

## **ESSENTIAL OILS & AROMA CHEMICALS –VISION 2007**

**SCOPE, POSSIBILITIES, DETAILED EXPLANATION AS ON 10<sup>TH</sup> DECEMBER' 2004**

India is blessed with many positive factors, which enables it to stand at unique position in agriculture-based product. After achieving self-dependence on food front now India is in position whereby it has become net exporter of agriculture based product.

Aromatic plants are very important part of agriculture and have been grown in India for their fragrance and therapeutic use from ages. In last four decade due to effort of CSIR, ICAR, CIMAP, University and industrial houses many crops could be taken on large-scale cultivation and many of them have made very good success. Mint is very live example of it, which made India no. 1 producer of same driving away very strong competing country like China, Brazil that has many strength like India in agriculture sector. Many advance country like Germany and Japan with very strong production base of synthetics also are finding it very difficult to compete on price and quality with Indian produced natural Menthol. This shows very clearly that if planned efforts are put India can be no.1 player in these field with very strong position in agriculture fields which can be considered as “LABORATORY UNDER SUN”.

After revolution in information technology lot of thrust to develop application of Bio- technology through extensive work by CSIR labs on Bio re-sourcing database opened up new revenues in economic production of essential oils on mass scale where by success story like Mentha Arvensis started getting repeated in other essential Oils. Introduction of high Mentha furan rich variety CIM\_INDUS (CIMAP/MP20) by CIMAP based on need of industry in 2003 enabled India to become no.1 producer of Mentha Piperita in 2004 surpassing USA which has been largest producers of same from many decades. Introduction of many new variety in Cymbopogon, Ocimum which gives high yield/acre with high % of desired component will enable India to make major break through in many terpene chemicals which over last few decades were replaced by synthetic equivalent for which starting materials are petrochemicals & turpentine which are becoming scares in new millennium. Extensive plantation on millions of acres of these two species as intercrop with horticulture or on waste land will not only improve's environment only but same will generate millions of job on rural level which is need of time.

Recent noble prize on 4<sup>th</sup> October 2004 to Mr. Richard Axel for his contribution towards Aroma Science for medicine proves that future medicines will be based on Terpene & Sesquiterpenes for which essential Oils are best source. Synthetic molecules which often have three un-natural Character namely a) Non bio-degradable b) Non Chiral c) Non natural identical may not be accepted by human body and may be treated as toxins which has to be evaluated very carefully before allowed to enter human body. This whole new branch of science may emerge as new medical science which described beautifully in CIMAP director's report in 2003. Dedicated Laboratories of CSIR like ITRI with extensive work on such common Terpene Chemical used frequently for F & F industry along with cosmaceuticals may prove very clearly how natural Terpenes & Sesquiterpene based Chemicals are superior on above three criteria as compare to Synthetic equivalent Chemicals such work will allow

entire world to shift from Synthetic to natural through green Chemistry with green path. This development puts India in whole world in unique position as production base for natural essential oils.

Based on need of essential oils and their isolates (natural or synthetic) on global scale a planned projection is done in Annexes I. There is urgent need for strategy for planning for essential oil segment so that we can achieve this goal. In projected figure price projected may seem to be very low compare to prevailing price for same oils in market. Here we have to take in consideration competition from synthetic materials, which are derived from turpentine, and petroleum feed stock like Isoprene. These materials are processed on very large scale so economy of scale favors final prices of this synthetic derived molecule at present compare to equivalent natural isolates. However we should take in consideration following factor for future, which can favor production of these isolates, derived from natural essential oils.

- 1) Prices of petroleum products are going up so in future with depletion of it prices are expected to rise further.
- 2) Prices of turpentine is going up gradually because of high cost of labour in producing country like China, Brazil & Indonesia. As Turpentine is obtained from gum resin which is very labor intensive & requires labor in hilly rural areas which is becoming less & less with urbanization.
- 3) Recovery of turpentine oil from crude sulfate turpentine liquor also require lot of energy which is derived from petroleum as fuel so prices for these are rising in last few months. It is expected that same trend is going to continue in future. Again for separation and conversion of Alfa and beta Pinene from turpentine to it's desired basic derivative like Geraniol, Citronellol, Citral, Linalool also requires lot of energy and chemicals, which are derived from petroleum feed stock.
- 4) Conversion of petroleum feed stock and turpentine to above mentioned derivatives require use of lot of hazardous reactions, which leads to generation of many pollutant as well as explosion hazards. Now with more emphasis world over on neat and clean technology these facility of production may find it difficult to product derivative like Geraniol, Citronellol, Citral, Linalool at very low cost as they may have to spend lot of money on pollution control and safety of operation.

Idea is to explore possibility for new development for extending essential oil crops through out India so that Vision 2007 can be implemented.

Current position of many essential oils projected in Annexes I show much strength in favor of India, which are as follows: -

- 1) Agro technology for all essential oils are standardized and same has been practiced successfully also. However there is need for further improvement in yield as well as developing cropping pattern. If essential oils can be grown with regular horticulture crop as inter crop it will bring down cost burden on essential oils making them more economical. Suitable crops rotation along with proper intercropping for all essential oil is need of time to bring down cost. In mentha food crops like rice & potato are done in same fields. Also some farmers are cultivating Poplar for wood & chillies as inter crop making whole production more economically viable.

- 2) Utilization of bi product from processing has made many essential oil economically viable. For example Sclareol from Clary sage spent biomass by solvent extraction, Cis-3 hexenol from mint terpenes and distillation water. Thus more utilization of bi product can be looked in to so that final essential oils become economical. To illustrate unique position of Indian consuming industry we can take here example of Patchouli oil which is becoming very important oil for cultivation. Bi product of Patchouli oil cultivation and extraction in form of twigs and spent leaf can fetch more than 60% of raw material cost by Agarbatti Industry for making there raw Agarbatti making production of Patchouli economically viable. So in future India can even compete strong producing country like Indonesia and China, which are controlling maximum market share so far.
- 3) Post harvest processing of essential oil bearing biomass involves steam distillation where fuel cost is very important. Most of units operating in mint belt are working on spent biomass as fuel thus making cost of distillation per kg very economical (approx. Rs.30-35 per kg.). It can be brought down even further if same equipment is used through out year instead of 2-3 month at present. There is labor cost of distillation, which ranges Rs.18-20 per kg however if equipment is utilized through out year for other crop distillation cost per kg will come down further making essential oil more economically viable. This will develop much needed employment.
- 4) Essential oil processing in form of value added product to its isolates are done through multi-component fractional distillation. In last two decade more than adequate capacity for it has been installed in producing as well as consuming area with in India. This capacity is many times more than total current production of essential oils making this capacity as spare. If production of essential oil is increased as per Annexes I this capacity can be utilized very well without new investment. This can make availability of value added isolate at very economic price enabling same to compete with synthetic equivalents.

If we examine Annexes I carefully we see that .....

PALMAROSA/ JAMROSA : CAS No:- 8014 – 19 – 5 HTC 3301- 29 - 50 – 50. This oil can be grown in any part of India in plains and it comes like weed in certain section of Maharashtra and Madhya pradesh. Thus commercial cultivation on non-prime land can be ideal for growing same. Projection of 5,000 MT/y at 5.00 \$/kg by 2007 is made with idea of producing natural Geraniol and derivatives like Geranyl acetate out of it. Then Geraniol out of it can be offered easily at 8\$/kg. Replacing synthetic Geraniol partly. This crop can be taken on many open lands where lands are lying vacant and can be managed through chain of small enterprises involved in processing of oil from grass. Jamrosa very much like Palmrosa can be used for processing Geraniol and it's derivative. By increasing other component like Farnesol, Ocimene etc through biotechnology these additional molecule can be generated on commercial level. By reducing cost of finished product not only import of synthetic Geraniol can be brought down but it can be exported also. Jamrosa crop has been found suitable in preventing any weed development in horticulture farms making it most ideals for horticulture development. Along with oil it generates 4-5 Mt/year/acre of dry biomass which can be very easily

utilized for a) Cattle feed b) fuel c) Vermi-compost d) much around fruits tree e) making ropes as strong fiber f) hand made paper. Suitable use of spent biomass can generate lot of needed employment at least cost with no capital investment which is very much needed for country like India. With oil production of 100 Kg/year/acre, this crop is most economically viable among Cymbopogon species.

PATCHOULI : Serious attempt for propagating cultivation in various coastal part with high humidity has been done in last couple of years & has resulted in good results where by we can expect India to lead in same by 2007. Now there are very good chances that by 2006 India can become atleast self sufficient for its consumption of 400MT/year. If more area can be taken with coconut and arcanut growers as intercrop it may be possible to gain major share in +1500 MT/year market. Advantage in case of India is utilization of spent leaf for Agarbatti production, which can result in lower effective cost of oil thus making Indian Patchouli internationally competitive. Agro technique is already very well developed at this stage. Combination of BT with IT was unique and we feel by this way systematic progress could be much faster.

ROSE: Rose production is hardly 200 kg. /year where as global demand is more than 10MT/year, which is met by Bulgaria and Turkey. Seeing expertise in cultivation with Noorjahan (a variety of Rose Damascena) Rose and its processing with efficient hydrodistillation, it may be very much viable to take same on large-scale cultivation. There is need to bring down cost of oil to make it competitive on global scale with better quality which can make India leading Rose oil producer. Recent commercial cultivation of one party at foot hill of Himalya in Punjab with Rose as intercrop with Amla on large scale has shown encouraging result with organic farming. Such type of many attempts may make Rose as one of large crop in areas where there is already large-scale cultivation of Amla eg. Faizabad, Pratapgarh etc. Seeing excess demand of Chawyanprash and other preparations from Amla there can be very nice scope for such intercrop of Rose and Amla where both aromatic and medical plants are grown side by side with one short term crop as Rose and other long term crop as Amla. Similar project has already started in Rajasthan on large scale from where we owe our Rose water. April MAY is crop time in Bulgaria & Turkey. Rose of Edward (Bourbians) is more popular among farmers as it gives flowers for 10 month in year making it as regular crop for flower market. This has generated large base for other value added products like Gulkand (which is very nice laxative according to Ayurveda), Rosewater (used in large quantum for syrup, natural cosmetics & as room freshener & dry Rose petals/ used for herbal tea, potpourris). Apart good revenue can be generated by supplying demand based supply at high price to flower market making flower for oil extraction as byproduct. It is worth visiting city like Pushkar / Ajmer, Rajasthan, where large scale cultivation is done as eco tourism. So flowers are available on multi-tonne level everyday uplifting rural economy & developing clusters of micro enterprises producing value added products like Rose water, Syrup, Gulkand, Confectionaries etc. If same model is repeated on various city throughout India it is not difficult to achieve target of 10MT oil/year before time. Already multi-hundreds of acre of plantation started in state like Maharashtra where farmers are very visionary & successful implementer. Planting material can be obtained from Pushkar areas during Nov-December, January when pruning is done.

'Barahmasi' Rose which gives flower almost 9-10 months in year with peak harvest three times has been used for Gulkand, Rose water & dry petals production along with supply to flower market. Because of availability for more no. of days farmers get return from supply to flower market making cost/Kg lowest.

BASIL OIL : Few figures projected like 5000 MT/year of *Ocimum Basilicum* (Basil) is justified for both production and demand. During personal visit in Tarai belt in August, September it was felt that many distillation units used for producing Mentha oil during season remains ideal during this period. Also many fields were not planted with any crop after Mentha, Rice and in between potato season (November end to February). So this gives enough opportunity to increase cultivation and processing for this crop as already done by few farmers producing 600-700 MT/year of oil. By utilizing our resources, which is part of ERP (Enterprise, Resource, Planning) we can achieve this target. On demand side if our cost of sales comes down to 3\$/kg. It will be easily possible to produce derivatives like Anethole and Methyl Chavicol at less than 5\$/kg making easy penetration in same market which is served presently to extent of 3000-3500MT/year by Turpentine bi-product purification and Star anise oil. Moreover we will have 800 to 1000 MT/year of Linalool, as side product, will not only make us self sufficient but we can export same as natural linalool which is currently served by China and Brazil through there other natural essential oils like ho wood & Rosewood respectively. We are already accepted in world market for our quality of these three products namely Methyl Chavicol, Anethole, Linalool (Natural.) so now there is need for only increasing quantum so that we become global leader. There is already over capacity in Mentha belt for processing such derivatives so they will also get utilized.

Basil is unique crop, which can come up almost everywhere in short period of two month. It is also part of crop rotation where by it fits along with Potato, Mentha arvensis or Sunflower during monsoon season, as there will be no cost for irrigation since Basil is used for producing Linalool and Methyl Chavicol which in turn is converted to Anethol. if we can produce basil at less then 3\$/kg. we can produce Anethole at 5\$/kg. and replace turpentine derived Anethole which because of it's economic price is sold in more than 2000 Mt/year quantum.

Agro-technique for various type of basil's have been developed for commercial cultivation by CIMAP & RRL, Jammu which indicated that if these various type of Basil is even taken on commercial level in entire India on land where at present only rain fed crops are taken, it can generate profit /acre many fold.

Planned strategy for cultivating various type of basil in many suitable regions of India can enable us to replace many conventional molecule through basil like Eugenol, Methyl Eugenol, Iso Eugenol, Methyl Cinnamate, Camphor, Ocimene, Germacrene-D etc. Since these molecules are used in multi thousand tonnes in F & F industry, overall scope for Basil can increases many fold in India if same is produced at economical prices.

Basil is sacred to India & has been recommended to be planted in every house by our Ancestor. With urbanization it may not be possible to have forest of same near city like Mumbai, Delhi, Bangalore but it can be there in every village. This will take care of not only physical health as recommended by our ancestor but will also take care of financial health of village where it will be planted. Success story has

been seen around Badaun in U.P where many industries has come up based on Ocimum Bascillicum processing which enable India a net multi hundred tonnes of exporter. If serious attempt can be done for other Ocimum species rich in Methyl Eugenol, Camphor, Eugenol/Iso Eugenol it can generated many thousand tonnes of Basil as these molecule's feed stock which are consumed them self in several hundred of tonnes each.

Spent biomass generated from distillation can be very well utilized for natural Agarbatties making extracts containing natural antioxidants (which does not comes total in oil & remain in biomass). Distillate water from basil has been used in India from times immemorial for health care so same can be used for many health care formulation at very inexpensive price as same is wasted at present.

Basil flowers seems to attract very much so Basil honey can be produced from such large cultivation. These type of honey should be much better than normal honey as head space analysis of various basils by Sugandh Guru Dr. B.D. Mookherjee has clearly demonstrated that these aura contains health useful molecules like Ocimene, Cis-3-hexenol /acetate, Myrcene etc .which are present in very large % with very high concentration in Basil flowers. This was one of scientific reason that our Rishis has recommended same to be planted in every house so that aura emitted from same can make atmosphere of whole house healthy.

Beside these some basil plants developed by CIMAP Hydrabad center are beautiful in decoration so can be part of every garden.

Other variety of Basil which can be easily grown in areas where rainfall is less thus allowing to produce other molecule like Eugenol, Methyl Eugenol, Camphor, Methyl molecule like Cinnamate which has many hundred's of tonnes demand in F & F industry. Utilization of spent bio mass can bring lot of medicinal extract.

**LAVENDER :-** This Linalool, Linalyl acetate-containing species is used in soap, cosmetics, incense and Aromatherapy. Attempts for Lavender have been made in recent years to increase cultivation but still large-scale production is yet to come. There is good demand from cosmetic, Aromatherapy segment for high altitude, high % Linalyl acetate quality Lavender oil. Even dry flower and hydrosol can have nice market in future. It will also promote Eco tourism in hilly area. Extensive plantation on high altitude northern border of country can raise self employment potential which is helpful for border security. Lavender, Clary sage & other Linalool, Linalyl acetate-containing species are high altitude crops. China is working with planned strategy with such high altitude crops & trying to offer the same at the most competitive rates. Eg. China has taken Apple cultivation is so planned manner that their production has increased drastically & they flooded raw apples & also apple Juice. These apples & apple juices are offered by China at the most competitive rate which is less half the rate of India from Jammu & Kashmir & Himachal.

China is working on the same planned strategy in last couple of years in developing high altitude of China i.e. part of Himalaya where large acreage of Lavender & Clary Sage cultivation is done. By this, they are able to offer Lavender Oil @ \$25-30 per Kilo & Clary sage at very competitive price & so to Sclareol. Thus unless & until very economic cultivation of Lavender, Clary Sage & other such species are done in Missionary mode, we may not find any place in this Category in future.

LAVANDIN OIL :- Like Lavender, this Linalool, Linalyl acetate-containing species is used in soap, cosmetics, incense and Aromatherapy. Lavandin has +1000 MT/year market but same is mainly controlled by France which because of Eco tourism in southern France can offer same at very competitive price of 12-13 \$/kg as lot of subsidy is given to farmers by French govt. for promoting Eco tourism. It is difficult to make entry at such low level however attempt can be made by developing species so that Eco tourism can be developed in Himachal and Uttaranchal. Cultivation on both sides of road makes area very attractive and attracts lot of tourist during May till September. Bee keeping also generates lot of revenue as Honey ex Lavender and Lavandin flower is used for many therapeutic applications. Internet surfing on these two oil clearly gives very high economic potential of this crop.

SKIMMIA OIL :- This Linalool, Linalyl acetate-containing species is used in soap, cosmetics, incense and Aromatherapy. Skimmia Laurela is important source for lavender type of oil. However no commercial cultivation of it has been tried till so far. Small quantity is obtained through wild source in Uttaranchal, Kashmir, Himachal Pradesh. Linaloe berry/husk oil, which is also known, as Indian Lavender could not become popular so far and production remains below 1 mt/year in main growing state of Karnataka. Since it is new oil for world market and there is need for its market development. It can be grown in most part of India as ornamental tree. However here seeds of same can generate good revenue by distilling oil from same.

CLARY SAGE OIL :- This Linalool, Linalyl acetate-containing species is used in soap, cosmetics, incense and Aromatherapy. Clary sage can be nice crop for J & K, Uttaranchal and Himachal Pradesh Sikkim. Here Bio mass after steam distillation contains Sclareol, which can be recovered by solvent extraction, same is raw material for very important aroma Chemical Ambroxan. Recovery of Sclareol can fetch enough money to make Essential oil as byproduct. Sclareol is converted to Ambroxan by enzymatic reaction. It will be interesting to increase production of Clary sage seeing demand of it in world market. At present it is cultivated in USA, France, Bulgaria. China has already planted large acreage of same in high hilly region & created big presence in world market. This has already reduced the price of both sclareol & clary sage oil ultimately Ambroxan.

ClarySage cultivation is ideal crop for high attitude area where ice falls & very few other commercial cultivation can be done with less labor force. This has been successfully implemented by DRDO in Leh/Laddakh. However commercial processing is lacking due to clear understanding on processing aspects. If same is done with extended area of cultivation in entire high Himalayan region it will have many advantage which are as follows:-

- a) It will increase population density at high Himalayan region which is very much needed for secure borders which is surrounded by country like Pakistan & China.
- b) Based on head space analysis done by Dr.B.D.Mookherjee. Aura emitted by clary sage has very positive molecules used in Aromatherapy for removing too much aggressiveness. This may help in improving thinking of border people who are turning towards terrorist activity.
- c) Leaf of clary sage is even more useful as sources of oil. Rich in valuable sesquiterpenes apart flower spikes.

d) Clary Sage cultivation on massive scale can increase eco-tourism in very high hilly region so it may be producing again oil as bi-products in Himalayan States like Uttarakhand, Himachal Pradesh, J&K, Arunachal Pradesh & North West Bengal.

e) Dry flowers of Clary sage & herbs can be very nice for potpourri from such areas as it will be of wild/organic produced type compared to cultivated type in Europe & USA where there is huge demand for same due to its nice shape, colour & relaxing fragrance.

Fool moon days harvest can be sold at very high premium, as it will have high aroma as compared to normal day harvested material.

India has missed opportunity due to lack of speed in implementation even though technology of cultivation for the same has been developed few decades back & commercial paper for scope has been published/presented by us at seminars in CSIR Lab Organized by EOAI in 1997. China due to serious implementation has become world leader in last two years by cultivating it on other side of Himalayan (Where it is seen cultivating on wild scale in many areas during our visits)

We still feel there is scope for India to cultivate same as we have huge market for its value added products which are imported from European country specially Germany & small country like Israel which is importing it from country like China. Even China has started making value added products like Amber compounds for which this is only commercial source from nature. After ban on recovering Amber compound from animal source, demand from natural has increased making cultivation more viable.

**GERANIUM :** Attempts to promote Geranium at various hilly regions have been initiated and in years to come we may see India, as largest producer of these commodity as at present India is largest user and importer of it.

Nice beginning for extending this crop has already been made through out India. However we feel seeing many results of last 5 year that it will be ideal for hills of Himalaya mainly in Uttarakhand, Sikkim, Arunachal Pradesh and Himachal Pradesh. Due to increase use of this oil in after-mint & chewing tobacco industry, India become a net importer of it in late 90's. Every year, more than 100 MT/Y of oil is imported mainly from France, China, Egypt & other European country. Out of this, approx. 10% may be authentic oil & rest is Geranium type synthetic reconstituted compound which is imported between 5 to 25 \$/ Kg depending on application. However 10% of same which is > 10 MT/Y of Geranium oil also makes India net importer for this oil as production went down to as low as 2-3 MT/Y.

Chemical component of Geranium essential oil depends on following factor...

a) Botanical species selected.

b) Climatic condition, soil type, harvesting method, irrigation.

c) Post harvest treatment like drying, transportation etc.

d) Processing method: This is one of most important aspect, which normally is not taken very seriously although it can change component profile drastically.

Serious attempt of CIMAP based on sponsored project by TRIFAC has opened new dimension in commercial production of Geranium. Lower quantum production of this oil was due to high price of Indian produced Geranium as compare to china & Egypt although quality was not major issue. Mission mode operation of CIMAP team through there north India center from 2001-04 particularly at Lucknow, Purara & Pantnagar enable to develop agro-technique suitable for economic cultivation of Geranium.

Last couple of years of experience of ours in dealing very closely with CIMAP, NBPGR (Bhowali center), IHBT, and universities in Maharashtra & South India, we feel at this stage that Geranium is at stage where mentha was about decade back. With aggressive farming Community around Punjab, Haryana, Uttar Pradesh, we see part replacement of wheat & other conventional winter crops in north Indian planes. If this happen even 1-2% of same will enable India to produce more then 1000 MT/year of Geranium at less than 25\$/Kg price.

With increase in contract farming in planes & established distillation industry around on large scale implementation of same will be much before 2007 as planned.

With excess in wheat production & upcoming new areas around Rajasthan, Madhya Pradesh scope for economic cultivation of wheat around Punjab & Haryana is economically challenged making net return/acre/crop less than Rs 5000/- even after support of Rs 6.20 by Government which is resulting in net loss to national exchanger causing wastage of hard earned money paid by tax payers. With upcoming of implement of WTO from 1<sup>st</sup> January 2005 such cultivation needs serious replacement.

Geranium is one of best alternatives which has been tried successful in 2004 during winter in Punjab in place of Mentha. At present level of yields of even with one cutting same can give 10 Kg/acre Geranium oil which with latest new findings by CIMAP & release of new variety may go easily to 20 Kg/acre in year to come. In that case 50,000 acre plantation can yield 1000 MT/year oil which may be possible in few districts of Punjab where distillation facility for mentha already exists. Since scope for mentha in area like Punjab & Haryana may not be economically viable as compare to eastern U.P & Bihar which can produce at least cost due to very low labour cost in same areas & lack of awareness about sophisticated crops like Geranium.

Considering a realization of Rs 1000/- per Kg, still geranium will fetch higher returns to farmers in Punjab making them still interested at even such low price compare to high existing price of Rs 2500-3000/-.

Regarding scope for market of this crop, there exist huge market (>500 MT/year) of levo Citronellol which is major component of this oil which occurs from 20-60% in same oil. If recovered by fractionation & offered in competition with synthetic Levo-Citronellol still same may be economically viable. Levo-Citronellol being important large % occurring molecule of Rose oil finds huge market in fine fragrance industry which is upcoming very fast domestically with rise in income level. At present

synthetic levo Citronellol is made by two international fragrances giant namely Takasago & IFF. Large % of Levo-Citronellol is converted to levo Rose oxide which can be recovered from same oil as well converted by Photo-oxidation for which facility & expertise is already existing in India to globally competitive level which is enabling India to export large tonnage of Rosé oxide to world market.

Other ingredient of Geranium oil like Iso-menthone & linalool has very important odor profile due to which it is used successfully in F& F industry. It is interesting to know that all these molecules are chirally active providing very good bio-activity along with active C-13 carbon atom which may not exist in synthetic molecules.

Many mis-concept about areas of cultivation has now cleared with in depth study conducted by CIMAP during it's multi-locational trials. Earlier whenever failure occurred like Hydrabad & Pune (Pune Agro University) was due to water logging or less rainfall. In case of excess rain in planes water logging can create mortality of this plant as well high humidity during harvesting time can create fungal attack on harvested part. In winter time till summer there can be low growth during extreme winter in December January but there will be no such problems of water logging & high humidity. So mortality will be very less. Even excess rain can be tackled in areas where Greanium is planted in slopes. Area like Bhowali, Jageswar, Gowaldham in Uttaranchal & Kullu, Manali in Himachal are typical examples where Geranium has been grown on perenial basis making them as sources of planting material for planes. During recent study conducted by CIMAP it was proved practically that top leaves can be harvested for distillation will result not only high % of oil (0.2% on average) but also generated enough planting material from stems with buds. Thus smaller farmers in hilly region of Uttaranchal, Sikkim & Himachal can become source of supplier for planting material from October till February for farmers in planes of Punjab, Haryana, West-Bengal, & Uttar-pradesh. This can generate more income for them by selling planting material even compared with oil sales. Thus prices of oil in hills can be also brought down enabling them to stand in competition with farmers in planes.

Geranium crop cycle in china is July-August-September. In Egypt June-July & in Reunion April, September & December.

Major production of oil in future is going to come from planes so oil will be available from April-May-June until mid July so it will be earlier than China & Egypt which are major producer. So offer of same at lower rates with approval of sample in International Market can make very timely dent to do penetration. It can be tried by increased plantation through contract farming in Punjab, Haryana, Uttar-pradesh & Tarai part of Uttaranchal.

Places like Jollikot in Kumaun region can become planting for taria region of Uttaranchal & Uttar-pradesh where there is lot of spare capacity on mint distillation.

Kullu, Manali, Mandi, Palampur can become center for planting material supply for Punjab, Haryana on plane side. Kangara valley with 4000 acres of tea plantation can become center for Geranium as

these land holdings are not in 'Nalli' but few hundred acres in hand of tea planters. Cut stems can be transported within 6 hrs to plane area from Palampur & can be put straight in fields avoiding transplantation through polythene bags. This will not only save time for developing & growth of plants but avoid double labor cost in preparing saplings. Distillation of fresh biomass of leafy type can be done at high altitude.

CIMAP at Purara, Pantnagar, IHBT at Palampur, HRDC at Dehradun & Gopeshwar can play very important role in organizing training on improved cultivation practice, distillation developing planting material franchise propagation center. Oil collection center at Haridwar, Pantnagar, Pathankot can enable very effective message of assured message to farming community & processors of Geranium.

Geranium flowering in hills & planes can be organized with honey collection which will be like Rose honey as most of components are similar.

For initial 2 year i.e. 2005 & 2006 harvesting has to be done with propagation of planting material, so leaf & stem has to be utilized separately to produce planting material & oil. This at first instance will bring down cost of planting material which is very high at present.

In planes also large size economic poly-houses should be put near plantation areas which are near big cities like Jalandhar, Chandigarh, Ludhiana, Kurukhetra, so that planting material can be sold to new farmers joining Geranium cultivation at competitive price. Last few years of practical experience at Bhowali first & then at Kullu, Gwaldham has showed that farmers can make more money without any risk even by selling planting material. This trend is anticipated to continue till next two year till sufficient propagation of more than 10,000 acre occurs. NGO can also play important role in raising planting material through such poly-houses or small cluster of cultivations in hills with sloppy land with above average rainfall & source of water for whole year.

Proper selection of original planting material is very much need of hrs. At present various genotype available on large scale are basically one type which contains 10-epi- $\gamma$ -eudesmol as major sesquiterpene and almost equal % of Citronellol & Geraniol (varying between 20 to 30 % each depending on location). This material are hardly having 6,9 guaiadiene on sesquiterpenes side making them of type like African or Egyptian type. However market demand is more for Bourbon & Chinese geranium which are used in cosmaceutical & Pan masala industry due to it's unique profile of sesquiterpenes emerging from 6,9 guaiadiene & high % of Citronellol & it's esters. Thus there is need for such material so that entire spectrum of Geranium commercial varieties can be covered.

Other variety of Geranium rich in molecule like rose-oxides, Linalool oxides, Menthone can be tried on buy back basis.

CITRONELLA OIL : Extension of Citronellol rich variety is need of time & can create big market. Recent visit to Assam and few southern states like Andhra Pradesh, Orrisa gave some findings on this oil. In

Assam production of same oil has gone down from 450-500 MT/y in 1995 to <100 Mt/year. Reason was reshift of many tea Gardens from it to tea when price of tea were remunerative. In last 5 year whole scenario is changing and these changes will be more in coming years as WTO is implemented fully. We all know very well that Shrilanka, China and Kenya has emerged in very big way as producer of tea and there is over production of Coffee world over. This has resulted in drop of auction price of tea from Rs.100 to Rs. 55 per kg. (April 2004). Seeing less demand (due to alternative cheap source like Kenya and Shrilanka) and supply figures with fall in import duty to zero for import from especially Shrilanka chances of rise in price is very big question. With such large acreage of tea plantation in Assam with still limited market for other perishable crop, Citronella and Patchouli can be ideal diversification from tea for few thousand hectares, which can restrict supply of tea to make again price at sustainable level. After seeing Shrilankan plantation with high productivity and very low labor cost there is urgent need for crop diversification in Tea & Coffee Plantation, other wise it may also pass through sickness like Jute industry. Assam and Arunachal Pradesh with lot of rainfall has shown that it is ideal for Citronella and Patchouli cultivation. Very high cost of production in past can be brought down by efficient steam distillation unit like Mentha where cost of production per kg oil is less than Rs. 20 per kg.

Conventionally in 70' Citronella oil has been produced world over at 7000 Mt/year level where by most important Aroma Chemicals like Citronellol, Citronella, Hydroxy Citronellal, Geraniol were produced mainly from this oil. Also Menthol was produced by Japanese co. like Takasago from same oil. However with rise in price of same oil, interrupted availability, optimization of synthetic equivalent derivative from petrochemicals and Turpentine made this oil replaced and total global production went down to 1200 MT/y at present mainly coming from China, Vietnam, Indonesia, Argentina, Madagascar, India.

Seeing all above mentioned consideration production of 10,000 MT/year at 3.0\$/kg. can produce derivatives at 5\$/kg. with 6500 MT/y replacing partly synthetic equivalents, which are having +20000 MT/year production and demand. As mentioned derivative processing facility already exists with more than 1,00,000 MT/year spare capacity so it can be effectively utilized.

With very slow plantation extension in northeast region which is best areas for Citronella plantation alternate can be looked in other areas where farmers are eagerly looking for alternative crops. Development of Cymbopogan strain by CIMAP for excess water like 'Jallpallavi' & Strain developed by Hyderabad Center for dry areas can bring major change in time to time.

**LEMONGRASS OIL :** Very high projection of 40000 MT/year is made, as this is most versatile oil, which can be grown in plains at many wastelands also. Moreover major content of this oil is 75% Citral which is basic building block for many pharmaceutical's and Aromatic chemical. It is starting material for Vitamin A. In past it was made from Lemongrass, which was growing in bulk quantum in 50and 60's on south -west coast of India. India once upon a time exported more than 1500 MT/year of this oil from wildy cultivated sources mainly from south Karnataka and North + Central Kerla. With time shift to other more value added crop and reduction in prices from synthetic route, reduced importance of Lemongrass and production came down to around 150 MT/year. Oil is presently grown in many new area like Madhya pradesh, Andhra pradesh, Gujrat, Uttarpradesh apart conventional

area like Karnataka and Kerala. It is coming up very well in these new areas and cultivation is increasing gradually.

Enough work on agronomy has been done by many institutes so planting material and technology for cultivation is not a problem for increasing area. But getting economic oil so that it can compete even synthetic source is basic object of these exercises. It is possible to bring down the cost of production provided

1) It is grown on land for which no cost should be taken for calculating cost of oil production: like cultivating in waste land or around railway siding so that it can provide nice look to whole journey in train.

2) Cost of Irrigation and processing should be minimum. Like cultivating in certain wasteland in UP where other things cannot be grown although lot of water is there so nice inexpensive irrigation can allow very high growth of such grass. Energy efficient distillation, which can run on spent, dried biomass dried under sunray should bring down cost of oil processing less than Rs. 20 per kg like Mentha oil.

In all if price of oil can be brought down to 3.0\$/kg. than it can compete synthetic Citral which is available at 4.0\$/kg. from Isoprene Ex petrochemical route. It is offered by M/KURRAREY, Japan and BASF, Germany who makes same is expanding to 15,000 and 30,000 MT/year respectively. Apart Vitamin A, many bulk aroma chemicals like Citronellal, Hydroxy citronellal, Citronellyl Nitrile, Geranyl Nitrile, Citronellol, Dimethyl octanol, Ionones, Methyl Ionones etc. can be made easily. India has excess capacity to make these derivatives and apart catering to local market can also supply these value added derivative to world market. In last few years 400-500 Mt/year of synthetic Citral is imported to make these derivative for local market. Low price can also avoid import of Litsea cubeba oil from China, which is cheapest natural source of Citral. Consumption of Lemongrass in Ayurvedic preparation like Balm is also increasing. If cost is at 3.0\$/kg. It can become attractive for direct perfuming of laundry detergent also replacing many synthetic perfumes. Application wise it can be largest cultivable oil for which seeing variety of use and prospects for green renewable chemistry large-scale plantation can be planned. Lemongrass grows very well under shade also with many horticulture crops so plantation should be done with intercropping. Large organizations like Reliance have already initiated some plantation in Gujarat to keep atmosphere near refinery green and beautiful. If such examples are extended and repeated in much area it is not difficult to achieve target.

## EUCALYPTUS OIL

**Eucalyptus Globulus oil:** This oil has been important from not only perfumery but also medicinal point of view. Commercially this oil has been available from Nilgiri hills in south where production is 400 MT/year at present. In last few year due to increased demand (700MT/year) India become net importer of 300 MT/year from China, which is producing 4500-5000 MT/year making them as global leader in this oil. Unplanned plantation of Eucalyptus made India even bigger cultivator of Eucalyptus tree with wrong species with very little commercial value for its leaf oil. Where as in China planned forest cultivation at back of Himalya around Kunming made it to produce such huge quantity from waste leaf which comes from plantation done to prevent soil erosion and raise forest. This provided employment to many thousands of family, which are given on preferential lease rights for collection,

and processing of such leaf without harming tree. During visit to these area in 1999 enabled us to see many such industry, which has come on rural level, and makes export to country like India as well to USA, UK also.

Few nice species has been identified in Uttaranchal, which shows high content of Cineol (which is needed). Such species if multiplied with help of forest department on massive level can make India not only self sufficient but net exporter of this oil. This can provide ample of employment in processing industry of distillation around Uttranchal, Himachal in time to come and make this hilly region more green which is very much need of time. Eucalyptus Globulus tree has been attracting many lacks of visitor in Ooty and Kodaikanal from last many decades.

**Eucalyptus Citroedora oil:** This oil is very important from derivative manufacturing. Derivatives like Citronella, Hydroxy citronella, Citronellol, Rose oxides are made out of it. It grows very well between 400-700 mt. but can also grow in plains also. Production of it is again limited to 50-60Mt/year making India net Importer (45-50MT/y) from country like Brazil and China who are major producer of it.

Commercial plantation of it can be seen around Bangalore, Coorg, Harihar and Dharwad (Karnataka), Wyenad (Kerla). It was observed that quality of oil is much better at high altitude 2000 ft. (eg. Sultanbattery, Wyenad). A sub species of Citroedora namely Boucosia type can be of very high quality from odor point of view. Plantation of it can be taken around Uttranchal, Sikkim, Arunachal Pradesh Hills.

Emphasis on organic farming and increasing cultivation of other crops like Basil, Palmarosa, Lemongrass, Citronella, Geranium, Eucalyptus, Citroedora, Vetiver etc. in suitable lands which can not be used otherwise. Thus if cost of this oils can be brought down by efficient agronomy and processing, India can become largest producer of essential oil of major category. For commercial success in essential oil production for such perennial crop with intercropping can bring down cost making same more viable.

**MENTHA :** Mentha Industry is an industry, which prospers in area where houses are made of "Chappar"(a type of roof which is made from straws available from agriculture waste) and walls are made out of mud. Same prosperity turns such houses in nice RCC houses, which we can see in western UP in Tarai where Mentha Industry started around Rampur. Slowly cultivation of this crop has been shift to Eastern UP via Barabanki area where still we can see many houses with "Chappar". Thus production of Mentha instead of decreasing from 14000 MT/y increased to 18000 MT/y making India world leader with 90% share driving away China to less than 1000 MT/y with less than 5% market share. Also unlike other countries Japan, Brazil, China who were major producer in 60's, 70's, and 80's and later lost due to Industrialization, India still maintained it's leadership from last two decades.

A rapid rise of 400% in cultivation area in Bihar for essential oil crop in 2004 shows that crops like Lemon grass, Mentha is going to grow very fast in this area which requires fertile land, water & labor which are more than required in Bihar.

**Mentha Piperita oil:** 3361.24.00.00. CASNo .8006.90.4 Mentha piperita has +2500 MT/y demand most of which was met by USA. But seeing high cost of production in USA it will not be long when India will easily produce around 2500 Mt/y to meet major demand of world market. This oil is one of most important oil for which target of 2500 MT/year can be achieved even by 2005 making India world leader in this oil. India is already on growth path for this oil with expected production of 1000 & 1600 MT/year in 2003 & 2004. As stated due to development of CIM\_INDUS (CIMAP/MP20) by CIMAP, India already become no.1 producer of same.

Few more suggestion which can help in achieving target are as follows :-

- 1) Clear projection of demand among farmers in Tarai belt is only needed for achieving this Target as there is already over production of Mentha arvensis. So even partial shift from Arvensis to piperita can be of help on both sides.
- 2) Clear objective of higher Mentha furan, Cis +Trans Sabinene hydrate, Germacrene-D with few other minor components responsible for enhancing flavor value like Cis Jasmone should be taken as target for making new variety available based on biotechnology approach.
- 3) Since Mentha piperita is used for direct use in toothpaste, confectionary so cultivating through organic farming can create nice value addition along with higher acceptance in western market.

**Mentha Arvensis oil: There is over production of Mentha arvensis. So there is no scope in further extension of this crop,** as we have reached a stage where by if we increase further production we will lower our own price due to internal competition. After achieving no.1 position in world market with 18,000 MT/year of production there is hardly any scope for further expansion. There can be some additional scope for going in organic farming from western market for export.

**Spearmint oil:** In Spearmint oil still we have to travel a long, as our production is hardly 300 MT/y where as global demand is +1500MT/y where major production still comes from USA and partly by China (as there quality is different). This oil like Mentha piperita can be easily increased to 1500 MT/y to get major share in world market. In this case there is **competition from synthetic L-Carvone**, which is made out of d-limonene. So unless yield is increased by adopting proper strain chances of price coming down are very less so difficult to achieve target.

#### **Sandalwood import in US**

YEARS	2000	2001	2002	2003
QTY	20	18	31	28

#### **Vetivert** 3301.26.00.00 CAS NO.8016.96.4

Import :- Haiti, Indonesia, China

YEARS	1996	1997	1998	1999	2000	2001	2002	2003
EXPORT	21	48	24	26	24	5	5	5

In Haiti crop time is January to July where as in Indonesia April to September. In Reunion it is June to October.

#### AROMATIC CHEMICALS :-

**LINALYL ACETATE** :- It is important constituent of fragrance and flavor trade which at present is mostly supplied through synthetic source. Many essential oils like *Skimmia Laurella*, which occurs wildy in J&K along with few cultivated oils like Lavender, Lavandine, Clary Sage etc. can become important source for it if produced economically.

**EUGENOL** :- Similarly Eugenol is used in F&F industry .At present entire need is meet through Clove leaf oil imported from Indonesia and Madagascar. It can be derived from some *Ocimum* species, which can be grown very well in many regions. However till few months back due to very economic price of Clove leaf oil these crops could not be commercialised. However if planned properly with economic production it can become important source for Eugenol replacing Eugenol ex. Clove leaf oil.

**Eugenol rich variety**: India is importing entire requirement of 250 MT/year of Eugenol and it's derivative in form of Clove leaf oil or direct derivatives like Eugenol and Iso Eugenol. So there is very good scope for developing planting material on large scale where oil is rich in Eugenol. High target of 2000 MT/y is made with idea of possibility of developing derivatives based on these oils for which already there is enough capacity in India.

In past nice attempt has been made by RRL, Jammu to develop Eugenol rich *Ocimum* species but unfortunately no large scale cultivation of it was done which can give few tones of oil for producing Eugenol. Some species of Cinnamon containing high Eugenol in leaf was also attempted but again no commercialization is there at present.

There is scope for converting natural Eugenol to Vanillin via Biotechnology. So right species for getting Eugenol at economic rate is need at present. High price of it may not be possible as Clove leaf oil is obtained as bi-product of clove tree in Indonesia and Madagascar which are major source of oil at present at approx. 3.0 \$/kg with 78 to 80% Eugenol.

**GERANIOL, CITRONELLOL, CITRAL, AND CITRONELLAL** :- Isolates like Geraniol, Citronellol, Citral, and Citronellal are important building block for fragrance and flavor industry. Due to economic price synthetic has replaced natural isolate more than 90%. However as mentioned above if we plan properly extension of crops like Citronella, Citrodora, Lemongrass/ Jamrosa etc. keeping in mind price as indicated in Annexes I we can defiantly become competitive in producing finished product based on these isolates.

India has seen major change of mind set at grass root level in last decade for which major credit goes to TV channels, which are now more than 100. Lowering of TV prices and liberalization on its policy by govt enabled its reach to common people. Many of them are giving very effective coverage on development on global scale.

**Emphasis on direction for research in Aromatic plants** :- As per our excel sheet of Vision 2007 for 15 major essential oils, which can enable India to achieve 470 million \$ turnover by 2007. Clear explanation was given for very high hypothetical figures for 2007 keeping in mind following aspects, which are current time based :-

1) Excess of conventional crops in India: Due to efforts of govt. encouraging policy, ICAR, Universities and progressive Indian farmers, India not only become self sufficient but become net exporter of many conventional crops like Wheat, Rice, Sugarcane, Tea, Coffee, Potato, Onion, Rubber, oil seeds etc. However seeing excess production of all these an urgent need for crop diversification draws attention towards Medicinal & Aromatic plants (MAP) seeing rising demand in global and local market.

2) Rise in Unemployment: Due to increasing efficiency in both private and public sector due to globalization and computerization rate of unemployment is rising at grass root level leaving very few job opportunity on Industry on large scale. Saturation on IT scenario on global scale is leaving very less opportunity for IT based job although telecommunication is on rise but again same can not create jobs for long term. Thus jobs through BT (Bio Technology) with effective implimentation of it through large scale implementation of Medicinal & Aromatic Plants is best answer to solve problem for country like India which is having largest pool of scientist and agriculturist.

3) Green Chemistry: With development of advance analytical chemistry and instrumentation we know that most of molecules, which are made synthetically can be made naturally through MAP in more effectful manner. These molecules being natural will have much advantage like very high enetiomeric excess (Chiral molecule), active C-13 carbon atoms. Moreover in producing these molecule through cultivated MAP there is practically no pollution where as in synthetic molecule there is huge pollution. Feed raw materials like petroleum feed stock, minerals for synthetic chemicals are depleting and are non renewable. Many of synthetic molecules like Galaxolide etc. are found non-biodegradable. So demand for natural driven molecules are on rise and in time to come if natural molecule cost can be controlled, it can easily replace synthetic molecule totally. Thus vision of green chemistry can be effective by having "Laboratory under Sun" with many MAP as miniature reactor.

4) Eco tourism: Many countries like Australia, France, Spain, Italy, Ukrain has already implemented crops like Lavandin, Citrus (Lime and Lemon), Coriander respectively to make whole tourist circuit very environment friendly with beautiful road/rail sides. In India we have massive program of improved road under Priminister's "Golden Quadrangle project" which has become partly effective and will be completed by 2005. This will open huge potential for travel through roads to many site of commercial and tourist interest. Plantation on road/rail sides can not only enhance tourism but also raise income level of farmers putting such facility on roadsides. A beginning has already been made last year on roads of Uttranchal from Bowalli to Bageswar with Geranium plantation where people can stop on tea stall where they can see Geranium under cultivation with processing unit side by side. So far they had only Gandhi Ashram for purchasing and seeing making of Khadi cloth but now they can see also cultivation and processing of MAP which makes their life healthy. India after obtaining complete self sufficiency in "ROTI, KAPDA, MAKAN"(Bread, Cloth, Shelter) will need healthy people on both mental as well physical level for which large scale cultivation and processing of MAP on every road is need of time.

Like Barabanki-Gorakhpur route, which passes through Ayodhya after Faizabad, Barabanki was considered earlier as small town but in last few years due to good road and over all development particularly in Mentha it has almost become suburb of Lucknow although it is 50 kms. from Lucknow. We can see many new medical and Engg. College on both sides of road as well as many small commercial establishments. Market of Mentha, which is on side road of main crossing, one could see many shops having few drums used for storing Mentha Arvensis oil. Many fabrication units on same road can be also seen where prototype distillation units are sold on ready-made basis. This shows how business of Mentha has expanded in this area and more than 10000 MT/annum of Mentha oil comes from this area alone. Due to this major exporter of Mentha oil and Menthol have started there branches in this area for procurement and some cos. have put multi thousand tones of processing unit also. At Faizabad, we could see few distillation units on roadside. It made us to understand very clearly how shift of farming of Mentha from western UP to eastern UP towards Gorakhpur is converting houses of "Chappar" to RCC with prosperity level coming up. It also reminds some one's saying, "Paddy and poverty goes together". This is what exists in India still at rural level. During last few years of extensive travel in rural India, it is realized that still many people grows conventional crops like wheat and rice for which prices are very low. So with smallholding of land even after putting lot of effort they remain much below poverty line. Reason for not going to other crops are many but following are main reason as understood by talk with few knowledgeable people

1) Lack of awareness for other crop diversification at rural level: Because of lack of exposure. Farmers in small village have been exposed only to conventional crop, which can give them enough food for their survival. Extra grains, which they grow, are used for purchasing clothes and some amount is utilized for reconstructing house (not in case of "Chappar" type houses) or occasion like marriage or childbirth. Education at village level is free so they do not have much expense on it. Whenever they are sick they take help of local Ayurvedic or traditional medicine or in extreme case goes to govt. hospital, which is again free. Other common crop is Sugarcane, Mango (partly for self consumption and making pickles), Potato, Onion, and Garlic etc. This has resulted in excess of all these crops so many cold storages are made to store these crops during season. However food-processing units are absent in rural level. Other crop, which is becoming popular, is Sunflower whose seeds are used for extracting edible oil for which there is large consumption in India. We saw many weekly market carefully and observed that other things, which are sold most commonly, are plastic utensils, footwear, cheap cosmetics or spices.

2) Orthodox view on diversification: Many people in village side still believe that they should grow there own food in there farm and never purchase any thing from market. They feel it insult to them if they start purchasing from market. According to them only those people who does not own land purchase grains from market and such people in olden days were considered lower segment people who were called "Sudra" or servants. This inferiority complex is slowly going with education and younger generations who are educated are ready to go for diversified crop. Growing grains to vegetable was very common in olden days for self-consumption or barter or gift but common purchasing across market was not there in rural India and it even exist to large extent even today. Under such situation we cannot think of many restaurant in village.

With changing scenario on all fronts now things are changing very rapidly and we may see lot of diversified crops in time to come in rural India, which will be responsible for removing poverty. Our aim is to identify few progressive farmers in each area with help of Govt Institutes so that they can become model for other in extending MAP and their processing. Constant support on technical side for implementation will be given by these institute's in there area and we can come for providing updated commercial information's and procurements based on market need.

Very nice beginning on implementation of value chain at rural level has been started with beginning of new millennium by large corporate Cos like ITC effectively utilizing Information technology through “**E. Champa**”. With result with in 4 year many millions of farmers started getting benefit for their hard work. Similar attempts on aromatic crops cultivation & there effective utilization will lead to open new happiness both among producer & user.

Overall if we calculate total value of essential oil production as indicated in Annexes I it comes out to be 0.47 Billion \$. It may appear very high figure as compare to 250 million \$ for all essential oils at present however seeing strong position of India in Agriculture same can be possible if proper planning and implementation is done very seriously.

After doing actual survey of many essential oils grown currently and considering Impact of WTO post 2005 it was felt that a very clear strategy has to be formed to make India in no.1 position with major market share in field both in quantitative and value term. This can bring many advantages, which are as follows :

- 1) **Net foreign exchange earner**: Basic raw material needed in production of essential oil are sun rays, water, land, labor which are available plenty at many place in India. Thus there is no content of imported raw material, which makes this segment net foreign exchange earner. It can also generate many natural chemicals, which are other wise imported in form of there synthetic equivalent, which involves lot of outflow of foreign exchange.
- 2) **Low capital cost/manpower ratio**: Each stage of essential oil production or its value added derivative require lot of man power both of unskilled and skilled type resp. Thus if ratio of investment v/s manpower is taken then it will be lowest among all industry.
- 3) **Environment balance**: Cultivation of essential oil bearing plants defiantly improves environment and reduce pollution. Where as equivalent chemical if produced synthetically develop more chemical waste, which are causing severe pollution and health hazards.
- 3) **Development of hilly and underdeveloped region**: Many essential oil bearing plants can be very successfully grown in high altitudes even at land with slop. This can bring lot of employment to these area which is very much need of time in many state like Uttranchal, Sikkim, Himachal pradesh, Jammu and Kashmir, North eastern states etc. Since finished products are in concentrated forms transportation will not be problem.