling sets of the usual type are set up on the bank of the river Kevari, owing to the convenience of the water supply for the condensers and for cleaning the roots and steeping them prior to distillation.

(h) *Nawabganj*: Nawabganj in the district of Gonda is another important Khus centre. Here also the extraction parties from Kanauj camp during the

season and carry on distilling operations. The Khus growing areas round about this place are mostly jungle tracts comprising of the following villages—Kempur, Mhangpur, Choukharla, Sakipur, Tulsipur, Gokula, Dathragar, Rangi, Ghauncha and Jumthara. About 100 tons of roots are available in these parts for oil extraction. The grass attains a good sturdy growth and the roots are of excellent quality. The soil is sandy loam. About $\frac{1}{2}$ tons of roots is the yield per acre.

(i) *Jaunpur*: Jaunpur is noted for the manufacture of scented oils. Mr. Beniram Chedilal and Haji M. Zakharish are two local merchants of repute there. About 80 lbs. of Khus oil is consumed in Jaunpur in the preparation of scented oils and this quantity is supplied by the Kanauj dealers.

(j) *Ghazipur*: The “Rakshit Gardens” at Ghazipur owned by Mr. J. N. Rakshit were also visited. Different essential oil plants of botanical and scientific interest are found here, notwithstanding the somewhat neglected condition of the garden. Three specimens of Khus were taken for botanical study. There was no perceptible difference between these, except for slight variations in the nature of their root formation. Mr. Guchanan Ram Gaya Ram, a leading perfumer of Ghazipur buys about 40 lbs of Khus oil from Kanauj every year. The market rate for Khus oil was about Rs. 8 per tola (=Rs. 320 per lb.).

(k) *Musanagar and Manchela*: Musanagar and Manchela about 20 miles from Pokhrayan Railway Station in Cawnpore district are important centres for the production of Khus root. More than 100 tons of root are available in these parts, most of which is distilled for oil by Kanauj firms. The grass is of sturdy growth with thick long roots which yield about 3 oz. of oil per maund. The method of extraction is the same as followed elsewhere. Being jungle area, great difficulty was experienced in collecting samples.

(l) *Etawah and Hathras*: Another important centre in the United Provinces is Etawah. 150 tons of root is the estimated output in this area. Hathras is also an important centre close by. The roots are plucked by the local people who sell them to petty contractors who forward them to Delhi and other places. Samples for chemical and botanical study were collected from a village called Bhasria, 13 miles from Etawah, with the help of the Superintendent of the District Agricultural Farm.

(vi). *South Malabar*: In Malabar District, the cultivation of Khus is centred round Chowghat in Ponnani Taluk—the important villages being Kaipamangalam, Chentrapinni, Peringanam and Koolimuttam. The soil in these parts is mostly sandy mixed with some loam. Growing of Khus by poor villagers in small patches of land adjoining their huts has been going on for some

years in this part of South Malabar. In some places larger plots are found under this crop. Of late, there has been an appreciable increase in the area under cultivation, about 500 acres being a fair estimate. Small slips are planted 8" to 10" apart on prepared land during the months of January, February and March. The roots are ready for cutting after 10 to 11 months of planting. Watering and manuring are resorted to by some people. The roots are long and spreading. The estimated yield is about $\frac{1}{2}$ to 1 ton of root per acre. The merchants advance money to the poor ryots who are obliged to part with their crop for a paltry amount, whilst bulk sales are effected by the merchants at fairly high prices. The roots are packed in small bundles of 30 lbs. for export and the price of the root is Rs. 70 to Rs. 75 per candy of 652 lbs. i. e. Rs. 9/8/- per maund of 82 lbs. (= Rs. 245 to Rs. 258 per ton). Of late there has been a growing tendency on the part of some unscrupulous dealers to adulterate the Khus root with similar looking though worthless roots of other plants such as bamboo etc. Samples of roots were taken from Kaipamangalam for chemical and botanical examination. The principal market for the roots is Cochin whence it is exported to Bombay and other places.

(vii) *Travancore*: Neyyatinkara in South Travancore is a Khus growing area about 12 miles distant from Trivandrum. In the adjoining villages of Kalaikavalai, Kattakadai and Aralamedu, Khus is cultivated; it is seldom found growing in wild state in these parts. The area under cultivation has been considerably cut down since the war began and it may be about 250 acres at present. The Government and the people of Travancore are concentrating mostly on the raising of food crops such as tapioca, paddy etc. to make up atleast a part of the food deficiency. Hence the growing of Khus is restricted and confined to mudwalls surrounding residential premises, bunds around plots of dry lands and available waste lands unfit for raising food crops. Samples of roots were collected for examination. The roots are fairly long, thick and good smelling. Haji M. Sayed Mohamad & Bros., Mr. Chellam Pillai and Mr. P. Raghavan Pillai are the three leading merchants dealing in Khus roots in Trivandrum. The roots are exported to Tinnevely, Tuticorin, Madura, Cochin, Alleppey and a few other places. The price of the root was Rs. 3 per maund of 30 lbs. or Rs. 8 per maund of 82 lbs. (= Rs. 218/ per ton).

(viii) *Cochin*: The bulk of the export trade in Khus roots grown in South India is handled at the port of Cochin. Two of the local merchants engaged in this business are Mr. Popatlal Goverdhanlal and Khan Saheb Ismail Haji Essa Sait. According to them about 200 to 250 tons of Khus root come into

Cochin market every year from centres like Chowghat and Trivandrum, most of which is exported to Bombay both by rail and sea. The ruling market rate (i. e. in January 1944) of the roots was Rs. 70 to Rs. 90 for a candy of 652 lbs. i. e. about Rs. 9 to Rs. 11 per maund of 82 lbs. (= Rs. 245 to Rs. 300 per ton). In Cochin, Mr. D. V. Deo, the local agent of Messrs. K. M. Dhamdhare—a long standing firm of perfumers of Bombay—is distilling Khus roots obtained from Trivandrum, Tuticorin, Tinnevelly and Chowghat. He has also planted a few plots in his garden with root slips obtained from Tuticorin. There are four copper stills heated by open fire. The yield of oil from the Travancore and Tuticorin roots is reported to be about 0.5% and that from Chowghat variety about 0.3%. Each of his still takes a charge of one maund of root and each distillation takes sixteen hours to complete. The oil is skimmed off and is filtered through a hot water funnel for removing the moisture. A clear oil, free from moisture, foreign matter etc. is thus obtained. The cost of production of oil from 1 maund of root is Rs. 15 inclusive of the cost of root.

(ix) *Madras Presidency*: The other centres in South India are Tinnevelly, Srivilliputtur, Madura, Tanjore and Chidambaram. In all these places, Khus is not grown as a commercial crop but is cultivated in small patches near the huts of poor people. Some wild growth of Khus has been met with on the field bunds near Mayavaram. Tuticorin at one time was famous for the cultivation and export of Khus of the finest quality much valued by the users, but the industry has greatly declined in recent years. A year ago, some plots of land covering about 10 acres on the sea side of the west coast of the Madras Presidency have been planted with Khus by the Industries Department, on a systematic basis under the direct supervision of an Agricultural Officer. The growth was reported to be somewhat satisfactory and lifting of the roots in some places was expected to commence soon after the monsoon of 1944. The other districts in the Madras Presidency, where Khus is met with partly cultivated but mostly wild are Kurnool and East Godavari. Small supplies of roots were obtained from the Agricultural Officers in Kurnool and Peddapuram for distillation experiments at the Kerala Soap Institute. The roots are thick and coarse, of a reddish colour with a faint aroma. The yield of oil was negligible. Evidently the roots were of poor quality or plucked before they were quite mature. In the Agri Horticultural Gardens, Madras, Khus grass is cultivated as a garden crop. The specimens of roots obtained were of average quality, but the quantity available is not much. There may be a few other places in the Madras Presidency where Khus is met with but so far no definite data regarding the extent of its area or quantity lifted are available.

8. **Cost of cultivation:** The cost of labour is the principal item of expenditure involved in the cultivation of Khus roots as will be seen from the following figures which refer to Malabar: Cost of labour etc. has almost doubled since 1943.

	<i>Cost per acre.</i>
1. Labour for planting (2 men @ Rs. 1/4/- each)	Rs. 2-8 0
2. Preparation of land (10 " " " " ")	Rs. 12-8-0
3. Earthing up and weeding (5 " " " " ")	Rs. 6-4-0
4. Cost of manure (ash)	Rs. 6-4-0
5. Labour for manuring (2 men @ Rs. 1/4/- each)	Rs. 2-8-0
6. Labour for watering (16 " " " " ")	Rs. 20-0-0
7. Lifting charges. (50 " " " " ")	Rs. 62-8-0
Total	Rs. 112-8-0

(N. B. Slips for planting cost about 8 annas to Re. 1/ per 10,000; in fact in localities where the roots are lifted, these are available almost for nothing).

In some places the cost is further increased by the levy of a royalty for the right of collection. The Bharatpur State, for instance, levies an octroi duty of Rs. 4 and royalty of Rs. 2-4 on every Bengal maund of roots collected.

9. **Adulteration of Roots:** Unscrupulous dealers often soak the dry roots in water and sprinkle sand and clay powder to increase the weight and buyers have found it to their cost, that several consignments of roots have proved hopelessly bad, as the actual workable quantities were only 30 to 35% of the total. Instances of adulterating the Khus roots with other roots of similar appearance but having no odour value are also common. Similarly once distilled roots for roots already used for "tattis" in a season are often brought into the market with a slight aroma being imparted to the roots by sprinkling a few drops of the Khus oil or admixing fresh Khus roots with them. It is difficult for an ordinary and inexperienced person to detect such clever adulteration and it is regrettable to note that the practice of adulterating the roots is on the increase.

10. **Uses of Roots:** The Khus root is used for a variety of purposes. It is made into aromatic mats and screens (tattis) which are in great demand in the hot season especially in North India for cooling the atmosphere and spreading a fine refreshing aroma; for this purpose the screens are constantly watered and kept moist. Artistic fans, ornamental baskets, brushes etc. are also made

from the roots. The largest consumption of the root is for making "tattis" for which the estimated quantity is about 38,000 maunds (=1390 tons) per annum. The roots possess a highly aromatic essential oil which finds manifold application in the soap, perfumery and toilet industries. The quantity of roots used for oil extraction is reckoned at about 31,000 maunds (=1135 tons) per annum, according to the statistics supplied by perfumers and merchants in Kanauj and elsewhere. Apart from the above uses, Khus root possesses medicinal properties and enters into various medicinal and pharmaceutical preparations much valued in allopathic as well as Ayurvedic systems of treatment. The root when made into a paste and applied to the head cools the head, cures headache and acts as a soporific. An infusion of the root is given as a febrifuge and used as a stimulant, refrigerant and stomachic and as a preventive against cholera. A paste of the pulverised roots in water applied externally is beneficial in fever, heat strokes etc. and also gives much relief to those suffering from prickly heat and attacks of itches and ringworm.

11. Morphological study of roots:

(a) The morphological characters of the Khus plant with particular reference to the oil content of the roots were studied at the Institute of Plant Industry, Indore, C. I. 14 samples of Khus roots were sent to Indore where they were planted almost immediately in plots arranged for the purpose as it was thought that the root system as also the appearance of stem and leaves of samples from different places might show differences which may have some relation to the oil contents, so that it may be possible to identify roots bearing high oil content from their aerial parts. Unfortunately, only one sample, namely, that from Bharatpur sprouted; probably the main reason was that the samples having had to travel long distances dried too much in transit. A table showing the root habits, soil and climatic variations in different centres where the samples were collected is shown on page 21 (Table II).

(b) Thick free hand sections of roots both transverse and longitudinal were examined under the microscope. The samples were treated with 1% osmic acid. External protuberances from the surface of roots were stained blackish brown, this colour reaction indicating the presence of oil. The structures containing the oil were identified as glandular hairs as shown in figure II. These and other morphological characters were examined and are tabulated on page 22 (Table III).

TABLE II

Table showing the root habits, soil and climatic variations in different centres from which fresh Khus plants were sent to Indore.

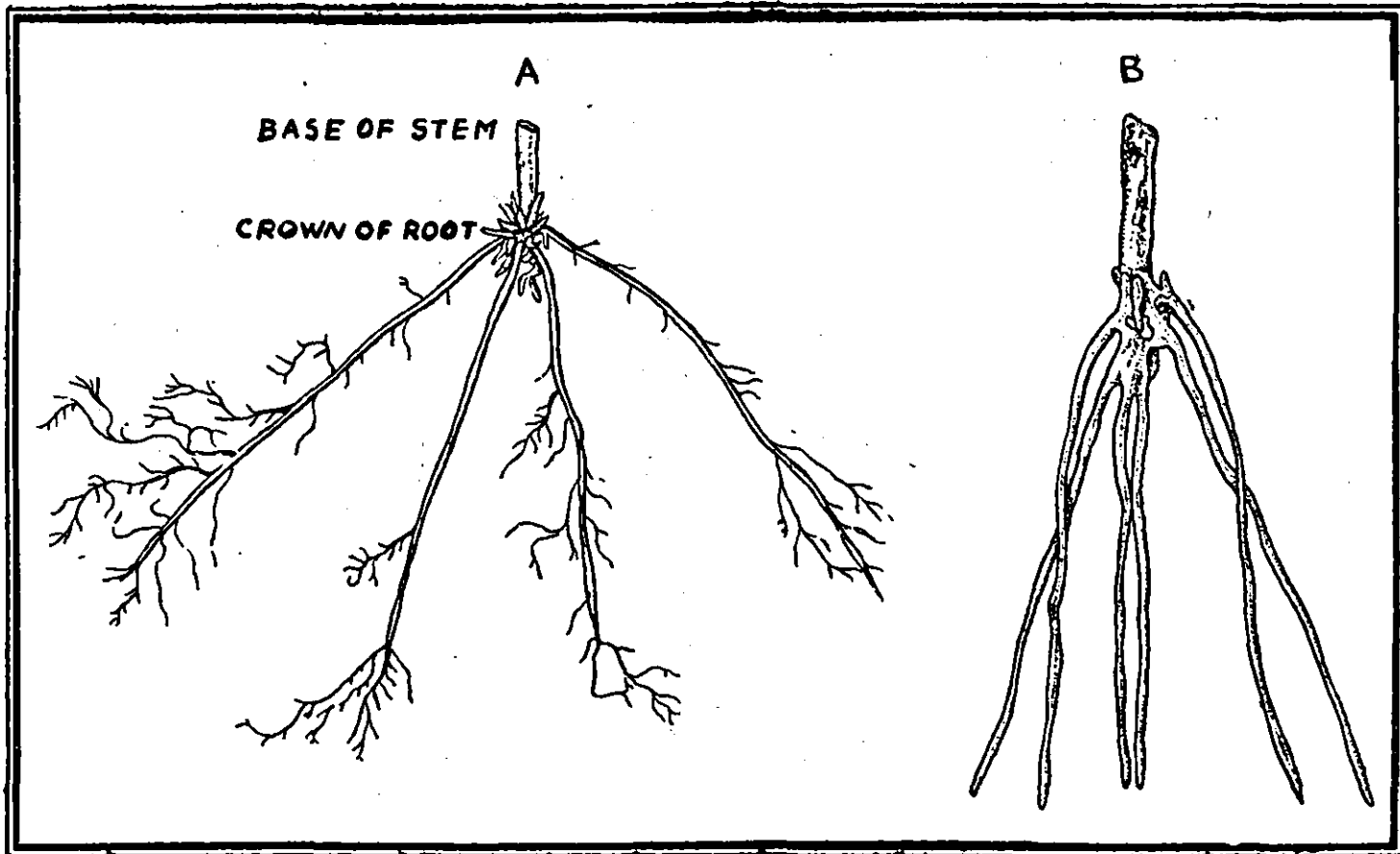
Name of centre.	Rainfall inches.	Nature of soil	No. of tillers per clump.	Height of plant feet.	Quantity of root per clump tolas.	Length of root. inches.	Thickness of root.	Root growth.	Root aroma	Climate.	Remarks.
1. Dehra Dun	60 to 110	Hard stiff sandy loam	20 to 25	4 to 5	1 to 2	4 to 8	Medium	Slightly branching	Fairly good	Extreme of temperature.	The spreading habit of the root can be correlated to the nature of the soil. It is more spreading in loose sandy soil than in the hard soil where the roots go straight in with very little spreading.
2. Ellanabad (Sirsa)	10 to 30	Sandy and sandy loam	10 to 20	4 to 6	2 to 3	2 to 8	Medium	Non-branching	Fairly good		
3. Siwan (Kaithal)	15 to 20	Loam and sandy loam	40 to 50	3 to 6	4 to 8	6 to 18	Main root thick and fleshy and fine branches	Fairly good branching	Fairly good		
4. Bharatpur	27 average	Sandy and sandy loam	40 to 50	5 to 7	6 to 8	6 to 12	Fleshy and thick	Slightly branching	Good		
5. Pilibhit	48 to 49	Loamy and clayey.	10 to 15	3 to 4	1 to 2	4 to 10	Medium	Very slightly branching	Good		
6. Biswan	30 to 40	Loam	30 to 40	3 to 4	3 to 5	6 to 12	Thick	Slightly branching	Good		
7. Nawabganj (Gonda)	40 to 45	Sandy loam	20 to 40	3 to 4	2 to 3	6 to 14	Thick	Slightly branching	Fairly good		
8. Ghazipur I	35 to 40	Sandy loam	20 to 25	3 to 4	2 to 3	6 to 7	Medium	Slightly branching	Fairly good		
" II	do.	do.	25 to 35	6 to 7	3 to 4	7 to 10	do.	Fairly good branching	Good		
" III	do.	do.	25 to 35	6 to 7	3 to 4	7 to 11	do.	do	do.		
9. Musanagar (Manohela)	40 to 45	Sandy loam	15 to 40	4 to 5	5 to 7	4 to 13	Thick	Slightly branching	do.		
10. Etawah	40 to 45	Loamy	15 to 25	3 to 5	2 to 3	6 to 12	Medium	Very slightly branching	Fairly good		
11. Kaipamangalam	80 to 115	Sandy	10 to 12	3 to 4	6 to 8	6 to 16	Fine and thick.	Branching	Fairly good	Humid & rainy do.	
12. Neyyattinkarai	80 to 110	Loam and gravel.	8 to 14	3 to 5	8 to 10	6 to 20	Thick	Slightly spreading	Good		

TABLE III.

No. Sample.	Length of roots, inches,	Root thick-ness at "crown."	Stem thickness at base	Root Branch-ing.	Colour.	Aroma,	Glandular hairs
1. Dehra Dun	3.6 to 8.2	Thick (3. Omm)	Thick (8. Omm)	Little	Light ash	Fairly good.	Many.
2. Bhawalpur	3.5 to 9.4	Thin (1. Omm)	Thin (2. Omm)	None	Light yellow	Strong but not Khus odour.	Very numerous.
3. Pilibhit	3.4 to 14.6	Thick	Medium (5. Omm)	Little	Brown	Fairly good.	Few
4. Biswan (P)	3.4 to 11.6	Thick	..	Little	Grey to Brown	Fairly good.	Few
5. Sirsa	4.2 to 14.5	Thick	Thick	None	Light Brown	Moderate	Numerous
6. Nawabganj (P)	3.7 to 14.5	Thick	..	Little	Light Brown	Good smell	Many
7. Kaithal	5.2 to 22.3	Thick	Medium	None	Ashy Grey	Very good smell.	Numerous
8. Bharatpur	4.3 to 13.6	Thick	Medium	Little	Orange Brown	Sweet good smell	Many
9. Ghazipur	3.2 to 9.8	Thick	Medium	Little	Ashy grey	Very good	Many
10. Musanagar (P)	4.2 to 19.3	Thick	..	Little	Ashy grey	Faint	Many
11. Etawah (P)	4.5 to 12.7	Thick	..	Little	Dark Brown	Fairly good	Many
12. Kanauj	..	Thick	Medium	None	Many
13. Trivandrum	4.1 to 19.6	Thick	Thick	Little	Yellowish	Brown Good	Many
14. Unknown	..	Medium (2. Omm)	Medium	Much	Many

N.B. (i) The sample No. 14 shown as "Unknown" reached Indore with its label torn off and its place of despatch could not be made out.

(ii) The sample No.2 from Bhawalpur was quite distinct from other samples in that its stems and roots were very thin and did not appear to belong to the regular Khus group. The odour from this root did not also have the typical Khus smell but appeared to have a touch of fennel odour (*Foeniculum Vulgare*) 'Saunf' in Hindi. Its glandular hairs were, however, quite numerous which indicated high oil content. That the Bhawalpur sample was not of true Khus type was also corroborated from the chemical examination of the oil from the roots as will be noted in para 12.



A—Medium Stems. Medium Branching Roots
(Unknown)

B—Thick Stems. Thick Non-branching Roots
(Bharatpur, Dehra Dun and the rest)

Fig. 2 KHUS PLANT

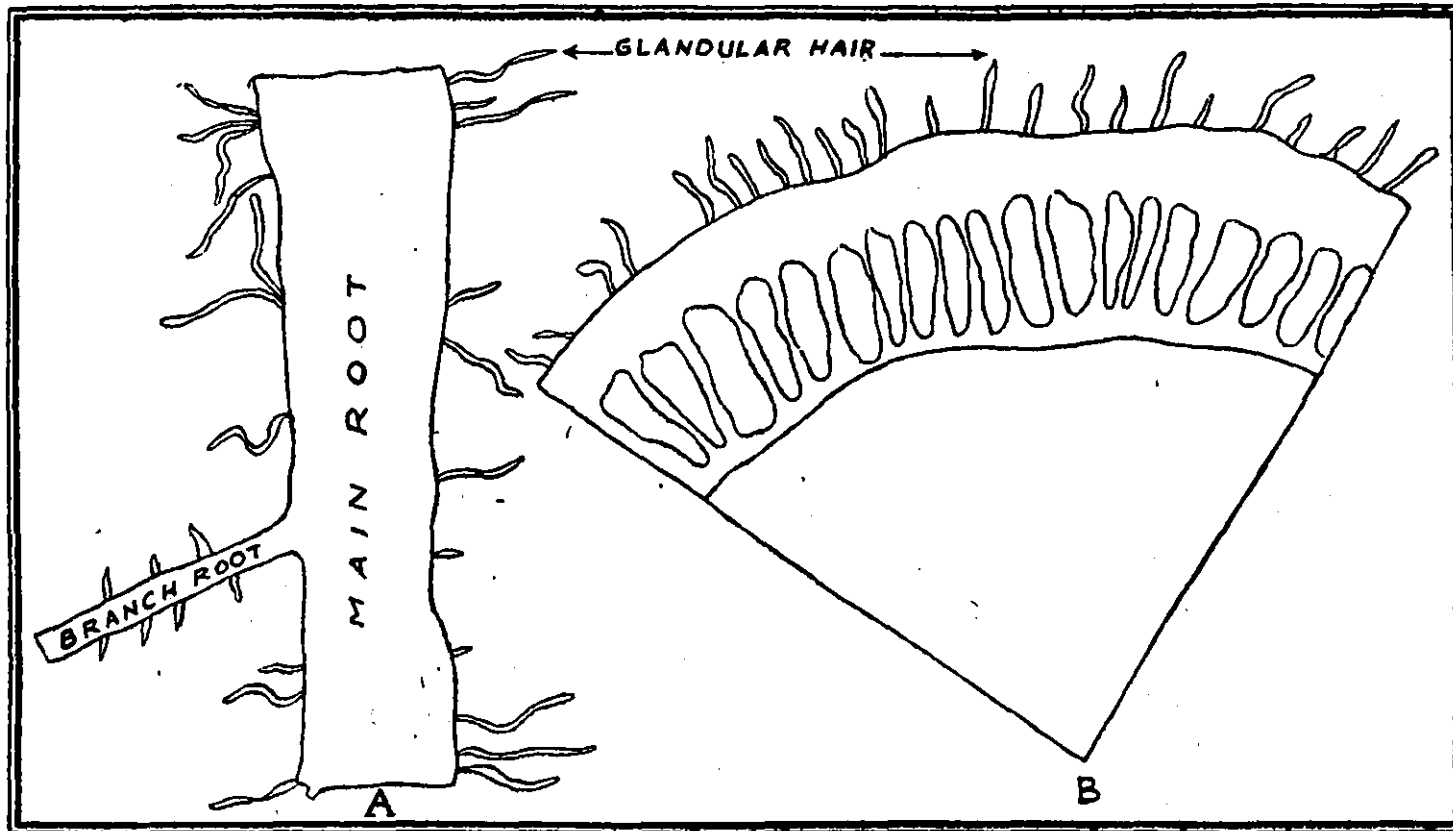


Fig. 3 Khus Root showing Glandular Hairs
(Structures bearing Oil) $\times 300$

Fig. 4 Quadrant of Transverse Section of
Khus Root

(c) From the morphological study it was observed that the density of the glandular hairs on the roots indicated a high oil content. Thus the roots from Sirsa and Kaithal appeared to have the highest oil content as compared with the samples from Pilibhit and Biswan which appeared to be low. The remaining samples fall into the group of medium oil content. Figure 3 represents a diagrammatic drawing of the Khus root showing the glandular hairs, the structures bearing the oil. There does not appear to be any definite relation of any of the other characters of the roots to the oil content in them. The internal structure of the root did not vary in any of the samples viz. the medium of thick roots. Figure 4 shows a transverse section of the root.

(d) The stems of four samples marked P in table III viz. No. 4, 6, 10 and 11 were very short in growth, indicating that the plants were lifted before the roots reached maturity. This premature removal probably affects other characters of the roots and should be studied further.

12. Chemical study of Roots: The chemical examination of the samples of roots collected by Mr. Ittyachan from different centres during his investigation, was conducted at the Perfumery Laboratory of the Tata Oil Mills Co. Ltd., Bombay. About a maund of roots was sent from each of the various centres, 9 from North India and 2 from South India for this examination and a summary of the observations made by the Tata Oil Mills Co. is quoted below:—

“The experiments on the 9 varieties of roots from North India and two from South India took about 3 months to complete. The roots were chopped to lengths of 2" to 3" taking care to exclude the husky parts. They were then soaked in cold water overnight, and in some instances, for as much as 36 hours, with a view to see whether the yields improved. The charges for steam distillation varied from 2 to 5 lbs. at a time. The optimum charge was between 3 to 4 lbs. The distillation was carried on for eight hours per charge, and it was observed that the major part of the oil came over, in every case, within the first four hours.

The apparatus used was a copper vessel of about 4 gal. capacity, fitted with a circular perforated coil at the bottom. The vessel was heated so as to avoid extra condensation of steam in it and the steam was dried as far as possible before its inlet to the vessel.

Difficulty was experienced in separating the oil from the water, as the oil was very viscous and the quantities which distilled over were very

minute. The crude oil contained water; so it was purified with benzene and dried over sodium sulphate. The results of the 11 varieties tried in this Laboratory are tabulated below :—

TABLE IV.

Roots (locality)	% Yield of oil from weight of moist oil collected.	% Yield of dry purified oil
1. Kaithal (Punjab)	0.165	0.152
2. Sirsa (Punjab)	...	0.110
3. Bharatpur	...	0.0214
4. Biswan (U. P.)	0.075	0.045
5. Nawabganj (U. P.)	0.04	0.023
6. Musanager (U. P.)	0.04	0.025
7. Etawah (U. P.)	0.05	0.03
8. Pilibhit (U. P.)	0.081	0.007
9. Kaipamangalam (Malabar)	...	0.14
10. Neyyattinkarai (Travancore)	...	0.091

13. Total output of Roots: Particulars of the production of Khus roots, quantity consumed for "tatti" making, distillation etc. are furnished in Table No. V. The present total output of root from all the principal producing centres in India will be about 77,500 maunds (=2840 tons). Of these about 46,500 maunds (=1700 tons) are used for making "tattis" and other miscellaneous purposes and about 31,000 maunds (=1440 tons) for the distillation of oil. Sarin's estimate of an output of 60-70 thousand maunds of Khus root as reported by Narielwala and Rakshit in their Report (Exploratory Essential Oil Committee (Page 17) in the Punjab is rather extravagant. According to the figures obtained from official sources, the present output of the roots in all the Khus growing districts in the Punjab is about 16,000 maunds and the maximum quantity that could be lifted is about 33,000 maunds.

Khus root was an article of export to England and some parts of Europe several years back, but of late there has been no export from India worth mentioning, as probably the entire European requirement is being met by Java and Reunion.

TABLE V.

Table showing the acreage, production and export of Khus roots in different centres.

Important District.	Centres.	Distribution Sq. miles.	Acreage estimated.	Present output of roots. maunds	Roots used for tatti locally maunds.	Roots consumed for distillation. maunds.	Export maunds.	Output if all available grass lifted. maunds.	Market.	Remarks.
UNITED PROVINCES.										
Western Circle	Dehra Dun, Mussafarnagar, Meerut, Agra, Farukhabad, } Bareilly, Pilibhit, Nainital } Almorah. }	1000	200	1000	Negligible	Nil	1000	5000	Delhi	
R. N. K. Circle		1500	250	1000	Negligible	Nil	1000	6500	Lucknow & Allahabad	
Sardar Circle	Cawnpore, Sitapur, Kheri. }	600	800	18000	1000	10000	6000	22000	Cawnpore & Lucknow	
Bhundelkand Circle	Etawah, Agra. }	500	300	1000	200	Nil	800	5500	Delhi.	
Eastern Circle	Fyzabad. }	100	75	500	100	Nil	400	1500	Cawnpore.	
N. E. Circle	Ghorakhpur, Gonda, Bhariech } Total: }	2000	700	5000	200	4000	800	16000	Lucknow & Cawnpore.	
		<u>5700</u>	<u>2325</u>	<u>26500</u>	<u>1500</u>	<u>14000</u>	<u>10000</u>	<u>56500</u>		
THE PUNJAB										
Hissar	Sirsa, Ellanabad, Talwara, Hissar, Hansi. }	150	450	6000	Negligible	100	5000	12000	Bikaner, Lahore & Delhi.	
Gurgaon	Ferozpurghurka, Soahna, Farukhnagar, Patavdi, Buddedu. Jarao }	300	250	3000	Negligible	Nil	2500	5000	Delhi.	
Rohtak	Jhajjar, Dadri }	250	350	5000	Negligible	Nil	4500	6000	Delhi.	
Karnal	Kaithal, Pahewa, Siwan. }	100	200	2000	Nil	Nil	2000	10000	Delhi.	
	Total: }	<u>800</u>	<u>1250</u>	<u>16000</u>	<u>Nigligible</u>	<u>100</u>	<u>14000</u>	<u>33000</u>		

Important District.	Centres.	Distribution Sq. miles.	Acreage estimated	Present output of roots. maunds	Roots used for tatti locally maunds.	Roots consumed for distillation. maunds.	Export maunds.	Output if all available grass lifted. maunds.	Market.	Remarks.
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BHARTPUR STATE.

Bharatpur State.	Bharatpur, Rup- baa, Kamelher, }	600	6000	20000	Negligible	15000	5000	50000	Bombay & Ajmere-	
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MADRAS PRESIDENCY & SOUTH TRAVANCORE.

Malabar District Ponnani Taluk.	Kaipamangalam, Peringanam Chendrapinni Koolimuttam }	100	500	10000	5000	1000	4000	6000	Bombay & Cochin.	
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**NEYYATTINKARAI TALUQ (TRAVANCORE STATE) AND ADJOINING
TINNEVELLY DISTRICT IN THE MADRAS PRESIDENCY.**

Neyyattinkarai & Tuticorin	Neyyattinkarai, & Kattakadai	256	250	5000	500	1000	3500	6000	Cochin & Tinnevelly.	
	Grand Total for all places :	7456	10325	77500	7000	31100	36500	155500		

N. B. The output of root per acre in the wild growth will be much less than that of cultivated crop. About 3000 maunds of roots are used for medicinal and other miscellaneous purposes.

* Small quantity used for miscellaneous purposes.

CHAPTER III.

Oil

14. Field.

(i) The yield of oil from the roots, as furnished by the perfumers in various centres in India is given below :—

TABLE VI.

S. No.	Name of centre.	Yield of oil from 1 maund (82 lbs) of roots.	
			%
1.	Sirsa (Punjab)	2 oz.	0.152
2.	Bharatpur State.	3 "	0.228
3.	Biswan (U.P.)	2½ "	0.190
4.	Gonda (Nawabganj) U.P.	2½ "	0.190
5.	Musanagar (U.P.)	3 "	0.228
6.	Utripura (U.P.)	3 "	0.228
7.	Kaipamangalam (Malabar)	5 "	0.381
8.	Neyyattinkarai (Travancore)	6½ "	0.495

(ii) There appears to be considerable variation in the yield of oil from the root, depending upon the soil, climate, maturity, time of lifting etc. The appearance and condition of the roots such as fresh or old stock, the preliminary treatment of the roots and the method of distillation are important factors which affect the yield. The presence of mud, sand, excessive moisture, stems and stalks and admixture with other plant roots etc. are the prime cause for the poor yield and lack of aroma. A better yield may be obtained from cleaned roots, but provision has to be made for the loss in weight etc., which invariably follows the cleaning operations. It was reported by Schimmels that about 1930-31 they obtained by distilling Indian Khus root 1.1% of oil, pale brown in colour and possessing a very intense and persistent odour. For commercial purposes, however, it is safe to fix the yield of oil from the average quality of the roots at 0.15%. It is, however, not beyond doubt that the Indian Khus root can yield not less than 1% of oil, if it is of the proper kind and quality and if the distillation process is conducted satisfactorily. There has also been a noticeable deterioration in the quality of the roots offered for sale in the various markets and this appears to be particularly so since the war started, presumably due to the unprecedented demand for the roots for distillation purposes, caused by the scarcity of oil as a result of stoppage of imports.

(iii) Published figures of the yield of oil in other parts of the world where Khus root is distilled are shown here by way of comparison. The countries which are actively engaged in this trade are chiefly Dutch East Indies (Java) and Bourbon (Reunion). Seychelles though once an important source of supply have apparently ceased to cultivate the root as a commercial crop, as no mention at all is made of the root or oil in the latest Annual Report of the Department of Agriculture (Colony of Seychelles) for the year 1938.

TABLE VII.

Place.	Yield of Oil%	Remarks.
Europe	0.4 to 1.00	From dry roots. Lowest from un-crushed roots.
*Java	2 to 3	
Reunion	2 to 3	
Malaya	3-3	
Manilla (Phillipine Islands)	0.3 to 1.9	
Gold Coast	2.25	
Seychelles	1 to 2	

*N.B. The oil content of the root in Java is said to be more in the cold weather, diminishes in the hot season and is lowest in the rains :

January to February...	1.1%
March	...1.1%
April-May	...0.8%
August	...0.45%

(iv) The following characteristics are associated with a root having good oil content:—

- (a) It should expose a hard surface when the skin is peeled off.
- (b) It should not break on bending.
- (c) It should be long, thick, hard and fleshy.
- (d) It should give a very sour taste when chewed.

In order to increase the yield of oil the roots should be well chopped and in some cases well crushed and steeped for a few hours in water. Steeping in water helps to shorten the time of distillation. To mix the contents in the still freely so as to expose every portion of them, to the action of the steam stirrers are some times provided which are kept continuously in motion during the operation.

(v) In Reunion and some other countries very good results in the yield have been obtained by adding common salt from 5 to 50% of the weight of the root to the water in the still before distilling. This had the effect of raising the temperature of distillation and probably in breaking up the oil cells. In Reunion also freshly lifted green roots are generally distilled and though the yield may be more, the oil is less viscid, paler and of weaker odour than that distilled from dry roots. The market value of such oil is also comparatively less. A European planter engaged in the distillation of Geranium leaves in Yercaud (Sheveroy Hills near Salem) some years ago distilled small quantities of fresh Khus roots gathered near the lake side in Yercaud. This oil had a sweet though faint odour, light green colour and rather thinnish consistency, the quality approaching more or less that of the Reunion oil. The smallness of the crop and the difficulty of growing the roots more extensively coupled with the low price of the imported oil at the time, militated against the expansion of this enterprise.

(vi) In Europe, the roots available for distillation are those imported from Java, Reunion and the West Indies. Such roots being rather dry, are coarsely powdered and distilled by superheated steam in specially designed stills, so that the maximum amount of oil is obtained. The lighter oils come out easily but for winning the heavier portion prolonged boiling is required, involving much labour and expense. Some qualities of oil shipped from Europe are superfine whereas a few are far from it—probably these are the lighter oils made in Java or Reunion and re-exported from Europe.

15. Distillation of roots: The time honoured method followed by perfume makers throughout India is distilling the roots in an alembic (copper still) with water, over open fire and collecting the oil by itself or mixed with Sandalwood oil, white mineral oil etc. The roots are cleaned by removing the adhering earth, sand etc. which amount to 15 to 25%. The dryage of the fresh root after storing for a few days is considerable—30 to 40% being the average loss in weight. The cleaned roots are usually steeped in water for about 12 to 16 hours and then chopped into small bits and transferred to the still where about 4 or 5 times their weight of water is added. The neck of the pot, the tube connections etc. are made steam tight by applying "Atta" (flour) or a kind of sticky clay "matti". Then the fire is started and heating is continued for about 8 to 12 hours or more. It is advantageous to run a battery of stills at a time, as the labour and supervision charges are thereby reduced. The Kanauj model of still is met with throughout India and costs about Rs. 250 to Rs. 300. An improved model was employed in Sirsa by the Essential Oil Demonstration Party of the

Department of Industries, Punjab, where the chief innovation is the provision of copper pipes instead of bamboo tubes for conveying the vapours from the pots besides a few alterations in the water cooling system. The cost of such a unit is Rs. 500 to Rs. 600. Sketches of the two models are shown in figures V and VI. The capacity of the still is about 1 maund of root per charge. Fresh roots, lifted during the day are distilled almost immediately in centres in North India except in cities which import the roots from the Khus growing areas ; whereas, the practice in South India is to distil the roots after several weeks as the stills are located in distant places to which the roots are generally transported by road, rail or canal (in Malabar). The roots being thin rapidly lose weight in storage and transport and the sellers provide against this loss by liberally wetting the root and admixing sand etc. So, the pure material available for distilling except in rare cases, is considerably less than the purchased weight. In calculating the oil content and the yield, this point has to be borne in mind.

16. Cost of distillation :

The cost of distilling one maund of Khus roots in some of the principal centres was found as under :—

(a) *United Provinces :*

	Rs.	As.	P.
Wages of 5 men to collect 1 maund of root @ Re. 1 each	5	0	0
Wages of 2 men for working the still @ Re. 1 each	2	0	0
Cost of firewood	3	0	0
Tax for collecting 1 maund of root	2	0	0
Depreciation on plant	0	8	0
Total expenditure	12	8	0
Sale proceeds on an average yield of oil of 5 tolas per maund of roots @ Rs. 3 per tola	15	0	0
Profit	2	8	0

N. B. 40 tolas = 1 lb.

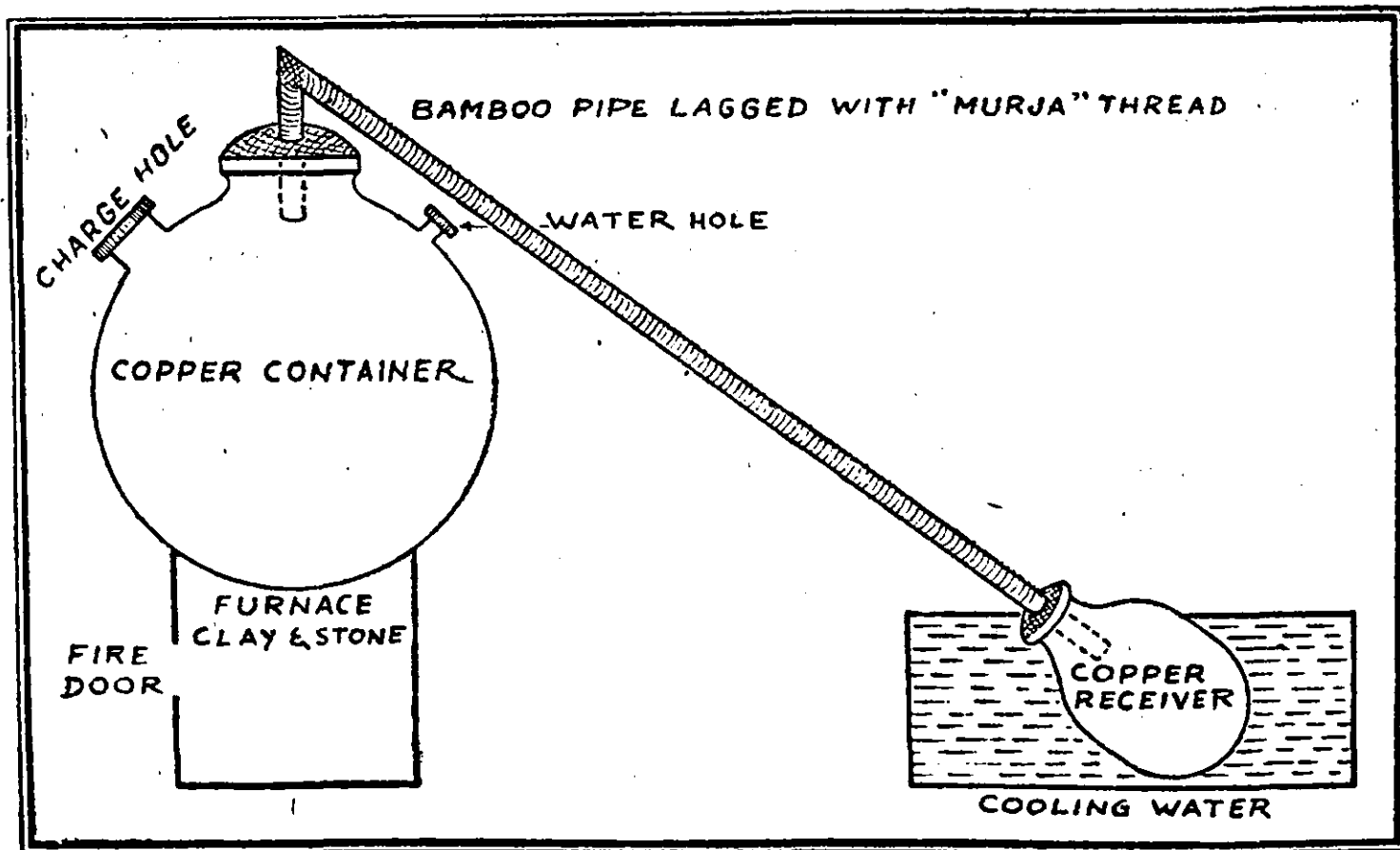


Fig. 5 Essential Oil Still (Kanuj Model)

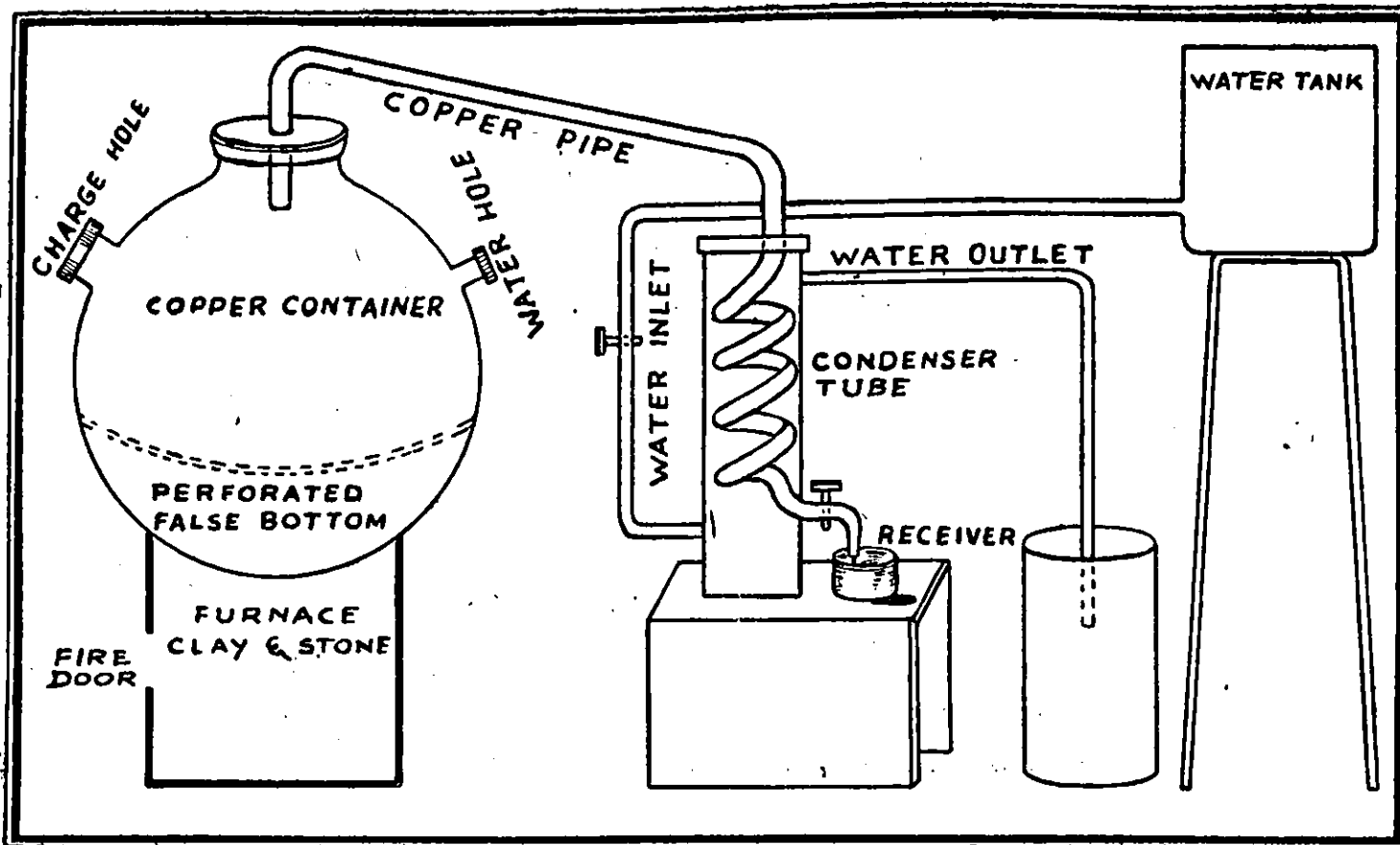


Fig. 6 Essential Oil Still (Essential Oil Demonstration Party, Sirsa.)

(b) Bharatpur State :

	Rs. As. P.
Wages of 5 men for collecting 1 maund of root at 10 annas each ...	3 2 0
Wages of 2 men for working the still @ As. 10 each ...	1 4 0
Cost of firewood (15 maunds) ...	4 0 0
Octroi duty per maund ...	4 0 0
Royalty ...	2 4 0
Depreciation on plant ...	0 8 0
Total expenditure ...	<u>15 2 0</u>
Sale proceeds on an average yield of oil of 6 tolas (40 tolas = 1 lb.) per maund of roots @ Rs. 3 per tola (minimum) ...	<u>18 0 0</u>
Profit ...	<u>2 14 0</u>

(c) Sirsa (Punjab) :

Wages of 5 men for collecting 1 maund of root @ Rs. 1/4/0 each ...	6 4 0
Wages of 4 men for working the still @ Rs. 1/4/ each ...	5 0 0
Cost of firewood (15 maunds) ...	4 0 0
Depreciation on plant ...	0 8 0
Total expenditure ...	<u>15 12 0</u>
Sale proceeds on an average yield of oil of 4 tolas (In the Punjab 32 tolas = 1 lb') per maund of roots at Rs. 6 per tola minimum ...	<u>24 0 0</u>
Profit ...	<u>8 4 0</u>

N. B.—There has been an increase in the rate of wages and the cost of materials etc. since the investigation was undertaken.

17. Improved methods of distillation :—

(a) Experimental distillation of Khus root grown in different parts of India, by modern methods in specially designed steam heated still was undertaken by

the late Puran Singh of the Forest Research Institute, Dehra Dun, as far back as 1913. Results of his work are embodied in the following table :—

TABLE VIII.

Locality.	Month of collection.	Moisture %	Ash %	Oil %
1. Godhra Range, Panchmahal District, Bombay Presidency	April 1913	8.50	2.66	0.72
2. Ajmer Rajputana	March 1913	10.14	3.10	1.13
3. Pilibhit, U. P.	April 1913	10.46	4.30	0.69
4. Pilibhit, inferior sample, thin and white root	July 1913	9.51	4.71	0.37
5. Belgaum Forest Division Bombay Presidency	May 1913	10.88	3.84	0.99
6. Yeotmal Forest Division C. P.	August 1913	9.45	3.10	0.45
7. Delhi—from the bazaar	Jan. to Feb. 1914.	9.81	2.97	1.14

(b) Rao, Sudborough and Watson also carried out a series of experiments in 1915 and 1916 and published the results in the Journal of the Indian Institute of Science, Bangalore, from which the following particulars are culled :—

TABLE IX.

Steam Distillation of Khus Roots.

No. of distillation.	Weight of roots in kilos.	Quality of roots.	Treatment before distillation.	Weight of steam in kilos.	Weight of oil in Grs.	Ratio.	Yield % on raw material.
1	50.4	II	Disintegrated	670.8	102	0.00015	0.20
2	39.2	I	do.	754.6	244	0.00032	0.62
3	1.26	I	Steeped in water for 3 days.	174.5	10	0.00057	0.79
4	3.62	II	Kept in water for 24 hours in the still.	192.0	10	0.00052	0.28

N. B. The first three samples were from Bangalore Bazaar and the fourth from Agra. Steeping the roots in water for a few hours before distillation appreciably increases the yield of oil.

(c) B. V. Nath (the present Director of Agriculture, Madras) also made a few experiments on the extraction of oil from Khus roots obtained from the Agricultural Research Station, Taliparamba (West Coast) while working in the Agricultural Research Institute, Coimbatore. He found that most favourable time for lifting the root was March. The following methods were adopted for extracting the oil.

Method 1. The dried roots were distilled with water in a vessel, heated by a direct flame.

Method 2. The distillation was conducted by means of steam at ordinary atmospheric pressure.

Method 3. The roots were first extracted with boiling 80% alcohol for one day, the extract was allowed to slowly evaporate at 50°C and the residue submitted to distillation in steam.

N. B. In each case the roots were dried in vacuo over sulphuric acid before distillation.

TABLE X.

Date of distilling.	Method, 1 Oil %	Method 2 Oil %	Method 3 Oil %	Average Oil %
21st November 1912	0.28	0.28
21st December 1912	0.32	0.28	...	0.30
21st January 1913	0.23	0.25	0.22	0.23
21st February 1913	0.38	0.37	0.38	0.38
21st March 1913	0.55	0.50	0.55	0.53
21st April 1913	...	0.40	0.43	0.42
21st May 1913	0.33	0.38	0.34	0.35
21st April 1914	0.39	0.39	0.34	0.39

(Ref. Agricultural Department, Madras, Year Book 1918. Page 68-69).

(d) At the Kerala Soap Institute, Calicut, A. K. Menon carried out in 1938 and 1939 a series of semi large scale distillation experiments on Khus roots obtained from different parts of the Madras Presidency, particularly from the Chowghat area in South Malabar. A modern still fitted with dry and wet steam coils was employed, side by side with open fire heated stills to make a comparative study of the duration of the distillation, yield and nature of the distillate etc. Steam distillation gave better yield in many cases, although there was not much saving in time. Lighter coloured oils were produced by steam distillation; except in cases where the roots were brown or dark, when the oil

had an yellowish brown or dark colour. When distillation was conducted in fire heated stills, with an insufficiency of water the roots were found to get scorched and the oil had a burnt unpleasant odour. It was observed that the yield of oil from roots lifted in the hot months (February to April) in Malabar was higher than that from roots lifted from September onwards. This was probably due to the heavy rains in June, July and August which dissipate the aroma and weaken its tone at the time of maturity. Roots from Chowghat area which yielded from 0.4 to 1.2% of oil during February-March barely gave 0.2% during the latter part of the year.

(e) Owing to the very viscid nature of the oil and its specific gravity being almost the same as that of water, there is considerable difficulty in separating the oil from water. The oil is poured into separating funnels and the water is gradually drawn off and added to further charges of the roots in the still. To separate the oil more easily from the water, the aqueous distillate is run through a layer of petroleum ether (light petroleum b. p. about 50°C). The denser the oil, the better and more persisting the aroma and greater the fixitive property and value in perfumery. Some of the oils distilled from the Malabar roots at the Kerala Soap Institute by this method were found to be of excellent quality.

18. Chemical Analysis of Khus Oil :

(i) Samples of oil obtained from the roots collected by Mr. Ittyachan as also samples of oil purchased by him were analysed by the Tata Oil Mills Co. Ltd., and the results are shown in the following table:—

TABLE XI.

Locality.	Saponification Value.	Acid Value.	Est. as Vetyvery Acetate.	As Vetyverol Alcohol %
1. Kaithal (Punjab)	52.78	42.80	4.66	70.99
2. Sirsa (Punjab)	34.92	21.35	6.337	56.17
3. Bharatpur	35.77	15.6	9.63	62.58
4. Biswan (U. P.)	61.5	29.2	15.09	69.68
5. Nawabganj (U. P.)	80.42	44.93	16.55	46.54
6. Musanagar (U. P.)	83.84	51.93	14.9	49.16
7. Etawah (U. P.)	70.76	40.02	14.35	75.25
8. Pilibhit (U. P.)	77.74	49.16	13.35	57.98
9. Kaipamangalam (Malabar)	...	31.09	6.8	63.38
10. Neyyattinkarai (Travancore)	...	37.75	35.25	52.10
11. *Sirsa (Punjab)	95.03	14.99	37.38	46.14
12. *Bharatpur	53.34	12.03	19.29	58.2
13. *Utripura (U. P.)	59.58	12.47	22.00	51.06

*Samples of oil purchased.

As the yields of oil obtained were very poor and in no case exceeded 0.241% and far from comparable in any way with yields, either mentioned in the literature as having been obtained from Indian variety of roots or with the yields from Vetyver grass growing in Java or in the Islands or Bourbon, where it is reported that $\frac{1}{2}$ to 1% yield is obtained, the Tata Oil Mills Co. Ltd., were asked to elucidate whether there was any error in calculation or if any loss of oil took place during the process of purification and removal of moisture, which was possible considering the smallness of the samples handled. While admitting that there might be some loss, the Tata Oil Mills Co. Ltd., did not consider that the loss could be appreciable and they attributed the poor yield to the inferior quality of the roots. They also confirmed this fact from the results obtained from large scale distillation carried out by them on Khus roots obtained from Bharatpur for a period of three months where they reported the yield did not exceed 0.15%. From these results we can only infer that there has been a general deterioration in the oil content due probably to the immature condition of the roots of adulteration or any other causes which have escaped notice and which need further investigation. The minimum yield of oil from North Indian roots according to recorded statements was not much below 0.3% while the maximum yield was about 0.7%. In South India, the roots from Chowghat area had yielded about 1.2%. These facts go to show that the roots now brought into the various markets are far from satisfactory and that there is a definite and urgent need for improving the method of cultivation and resorting to proper manuring with a view to securing a better type of roots. In many cases the poor quality of the roots yield poorer results. There is also the possibility that in the process of distillation, the oil is not fully recovered and there are incidental losses by reason of its stickiness, viscosity etc. Perhaps, this is the reason why some manufacturing firms in Europe and elsewhere adopt the extraction process by the use of suitable solvents, which remove the odorous principle in its entirety. Such products are marketed under the name of "Resinoids". It may be advantageous to try out in India also distillation cum extraction method, provided the solvents are cheap, as thereby once distilled roots can be finally extracted in order to remove the last traces of the oil. It is reported that extraction of the Khus root by ether at the Kerala Soap Institute resulted in a yield of over 5% of a fine quality of resinoid of light brown colour with a persistent and agreeable aroma.

(ii) Owing to the large variety of roots met with in different parts of the world, differences in the growth and maturity of the roots and methods of extraction etc., analytical data recorded so far show considerable divergence.

In the case of oils distilled from fresh roots, the proportion of free acids is small compared with that from the dried roots, owing to the oxidation changes in the latter as shown below :—

TABLE XII.

		Oil from fresh roots.	Oil from dried roots.
Specific gravity at 20°	...	0.986	1.009
Acid value	...	6.1	32.4
Ester value	...	12.1	11.9

Theulier (Bulletin Soc. Chem. III 25 (1901) 454).

(iii) It has also been noticed that the volatile elements which constitute the major portion of the oil pass out in the earlier stages of the distillation; as the boiling point rises gradually the solubility also increases.

	Analysis of Bourbon oil.	Earlier stages of distillation.
Density	.9796	.9716
Solubility	Insoluble	Insoluble.
Op. Rot	+ 4.67	+ 5.31
Sap. Value.	10.6	8.4
Ester value	3.71	2.94

The temperature of distillation also affects the rotatory power of the oil, as ascertained by a French Chemist :—

Temp.	Op. Rot.
144 to 160°	— 4.10°
164 to 170°	— 3.20°
170 to 180°	+ 2.5°
180 to 185°	+ 31.40°
185 to 200°	+ 47.5°

The results on testing the oil obtained by complete distillation reveals a reduction in the density, a constant solubility and lowering of optical rotation. These three characteristics are constant in their relation to each other, the others do not always follow a regular course.

(iv) A table showing the analytical characteristics of Khus oils distilled in various parts of the world is tabulated on page 37 (Table XIII).

TABLE XIII
Physical and Chemical characteristics of Vetivert Oil distilled in various countries.

	Europe (Java Root)	Reunion.	Fiji Islands.	Seychelles	Malay	Jamaica	Indian.			
							1.	2	3.	4.
Sp. Gravity	1.014 — 1.040	0.98 — 1.020	1.0298	1.0282	1.032	0.9970	1.011	1.007	1.0005	1.0035
Op. Rotation	÷ 25° to + 38°	+ 15° to + 37°		+ 27		+ 17.8	—30.65	—67°50	—70°338	—14°54
Refractive Index.	1.5210 — 1.5270	1.5150 — 1.5280				1.5243	1.5165	1.5227	1.5221	
Acid Value	27 to 65	4 to 20	35.3	55.9	35.8	155	10.5	9.3	8.4	29.1
Ester Value	10 to 25	5 to 20		(67.3) (S.V.)						
Ester Value after Acetylation	130 to 160	105 — 140		11.4	11.8	10.0	69.6	12.3	9.3	
					162	117.9	132.8	145.6	147.5	146.7

- (a) The oil is soluble in 1 to 2 vols. of 80% alcohol, the addition of more alcohol causing turbidity. Solubility is the same in European and Reunion oils.
- (b) Soluble in 80% alcohol at first to a clear solution which becomes turbid after the addition of 25 vols. and more. Oil dark green colour.
- (c) Soluble in 1 vol. and more of 80% alcohol. Oil dark golden colour.
- (d) Finer roots grown in Government plantations—distilled by the Imperial Institute—London.
(b, (c) & (d) : Bulletin Imperial Institute 1912.
- (e) Oil was found similar to Commercial Reunion oil. Imperial Institute 35 (1137). 24.
- (f) Indian distilled and rectified. Soluble in 1-2 vols. of 80% alcohol. (Puran Singh) Chemist & Druggist 1914.
- (g) Soluble in 1.1 vol. and more of 80% alcohol.) It is noteworthy that these oils, in contrast to vetivert oils of other origin exhibited levo-rotation, which is more over very strong.
- (h) Soluble in 1.4 vols and more of 80% alcohol) Report of Schimmels & Co., 1932.
- (i) Soluble in 1.1 vol. of 80% alcohol. Distilled from Indian roots December harvest—tested at the Imperial Institute

19. Constituents of Khus Oil:

(i) According to some Chemists, Khus oil is in the main composed of mixture of ketones which they call Vetirone or Vetiverone having the empirical formula $C_{13}H_{22}O$ and probably consisting of several isomers boiling at about 150° (10. mm.) and with a Specific Gravity of about 0.900. They also reported the presence of two alcohols which, though of different formulae, were named Vetirols or Vetiverols— and had the following characteristics:—

Formula	I $C_9 H_{14} O$	2 $C_{11} H_{18} O$
Boiling point at 10 mm.	$150^{\circ} - 155^{\circ}$	$174^{\circ} - 176^{\circ}$
Specific Gravity	0.980	1.020

(ii) Genvesse and Langlois have isolated a sesquiterpene $C_{15}H_{24}$ which they named vetivene, a colourless and odourless liquid—and a sesquiterpene alcohol (vetivenol) a viscid light yellow odourless oil boiling at $169^{\circ}-170^{\circ}$ at 15 mm. According to these two chemists, the odour bearer of vetiver oil is the ester of this alcohol (vetivenol) with an acid or a mixture of acids of the empirical formula $C_{15}H_{24}O_4$. Some recent investigators state that there are atleast two isomeric sesquiterpene alcohols under the name of vetivenol with the formula $C_{15}H_{24}O$ and occur both in a free state and in the form of esters. Vetivenol is a yellowish viscous liquid of an odour resembling that of the oil but is sweeter and a very useful fixative and modifier for heavy perfumes of fine quality.

20. Qualities of Khus Oil:

(i) The Khus oil distilled in India is of varying consistency, colour and density according as to whether fresh or dry roots are used for distillation. The pure oil without any base—such as Sandal oil or white mineral oil—is known as “Ruh” or “Rooh” Khus—and has a light colour and greenish to brown tint and a fairly strong and fine aroma. Oils distilled from fresh roots in Northern India are not so viscid as those obtained from the dry roots in Southern India, the aroma is also not so rich and intense as of the latter. The colour of the oil varies from light yellow to dark brown and some times the oils have a somewhat greenish colour, which is partly due to the presence of copper salts from the use of untinned copper vessels. Adulteration of oil has also been noticed, the common adulterants being cedar wood oils and Terpeneol, which blend well with pure oil and being much cheaper in price are resorted to by unscrupulous makers. It has also been noticed that some of the oil offered in the market has a

certain amount of moisture and sludge. They add to the weight of the oil but are a distinct disadvantage to the quality of the oil as also its buyer.

(ii) The "attar" or "ittar" is the name given to the oil which is mixed with Sandalwood Oil; inferior qualities are those containing colourless paraffin oils, seasmum oil and some times castor oil etc.

These products have lighter colour with a faint odour of Khus—used mostly for perfuming cheap soaps, tobacco, agarbattis, snuff, hair oils etc.

(iii) The European distilled oils from dry roots of genuine quality are invariably yellowish to dark brown in colour, very viscid and possessing an intense and persistent odour. Some of the Java and Reunion oils—from fresh roots—have a pale colour, thin consistency and the odour is not at all intense; hence these oils fetch less in the markets. Some chemists dispute this point and think that oils with a dark brown or blackish colour emit a peculiar odour due to adulteration with ether, alcohol or some other volatile or fatty oils. According to them the best Java oil has a clear tea colour, is somewhat transparent and emits an odour resembling that of Sandalwood oil; such oils, however, are not favoured by perfumers on account of the weak odour and lack of fixative power as in the case of viscid oils distilled from the dry roots. As a matter of fact, the quality of some of the oils imported from Java and some other countries into India before the war was very poor indeed, the only attractive feature about them being their low price. Schimmels mentioned in their annual report on "Essential Oils and Synthetic Perfumes" (1938) that "in consequence of the greatly increased production, the quality of the Vetivert oil exported from Java has greatly suffered. In Java, a higher vetivert oil is being mostly distilled. The more valuable heavy oil whose manufacture incurs more effort and expense come less often from Java on the market."

21. Price of Khus Oil:

(i) Indian Khus oils are of fairly good quality but the quantity available is not sufficient to meet the demand. Before the war, prices ranged from Rs. 12 to Rs. 75 per lb. for such oils, according to the aroma, tenacity and fixative quality. The cheapest Indian oil would be the attar containing mostly paraffin oil mixed with some Khus oil. "Ruh" Khus prepared by Kanauj perfumers ranged in price before the war between 12 annas to Rs. 7 per tola (= Rs. 30 to Rs. 280 per lb.) and the attars were quoted from 2 annas to 12 annas per tola (=Rs. 5 to Rs. 30 per lb.) At present "Ruh" is available at

Rs. 4 per tola or about Rs. 160 per lb, the tendency is for pushing prices to abnormal levels, the war being the excuse for such jump in prices. The attars have also gone up in price in proportion and the current rates are about Re. 1 to Rs. 1/8/- per tola.

(ii) Prices of imported Khus oil vary considerably according to the quality and the make. Oils distilled in England and on the Continent from the dry roots imported from Bourbon (Reunion) and the Dutch East Indies (Java) are usually better than those distilled in the above countries and fetch a correspondingly better price. Java oil, once considered superior to Reunion oil, has to some extent lost its name owing to the inferior qualities—such as lighter portions etc. of the oil shipped abroad during recent years. Some of the Java oils were quoted just before the war at 12 *sh.* per lb. whereas Bourbon oil was quoted then at 17 *sh.* per lb. by the same firm. Some of the better qualities of Java oil (French distilled) were offered at 60 *sh.* per lb., but the average price did not go beyond 25 *sh.* whereas the Bourbon quality kept round about 29/30 *sh.* English distilled oils were quoted from 45 *sh.* to 110 *sh.* per lb. Terpeneless and sesquiterpeneless oils were quoted 30-50% more than the ordinary oils.

(iii) Vetivert Oil—Synthetic—was freely available at 10 *sh.* 6*d.* to 15 *sh.* per lb. The price of Vetiverol ranged between 45 *sh.* to 90 *sh.* per lb. and that of Vetyveryl acetate between 56 *sh.* to 95 *sh.* per lb. Only one or two firms were interested in marketing the other derivatives and the prices of these were:—

1. Vetyveryl formate	82 <i>sh.</i> per lb.
2. „ propionate	88 <i>sh.</i> „ „
3. „ isobutyrate	94 <i>sh.</i> „ „
4. „ valerinate	107 <i>sh.</i> „ „

22. **Uses of Khus Oil:** Khus oil is the oil par excellence and is much favoured in high class perfumery not only as an important fixative for the more volatile oils, and for its sweet and agreeable odour, but in blending and rounding off various boquets especially of oriental types owing to its tenacity, intensity and remarkable persistency. It enters into almost every kind of quality perfume, whether it be for scaps, toilet creams, talcum powders or hair oils. Its cool fragrance has a soothing effect particularly in tropical countries where it is mixed with sandal paste and freely applied to the body during the hot months. The oil mostly of the cheaper variety such as attars is used for scented sticks, agarbattis etc. Taken internally it acts as a tonic.

23. Output and consumption of Oil :

(i) In the following table, the figures of the quantity of roots distilled and oil obtained in 1943-44 in North Indian centres are given :—

TABLE XIV.

Centres of production.	Quantity of roots distilled maunds.	Quantity of Oil	
		in tolas.	in lbs.
1. Bharatpur State	15,000	90,000	2812.5
2. Biswan (U.P.)	6,000	30,000	937.5
3. Musanagar (U.P.)	2,000	12,000	375.0
4. Gonda (U.P.)	4,000	20,000	625.0
5. Utripura (U.P.)	2,000	12,000	375.0
Total	29,000	164,000	5125.0 OR 2.288 tons.

(1 maund=82 lbs. (32 tolas=1 lb.))

N. B.—The production of oil in the Punjab is confined to a few centres, where the Demonstration Party is engaged in showing the methods to interested parties; the quantity of oil distilled there will therefore be only a few pounds. Similarly in South India, the commercial production of oil is low, amounting to less than 25 lbs. in all at present.

(ii) The value of the Khus roots used otherwise than for oil in India can be estimated at about Rs. 696,000, (about 46,000 maunds @ Rs. 15 per maund). About Rs. 5 lakhs worth of oil distilled in India (164,000 tolas at about Rs. 3 per tola) is also consumed annually in India for various reasons. Therefore the value of the internal trade in Khus root and oil is about Rs. 12 lakhs. Narielwala and Rakshit—in their report (Exploratory Essential Oil Committee, page 18) estimated the production of Khus oil in India to be worth about Rs. 3 lakhs; since the prices have advanced now, the higher figure of Rs. 5 lakhs should be considered more or less correct.

(iii) To estimate the total consumption of Khus oil in India, we have to take into account besides the Indian output, the quantity imported from the overseas countries. Java has been the principal supplier during recent years. India imported from Java 501 kg. of oil in 1936 and 487 kg. in 1937 (Schimmel's Report 1938) i.e. roughly half a ton per annum. Correct statistics of imports

from Europe and other countries such as Bourbon (Reunion) are not available but we may take it that atleast a ton of oil is imported from these sources also. The total import would thus be about 1 ton, the value of which at Rs. 20 to Rs. 25 per lb. will amount to about Rs. 50,000. Of course, since the war started, nothing practically has come from Java and other enemy occupied countries. What little has been imported is from Europe and America under special permit for meeting the urgent needs of the Military and Civil Departments of the Government of India. After the war is over, we might expect a revival of the trade in this commodity; but it is not likely that the prices will be so low or favourable as during the pre-war period.

(iv) *Kanauj dealers* : Atleast one or two of them--have been engaged in exporting Khus oil and Attars to Africa and some other overseas countries. This year about 1000 tolas of oil are being consigned to Africa.

CHAPTER IV

Resinoids and Esters of Khus and Aromatic plants allied to Khus.

24. **Resinoid of Khus :** Vetivert Resinoid of the ordinary quality containing the natural aromatic fixative ingredients was sold under various trade names by European manufacturers at prices ranging from 15 *sh.* to 27 *sh.* per lb. They also used to market a superfine colourless quality at a high price of 88 *sh.* per lb.

25. Esters and Substitutes of Khus Oil and their prices :

(i) Many esters of Vetiverol have recently been put on the market such as formate, acetate, propionate, iso-butyrate and valerate, with the variations of the odour of the alcohol, more fruity or floral. These are very valuable in heavier, fancy, floral or oriental compositions. Of these, Vetiverol itself is an excellent fixative and gives character to many compositions. Vetiveryl acetate has a more floral note than Vetivert oil or Vetiverol.

(ii) An artificial oil of Vetivert was manufactured and put on the market before the War by a few manufacturing firms in Europe, as a cheap substitute for the pure oil, but the aroma in many cases was poor and sometimes quite unlike that of the genuine oil though the colour and consistency would pass for the lighter coloured imported natural oils.

26. Aromatic plants allied to Khus :

(i) "*Khavi*" or "*Khathran*" grass : Bahawalpur, a town 62 miles away from Multan, is not a Khus growing centre, but here a grass called "*Khavi*" or "*Khathran*" was found. This grass grows in a jungle area, 12 miles away from Bahawalpur town and both the roots and stem are aromatic. The quantity available is reported to be large and a local contractor, Haji Abdur Rehman is in a position to supply it, but as no use is found for it the grass is not collected. Samples of the grass were collected and sent for botanical and chemical examinations to the Institute of Plant Industry, Indore, C. I. and the Tata Oil Mills Co. Ltd., Bombay. The botanical examination showed that this grass did not belong to the regular Khus group and was distinct from it in having very thin stems and roots. The roots did not have the typical Khus smell but there seemed to be a touch of fennel odour *Foeniculum vulgare* (Hindi "*Saunf*"). The grass, however, had numerous glandular hairs which indicated a high oil content.

The high oil was confirmed by the chemical examination of the roots, the yield of oil being as much as 1.13%. The oil on chemical examination was found to have—

Sap. Value	...	29.50
Acid Value	...	12.57
Esters as Vetyveryl Acetate	...	7.907%
Alcohols as Vetyveryl Alcohol	...	15.20%

It would be worthwhile to investigate the oil obtained from this variety of roots with a view to determine its actual constituents as due to its similarity in some respects to typical Khus roots it may yield an essential oil of utility in the perfumery industry. It would also be interesting to know whether by crossing it with the true Khus, the yield of oil in the latter could be improved. If the results are satisfactory there are possibilities for the commercial exploitation of this grass.

(ii) "*Kuruver*" grass: In the Coleroon deltaic belt extending from Tanjore to Chidambaram, a plant belonging to the *Coleus* Species, (*Coleus aromaticus*) locally called "Vetiver" and known as "Kuruver" in tamil is found growing partly wild and partly cultivated in marshy and watery ground. It is entirely different from Khus, being a leafy plant and not a grass. There is a cluster of long thin, hairy roots—brown to dark in colour—with a fairly pleasant odour unlike that of Khus. These roots are made into garlands for decorating the idols in Hindu temples and by women for dressing the hair. Some roots distilled on an experimental scale a couple of years ago at the Kerala Soap Institute yielded about 0.4% of Essential oil; but as the quantity of the roots available is small and the price asked for very high, there is very little prospect of this material coming into commercial prominence.

(iii) "*Javasa*": A plant called "Javasa" is found in Ajmer and is used for making "tattis". It is devoid of any odour when fresh, but has a closely meshed net work of thorny leaves which lend themselves easily for being made into "tattis". It is available in large quantities at Rs. 2 to Rs. 3 per maund (=Rs. 54 to Rs. 82 per ton).

CHAPTER V.

Recommendations

27. In the Report of the Essential Oil (Exploratory) Committee, pages 40-43, Narielwala and Rakshit have clearly pointed out the possibilities of developing the Essential Oil industry in India in general and what steps should be taken to achieve this object. As a result of this special enquiry conducted on the Khus industry in North and South India, and from the particulars gathered from Provincial Governments and private parties, there is urgent need to improve the industry in all its aspects, on the following lines :—

(i) At present, all the available Khus grass is not lifted particularly in North India. Provincial Governments, States and private owners of land where Khus is grown, should be advised, in view of the high economic value of the root, to harvest the entire crop, either directly by appointing special staff such as the Demonstration Parties in the Punjab, or through other agency such as firms or contractors interested in collecting them for distillation purposes etc.

(ii) The acreage should be increased in every area suitable for its propagation and regular and intensive cultivation should be resorted to.

(iii) In view of the marked differences in the yield of root and oil in different provinces, field experiments should be conducted in selected localities, to ascertain and establish optimum conditions relative to soil, climate etc. for the proper growth of the roots of selected quality.

(iv) Cultural and manurial experiments on properly laid out plots, should be conducted under the supervision of a proper research staff as the grass responds to such treatment.

(v) Field and laboratory experiments should be conducted, so as to determine the best time for lifting the roots the seasonal variations in the oil content and correlation with the maturity of the root and other factors which have a bearing on the crop in order to arrive at definite conclusions and fix the necessary criteria.

(vi) The characteristics of the oil obtained from the roots in various centres of production should be thoroughly studied and a standard of grades and qualities should be fixed for the oil, in order to facilitate both the internal and export trade.

(vii) Experiments should be conducted to ascertain the best and cheapest methods of extracting the oil.

(viii) To carry out the above plan, it is necessary to establish research stations in important centres of production, with proper equipment, staff etc. The stations may be located in the following centres :—

1. Sitapur District (U P.) which will serve also the Central Provinces.
2. Hissar District (Punjab).
3. Bharatpur (Bharatpur State).
4. Cochin (Cochin State) to serve Travancore, Cochin, Tinnevely and Malabar Districts.

The cost involved in this scheme may have in the first instance to be met by the Government of India or partly by the Provincial Governments and States concerned. Details of the staff etc. required can be worked out if the scheme is acceptable.

(ix) The high octroi duty and tax levied in some states seem to exercise a check on the dealers from bringing into the market all the available root. This may particularly well apply to in Bharatpur State. The Octroi duty in that state which originally was eight annas per maund was raised to Rs. 1/8 per maund before the war. After the war began it has been enhanced to Rs. 4 per maund. A sum of Rs. 2/8/- per maund is also collected as royalty. It will be seen from the table of production in paragraph 7 (iv) that at present only 15,000 maunds of root are lifted annually only 50,000 maunds available in the State. The desirability of totally abolishing or at least reducing considerably, the octroi duty and royalty levied on exports of the roots from the State in order to encourage the lifting of all the available crop for distillation and other industrial use, may be impressed on the Bharatpur Durbar.

(x) As foreign competition is likely to be a serious factor affecting the development of the Indian Khus industry after the war, the Government of India may be requested to examine the question of levying on import duty to protect the Indian Industry.

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