

Summary of Completed/Ongoing Projects

COMMERCIAL RESOURCES OF *CINNAMOMUM* SPECIES IN EASTERN HIMALAYAN REGION OF INDIA : SURVEY, IDENTIFICATION AND CONSERVATION FOR SUSTAINABLE USE

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- * A total of 27 morphologically and chemically different taxa of the genus *Cinnamomom* associatic, spice and medicinal use of rural and aboriginal people in Eastern Himalayan region of India including its North-East part has been brought to light.
- * These 27 taxa of *Cinnamomom* growing in Eastern Himalayan region of India comprise 13 species and 20 infraspecific categories against the 11 taxa of species categories reported previously from the region, while one species *Viz. C.sulphuratum* is revealed to be a new record to the flora of the region. However, the remaining taxon *Viz. Cinnamomum* sp. (RRLJ 1805) is revealed to be a separate species other than the known ones from the region. Necessary process is on to confirm its naming.
- * The 20 infraspecific categories of *Cinnamomum* revealed in this investigation comprise 17 phenotypic variants and 16 chemotypes. Amongst the phenotypic variants, 11 taxa (three for *C.bejolghota*, two each for *C.camphora*, *C.sulphuratum* and *C.verum*) are indicative of varietal rank while five taxa (tree for *C.tamala* and two for *C.verum*) are of cultivar ranks. Amongst the chemotype, four taxa belong to *C.sulphuratum*, three taxa each to *C.bejolghota* and *C.Verum* and two taxa each to *C.camphora*, *C.parthenoxylon* and *C.tamala*.
- * Six species *Viz. C.verum*, *C.cassia*, *C.iners*, *C.sulphuratum*, *C.pauciflorum* and *C.bejolghota* (RRLJ 1600 & RRLJ 1847) are known in the region as "Dulchini" (Cinnamon) and their bark used as cinnamon spice of commerce, while four species, *Viz. C.tamala*, *C.impressinervium*, *C.bejolghota* (RRLJ 1603) including the unidentified one (RRLJ 1805) are know as "Tejpat" and used their leaves as tejpat spice of commerce, besides being the uses amongst some of them as folklore medicine. Interestingly, a taxon of *C.bejolghota* namely the RRLJ 1603 is known either in the name of "Dulchini" or "Tejpat" according to the uses of its bark as "Dulchini" and leaves as "Tejpat" by the people. Likewise *C.camphora* and *C.parthenoxylon* are known in the region as "Karpur" and their leaves are being used for culinary purposes, while *C.glaucacens* and *C.glanduliferum* and known as "Gondsoroi".
- * A taxa of *Cinnamomum* manly the RRLJ 1254 which was although identified as *C.tamala* variant, on the basis of herbarium discussion at CNH, Howrah, has been found to be indicative of *C.sulphuratum* in this investigation, as regards its morphology and chemical characters.
- * A simple and easier peeling technique for isolation of epidermis for *Cinnamomum* spp. has been developed and standardised.
- * A controversial nomenclature of a type of stomata occurring in *Cinnamomum* spp. Which has been describing so far till our work either as sunken or anomocytic or as paracytic has been solved detecting and characterizing its actual nature as sunken type (Baruah & Nath, foliar epidermal characters in Twelve species of *Cinnamomum* Schaeffer (Lauraceae) from Northeastern India, Phytomorphology, 1997, In press).
- * There is a positive correlation found between the size of leaves and their eugenol contents in essential oils, in case of the variants studied for *C.tamala*. Smaller in leaf size of variants, higher is the eugenol content in their oils. As eugenol is the main active ingredients responsible for quality of "Tejpat" spice, hence the *C.tamala* variants possessing smaller leaves could be considered as superior strain/cultiver/variety.
- * Of the 27 taxa screened for essential oils and aroma chemicals, 26 taxa comprising 13 species reveal positive indication.
- * Methodologies for seed propagation of *C.tamala*, *C.impressinervium* & *C.sulphuratum* and stem cutting propagation of *C.pauciflorum* & *C.verum* have been standardised.

- * About 100 seedlings, each for *C.tamala*, *C.impressinervium* and *C.sulphuratum* raised as a result of propagation studies have been transplanted into the Experimental R & D Plots.
- * About 200 voucher specimens representing a total of 27 *Cinnamomum* taxa surveyed, collected & characterized have been processed as herbarium specimens and preserved at the Herbarium of RRL, Jorhat.
- * About 2 acres of land has been developed as Experimental Botanic Garden (Herbal Garden) at RRL Jorhat introducing & maintaining the live plant germplasms of a total of 18 *Cinnamomum* resources comprising 12 species collected from different parts of the region.
- * A taxonomic key to the taxa based on morphological (including micro) and chemical characters has been formulated.

STUDY OF ALLELOPATHIC EFFECT ON FIELD CROPS BY SOCIAL AND AGRO-FORESTRY TREES IN GARHWAL HIMALAYA

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Fields survey in *Prunus cornuta*, *P. armeniaca*, *P. jacquemontii*, *P. amygdalus*, *Buxus wallichiana*, *Cassia fistula* and *Fraxinus micrantha* growing areas of Garhwal Himalaya were conducted with reference to the germination and growth of some companion crops at various sites of different soil fertility. Retardation in germination, growth and yield were noted in nearly all test crop plants, particularly on those sites where the percentage of soil organic matter was low. It was also observed that the magnitude of interference gradually decreases as the distance from the tree increases.

The extracts of the bark of *Prunus cornuta* in petroleum ether, ethanol, ethyl acetate and water were prepared and the residues after dilution were tested for their allelopathic effect on the germination and growth of *Raphanus sativus*. Significant inhibitory effect were observed with all the solvent extracts. Prunasin (a cyanogenic compound) and melilotoside methyl ether isolated from ethanol extract also remarkably inhibited the germination and growth of radish.

Aqueous and organic solvent extracts of the aerial parts of *Prunus armeniaca* were made and their residues were tested after proper dilution for their phytotoxic effect on germination and growth of test crop. Residues of light petroleum and ethyl acetate extracts showed maximum inhibition in growth and germination of test species. The isolated compounds were identified with the help of spectroscopic techniques and also bioassayed. B-sitosterol, 2, 6-dihydroxy-4-methoxyacetophenone and kaempferol were isolated from petroleum extract whereas aromadendrin, quercetin, B-sitosterol-B-D-glucoside, pleoside and tannins (four proanthocyanidins-A type) were characterized from ethyl acetate extract. Of these, proanthocyanidins showed maximum inhibition whereas quercetin, aromadendrin, kaempferol and genin of pleoside inhibited to lesser extent.

In the bioassay studies with light petroleum, ethyl acetate and alcohol extracts of the root and bark of *Prunus jacquemontii*, the ethyl acetate extract have shown more inhibition to the germination and growth of *Raphanus sativus*. Pavetannin and 13'-hydroxymahuannin from the ethyl acetate extract were more inhibitory than B-sitosterol and its glucoside. The aqueous and ethyl acetate extracts of the root were more inhibitory than the bark.

Aqueous and organic solvent extracts of the aerial parts of *Prunus amygdalus* were made and their residues were tested after proper dilution for their phytotoxic effect on germination and growth of *Triticum aestivum* and *Eleusine coracana* by conducting bioassay experiments. Residues of light petroleum and ethyl acetate showed maximum inhibition in the growth and germination of *Triticum aestivum*, whereas *Eleusine coracana* was found as a tolerant species in the test towards all residues. The compounds were isolated from the residues of light petroleum and ethyl acetate extracts and identified with the help of spectroscopic techniques and co-chromatography with the authentic samples. The isolated compounds were also subjected to bioassay. Persicogenin-3'-glucoside was found more inhibitory for the growth and germination of test species followed by naringenin and aromadendrin.

The phytotoxicity of aqueous and organic extracts of leaves and stem bark of *Buxus semperviens* syn. *wallichiana* was examined in the laboratory using local varieties of wheat (*Triticum aestivum*), lentil (*Lens culinaris*), mustard (*Brassica campestris*), radish (*Raphanus sativus*), finger millet (*Eleusine coracana*), barnyard millet (*Echinochloa frumentacea*), kidney beans (*Macrotyloma uniflorum*) and black gram (*Phaseolus mungo*).

The germination and seedling growth (root length and shoot length) of all crops were inhibited by aqueous and organic solvent extracts of leaves and bark. Among summer crops finger millet was found to be most susceptible crop whereas, black gram was more resistant crop. Five percent aqueous extract of both leaves and stem bark completely inhibited the germination of finger millet. Among winter crops lentil was found most inhibited sp. while radish was least affected sp. The phytotoxicity was found to be concentration dependent in increasing order of

1.25% < 2.5% < 3.75% < 5.0%. Chloroform extract of both leaves and stem bark was found more toxic than other organic solvent extracts.

Effect of organic and aqueous extracts of stem bark, leaves and pods of *Cassia fistula* on seed germination and seedling growth of *Triticum aestivum* was examined. The different concentrations of extracts i.e 2.5%, 5% and 10% of stem bark, leaves and pods significantly inhibited the seed germination and seedling growth of *Triticum aestivum*. The inhibition was noticed as concentration dependent. Bioassay with different solvents extracts showed that the ethyl acetate extract of stem bark, leaves and pods were more inhibitory than other extracts. The ethyl acetate extract yielded epiafzelechin, epicatechin, 1,8-dihydroxy-3-methyl anthraquinone (chrysophenol), 1,8-dihydroxy-3-methyl-6-methoxy-acetophenone (physcion), kaempferol and dihydroxykaempferol. The chemical studies revealed that the tannins and anthraquinone have shown maximum inhibition in germination, plumule and radicle growth of *Triticum aestivum*.

Aqueous leaves extracts of *Fraxinus micrantha* and coumarin compound (fraxetin) isolated from the leaves of the plant were tested for their allelopathic effects on germination and growth of *Brassica campestris*, *Eleusine coracana*, *Raphanus sativus* and *Triticum aestivum*, *Brassica campestris* and *Triticum aestivum* were found to be most susceptible to phytotoxic responses of aqueous extracts of *Fraxinus micrantha* and found to be concentration dependent. Coumarin compound (fraxetin) was found more toxic to all tested crops than the aqueous extracts. Bioassay of bark of *Fraxinus micrantha* with different solvents extracts showed that the butanol extract was more inhibitory than other extracts. The isolated compounds from butanol extract, (+)-1-hydroxypinoresinol and aglycone of fraxin (fraxetin) showed more inhibitory effect on the germination and growth of *Triticum aestivum* seedlings.

**STUDIES ON THE ECO-BIOLOGY OF SELECTED TRIBUTARIES OF RIVER
GANGA BETWEEN DEVPRAYAG & RISHIKESH**

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The present research work has been conducted under the project entitled "Studies on the ecobiology of selected tributaries of river Ganga between Devprayag and Rishikesh," during three years (1994-97) tenure of the project, sanctioned to us by the G.B. Pant Institute of Himalayan Environment and Development, Kosi, Almora. For this study, the water samples were collected from the six selected stations, which included three from tributaries (Goolar gad, Huanl west gad and Huanl east gad) and three sites from river Ganga (one each at Devprayag, Rishikesh and Shyampur). This Final Technical report of the Project includes 18 grand tables and 43 text figures/histograms/graphs. The following points can be summarised, out of this report :-

- * The air temperature was found low at tributaries as compared to river Ganga, this is mainly due to less time of its exposure to sunlight, as the rivulet sites and runway area is usually deep valleyed and shaded under forest canopy.
- * The water temperature was higher in tributaries as compared to river Ganga. This may be due to shallow water table of these rivulets (gads), and less sandy beaches around, as compared to the main river, besides the fact that the main river contains hundred times more water mainly arising from the melting of the glaciers, i.e. the main river is snowfed while the contributing rivulets are of spring origin.
- * In the tributaries the water shows greater periods of transparency than the main river, which is turbid not only during rains but during summers also when the snow melts at higher altitudes and brings a lot of eroded soil mass alongwith.
- * The current velocity was found to be directly proportional to the flood level and also with the gradients of the stretch. In tributaries velocity increases during monsoon and in river Ganga increases May onward, but was usually lowered during winters, on account of lesser water.
- * The turbidity was highest during monsoon period and lowest in winter. Turbidity was high in river Ganga in comparison to tributaries. For the selected sites of river Ganga, Shyampur station showed maximum turbidity, due to township sewage and factory drains of I.D.P.L..
- * The conductivity was always high during winter up to monsoon. The Huanl east gad and river Ganga at Shyampur showed high values of conductivity.
- * The total, dissolved and suspended solids were maximum in river Ganga as compared to tributaries.
- * pH was always observed neutral to alkaline in all six stations. High values were recorded during winter and low during monsoon months.
- * Bicarbonates were in higher amount in river Ganga as compared to tributaries. Among tributaries Huanl east gad showed maximum concentration.
- * The carbonate values were below the detection limit during July to September in Goolar, Huanl west and Huanl east gad, while in river Ganga, the values were very low in July-August. The higher values were noticed during winter.
- * Dissolved oxygen concentration was observed high in winter and low during monsoon. The high concentration was recorded in tributaries as compared to river Ganga.
- * High value of F-CO₂ was observed during monsoon months and low during winter months, at all six stations.
- * High value of BOD and COD were noted for river Ganga, as compared to the three tributaries. The COD vale was usually higher in all stations than the BOD.
- * The contents of calcium and magnesium were higher during winter months and lower during monsoon months, at all sampling stations.
- * The lower value of iron was observed in rainy season in river Ganga, while in tributaries no definite pattern of variation were found. Maximum values were recorded during winter months.

- * In tributaries high concentration of sodium and potassium was observed at Huanl east gad and Shyampur station in river Ganga. Lower values were recorded during winter and higher during monsoon months.
- * The higher values of phosphate were observed during June and July in all tributaries, but in the months of July and August in river Ganga. The lowest values of sodium was noted during winter months.
- * Higher phosphate contents in river Ganga were observed at Shyampur stations, and lowest at Devprayag stations. In tributaries Huanl east gad showed high concentration, as compared to others.
- * The nitrate contents were maximum during July in all tributaries, and round the monsoon period in river Ganga. The lowest values were observed during winter months.
- * The maximum chloride contents were observed during rainy season and minimum during winter months. In tributaries no definite pattern of variation were observed during the investigation period.
- * The DOM values were high at Shyampur in river Ganga and Huanl east gad as compared to others. High values were observed during rainy seasons and low during winter months.
- * The high density of benthic fauna was noticed at river Ganga at Shyampur station, as compared in the three tributaries. Among the benthic fauna, *Ephemeropterans* and *Tricopterans* constitute the maximum number, while *Dipterans* and *Crustaceans* contribute the minimum number at all sampling stations. The concentration of benthic fauna decreased during monsoon months.
- * Among the planktons, the Bacillariophyceae and Chlorophyceae constituted the minimum biomass at all sampling stations. Zooplanktons were high in river Ganga at Rishikesh and Shyampur stations.
- * The maximum productivity in terms of GPP and NPP was recorded at Goolar gad in comparison to others. Lowest productivity was observed at Devprayag for river Ganga, during monsoon.
- * The three tributaries of river Ganga harbors 44 species of freshwater teleost.
- * Among the diseases helminthic infections contributed, highest instances of parasitization. A total of about 207 fishes showing disease, is rather a higher proportions.

LANDSLIDES OF SIKKIM AS A FUNCTION OF THEIR AGE

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Sites of study were selected in the East District of Sikkim, viz. Dhanukey, Pacheykhani and Buduney all differing in the termination of their activities by a margin of 10 years. Soil from these landslides were collected by random sampling and was treated for separation of clay fraction, fulvic acid fraction and humic acid fraction. Clay fraction contained mainly chlorite, Illite and Kaolinite. Humic acid fraction was treated with Sephadex and predominant fraction was found to lie in the molecular weight range of 5000-10000.

Chlorite and Kaolinite, available in pure form in the market, were treated to obtain their Na-form in colloidal form of < 2 μm size with the following contents: Na-chlorite = 1.450g / 100ml and Na-kaolinite = 1.648g / 100ml. Na-kaolinite was treated with tetraethylthionine (TET) and Na-chlorite was treated with diquat and paraquat to produce complexes with the following contents:

Na-kaolinite-TET 1,225g / 100ml
 Na-chlorite-diquat 1.814g / 100ml
 Na-chlorite-paraquat 0.882g / 100ml

These were then treated with various organic and inorganic actions to study their capacity. The results are summarised below:

Exchanger	Inorganic ions	Organic ions
Na-kaolinite-TET TBA ⁺ DDP ⁺ <	i. Li ⁺ < Na ⁺ < K ⁺ < NH ₄ ⁺ < Rb ⁺ < Cs ⁺ ii. Mg ²⁺ < Ca ²⁺ < Sr ²⁺ < Ba ²⁺ iii. Co (NH ₃) ₆ ³⁺ < Co (en) ₃ ³⁺ < Co(pn) ₃ ³⁺	i. TMA ⁺ < TEA ⁺ < TPA ⁺ < ii. EDA ²⁺ < PrDA ²⁺ < BuDA ²⁺ iii. DTMA ⁺ < DDTMA ⁺ < TDTMA ⁺ < CTMA ⁺ < CP ⁺
Na-chlorite-diquat TMA ⁺	i. Li ⁺ < Na ⁺ < H ⁺ < K ⁺ < NH ₄ ⁺ < Rb ⁺ < Cs ⁺ ii. Mg ²⁺ < Ca ²⁺ < Sr ²⁺ < Ba ²⁺	i. TBuA ⁺ < TPrA ⁺ < TEA ⁺ < ii. DTA ⁺ < DDTA ⁺ < CTA ⁺ < CP ⁺ iii. EDA ²⁺ < PrDA ²⁺ < BuDA ²⁺
Na-chlorite-paraquat	i. Li ⁺ < Na ⁺ < K ⁺ < NH ₄ ⁺ < Rb ⁺ < Cs ⁺ ii. Mg ²⁺ < Ca ²⁺ < Sr ²⁺ < Ba ²⁺	As above

The process of adsorption of TET onto Na-kaolinite was found to be exothermic.

Water-intake capacity and toluene-intake capacity of the clays of the landslide areas decreased and increased respectively with the introduction of organic molecules in the order of increasing molecular weight.

The extent of binding of metals by humic and fulvic acids followed the order Pb²⁺ > Cu²⁺ > Cd²⁺ > Ca²⁺ whereas the proton releasing tendency due to the interaction of these ions with humic acid followed the other Cu²⁺ > Pb²⁺ > Cd²⁺ > Ca²⁺.

Follow-up Actions:

1. Analysis of landslides all over Sikkim in terms of their clay-mineralogical composition to be done.

2. Treatment of active landslides with large-sized organic cations to examine the effect of their hydrophobic character in lessening the water-absorbing capacity of soil to be studied.
3. The viscosity of landslide clay-minerals under high pressure to be studied to further get an insight into the mechanism of landslide occurrence.

**MASS PROPAGATION OF *DENDROCALAMUS HAMILTONII* AND *D. HOOKERI*
USING SINGLE NODE CUTTING**

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- * There has been an increase in the incidence of flowering in *D. hamiltonii* in these regions.
- * In some cases, a few culms show rejuvenation despite sporadic flowering where the flowering culms get shrivelled up.
- * A functional protocol for *D. hamiltonii* using nodal explants has been developed and tested for application in micropropagation and field transfer.
- * Elimination of shakers for multiple shoot and root induction has been a major accomplishment for reducing the overall cost of production.
- * Protocol is dependent on the rhythmic pattern of seasonal fluctuations and good rates of 'in vitro' proliferation are achieved only during the corresponding favourable seasons *ex vitro*.
- * Callusing and somatic embryogenesis in both the bamboos has resulted in accomplishing greater rates of plant production.
- * A suitable potting mix and poly-tunnels with fogging systems were designed and erected for ensuring acclimatization of bamboos.
- * Tissue culture raised plants of *D. hamiltonii* show faster growth in the fields as compared to the seedlings.