Standard Operating Procedure (SOP)
Agro techniques and market linkages of High Altitude RET (Rare, Endangered and Threatened) Medicinal and Aromatic Plants

NMHS Project: Establishment of Gene Pool, Propagation and Ex-Situ Conservation of selected sensitive high altitude Medicinal and Aromatic plant species and Nature Interpretation Site (NIS) for creating Awareness among the various stakeholders

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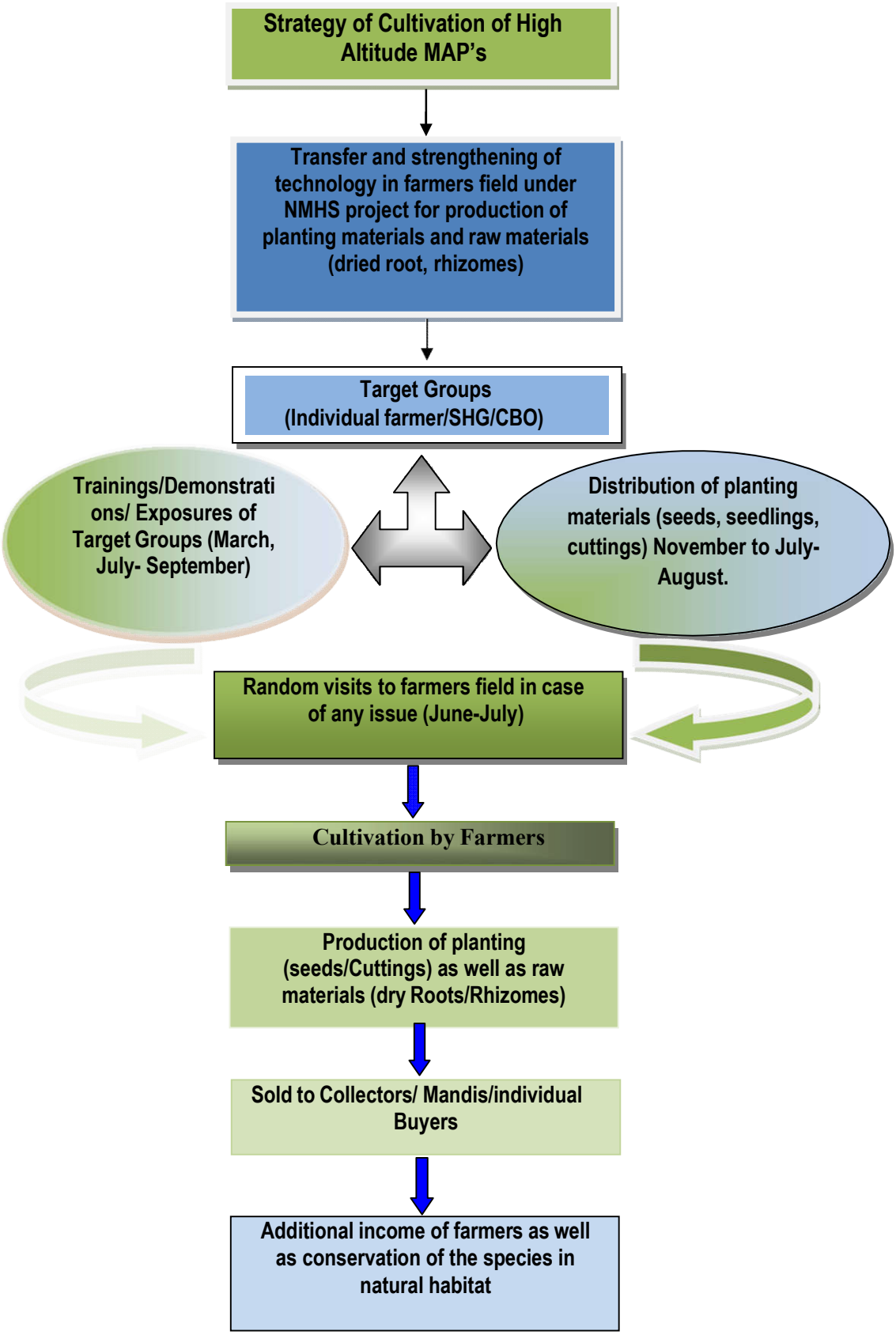
1- *Aconitum heterophyllum* (Atish)

The mentioned high altitude medicinal and aromatic plant species (MAP's) needs great concern for boosting their population in natural habitat and it can only be possible/ achieved by means of cultivation. Since, many of them are near to the range of extinction and if they are not highlightedthey will be certainly moved to the list of extinction in next few years. Hence, the following SOP will be helpful to the high altitude farmers for large scale cultivation of the species in their land/villages. For this, the main step is to find the reliable planting material i.e. seeds/ seedlings/cuttings. Since many of the species, like *Nardostachys grandiflora, Angelica glauca, Aconitum heterophyllum* etc., looses their seed viability quickly and needs proper seed storage.

***Aconitum heterophyllum* (Atish)- It is** Anti-inflammatory, analgesic herb and use against poisoning from scorpion or snakebite etc.
Active content: Atisine, heteratisine, histisine, heterophyllisine, heterophylline,heterophyllidine, atidine, hitidine, etc.
Scientific Name: *Aconitum heterophyllum*
Common Name: Ativisha, Atish
Family: Ranunculaceae
Potency: Cooling & bitter in taste
Habitat: 3000-4000m asl

Strategy (Graph) of Production/Standards of Procedure (SOP)of High Altitude MAPs



Aconitum heterophyllum (Atish) Cultivation Steps

Step 1: Soil Conditions

Well drained loamy soil, pH ranges from 5-5.5, and organic rich soil.

Step 2: Seed collection & Land Area (1 Nali):

13.9 gm of seeds and 2200 seedlings required for 1Nali of land.

Step 3: Planting materials

Quality material on subsidy basis (Research Wing of State Forest Departments, research organisations like HAPPRC, HRDI and from registered farmers of Uttarakhand)

Step 4: Seed sowing

Polyhouse: Inside the Polyhouse during winter months (November and December and during spring months February, March and April.)
Open Field: Open field or nurseries during summer months May and June. To avoid any damage through natural calamities, seeds sowed in open fields or nurseries should be covered with transparent polysheets. It will also help in early germination.

Step 5: Seedling transplantation

Seedlings can be transplanted either after 180 DAG (Days after Germination) or after one year of growth of plants in nurseries especially during monsoon season (July August). Mortality and survivability up to 60-70%.

Step 6: Space between Plants: 30x30 cm^2

Manure requirement (1Nali): Approximate 1-2 quintals dry matter. The forest litter is most appropriate for better growth and insect and pest control. Wet FYM is not recommended for growth/MAPs fields

Step 7: Irrigation

Preferably in day to day basis or condition of the weather (dry & moist) of theplace.

Step 8: Harvesting Time

It is a biennial plant and can be harvested after 3 years of growth (September or early October).

Step 9: Production (After three years)

1-1.5 Kg tubers from 1 Nali of land.
Approx. cost of 1 kg of dry tuber (Current): Rs.10, 000/Kg

Step 10: Cost benefit analysis of *Aconitum hetrophyllum* (Atish)

Seedlings requirement 1 nali of land (no.)	Cost (Rs.) of planting 1nali of land	Cost (Rs.) of cultivation* 1 nail of land for three years	Total investment (Rs.) after three years of cultivation	Approximate production (Kg) of dry tubers 1 nali of land after 03 year	Income from 1 nail of land after 03 years (Rs.)	*Net profit(Rs.) from 1 nali of land after three years

2200	11000 (@Rs. 5/seedlings	10000	21,000	3.5 kg	35000	14000

*Approximate income from 1 Nali/ Year = Rs. 4600

Figure 1. Photographs of different stages of cultivation and production of *Aconitum heterophyllum*. (A)Mature plant, (B) Seeds, (C&D) Seedlings, (E) Cultivation and (F-G) harvestedand dry tubers

2- *Angelica glauca (Choru)*

The mentioned high altitude medicinal and aromatic plant species (MAP's) needs great concern for boosting their population in natural habitat and it can only be possible/ achieved by means of cultivation. Since, many of them are near to the range of extinction and if they are not highlightedthey will be certainly moved to the list of extinction in next few years. Hence, the following SOP will be helpful to the high altitude farmers for large scale cultivation of the species in their land/villages. For this, the main step is to find the reliable planting material i.e. seeds/ seedlings/cuttings. Since many of the species, like *Nardostachys grandiflora, Angelica glauca, Aconitum heterophyllum* etc., looses their seed viability quickly and needs proper seed storage.

***Angelica glauca (Choru)*- It is** Stomachic, carminative, anorexia, digestive, stimulant properties.
Active content: Roots contain 1-1.5% volatile oil, valeric acid, angelic acid and angelisine resin.
Scientific Name: *Angelica glauca*
Common Name: Choru, Gandrayan
Family: Apiaceae
Potency: Warm, bitter-sweet taste
Habitat: 2700-3400m elevation
Status: Rare

Angelica glauca (Choru) Cultivation Steps

Step 1: Soil Conditions

It flourishes on well decomposed soil/ forest litter and drained system with pH ranges from 5-6.5

Step 2: Cultivation & Land Area (1 Nali):

125 gm of seeds and 1600 seedlings.

Seed sowing
Polyhouse: Inside the Polyhouse during winter months (November and December and during spring months February, March and April.)
Open Field: Open field or nurseries during summer months May and June. To avoid any damage through natural calamities, seeds sowed in open fields or nurseries should be covered with transparent polysheets. It will also help in early germination. Do not sow seeds below 1.0 cm depth.
Germination (%):50-60

Step 3: Planting materials

Quality material on subsidy basis (Research Wing of State Forest Departments, research organisations like HAPPRC, HRDI and from registered farmers of Uttarakhand**)**

Step 4: Seedling transplantation

Since this is a deep rooted crop and therefore, transplanting of seedlings at 60- 65 DAG (Days After Germination) is found suitable. Transplanting should be done at the monsoon season (July-August). If seeds geminated during the month of June, then transplantation of the seedlings can be done in the month of last August.

Step 5: Space between Plants: 45x45 cm^2

Manure requirement (1Nali): Approximate 1-2 quintals of dry matter. The forest litter is most appropriate for better growth and insect and pest control. Wet FYM is not recommended for growth/MAPs fields.

Step 6: Irrigation

Randomly or regularly day to day basis at the time of plantations and no need of irrigation during monsoon season. Plants need frequent irrigation inside the polyhouse and greenhouse condition.

Step 7: Harvesting Time

Since this is a perennial crop and therefore, harvesting needs to be done after 3 years of growth. Harvesting of crops preferably done in the month of September and October.

Step 8: Production (After three years)

20 Kg from 1 Nali of land.
Approx. cost of 1Kg of rhizome (Current): Rs.12. 000/Kg

Step 9: Cost benefit analysis of *Angelica glauca (Choru)*

Seedlings requirement 1 nali of land (no.)	Cost (Rs.) of planting 1nali of land	Cost (Rs.) of cultivation* 1 nail of land for three years	Total investment (Rs.) after three years of cultivation	Approximate production (Kg) of dry tubers 1 nali of land after 03 year	Income from 1 nail of land after 03 years (Rs.)	*Net profit(Rs.) from 1 nali of land after three years
1600	12800 (@Rs. 8/ seedlings/plant)	10,000	22,800	25	30000	7,200

* Approximate income from 1 Nali/ Year = Rs. 2400

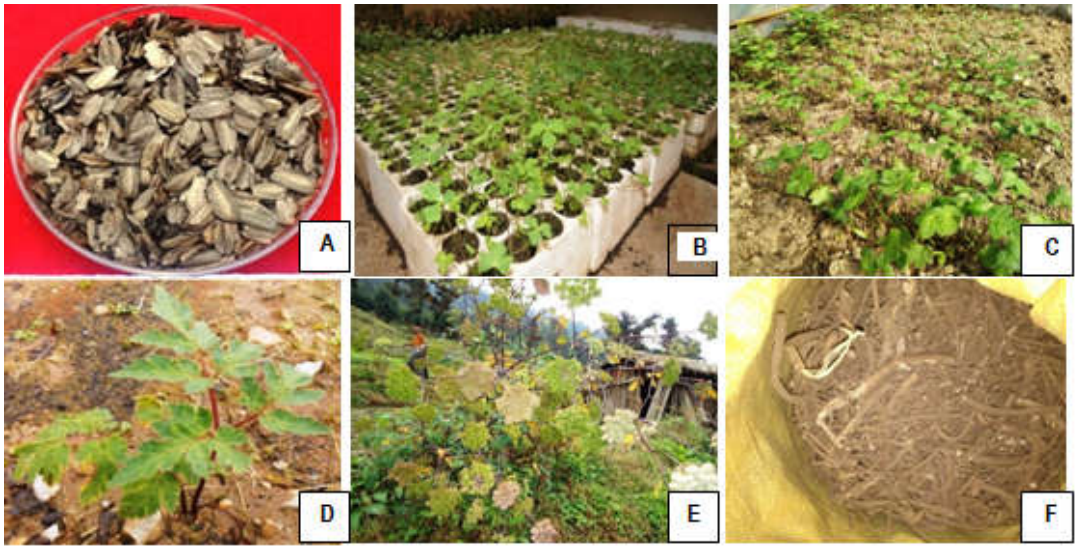


Figure 1. Photographs of different stages of cultivation and production of Angelica glauca A-Seeds, B&C-Seedlings, (D&E)-planatation & cultivation and(F)-harvested rhizomes.

3- *Nardostachys grandiflora (Jatamansi)*

The mentioned high altitude medicinal and aromatic plant species (MAP's) needs great concern for boosting their population in natural habitat and it can only be possible/ achieved by means of cultivation. Since, many of them are near to the range of extinction and if they are not highlightedthey will be certainly moved to the list of extinction in next few years. Hence, the following SOP will be helpful to the high altitude farmers for large scale cultivation of the species in their land/villages. For this, the main step is to find the reliable planting material i.e. seeds/ seedlings/cuttings. Since many of the species, like *Nardostachys grandiflora, Angelica glauca, Aconitum heterophyllum* etc., looses their seed viability quickly and needs proper seed storage.

***Nardostachys grandiflora (Jatamansi)* - It is** Oil is used as perfumery, promote growth of hairs, dhoop making, tonic, stimulant laxative, diuretic, spasdmodic, stomachic etc.
Active content: Jatamansone, jatamansin, jatamansinol, calarene etc.
Scientific Name: *Nardostachys grandiflora*
Common Name: Jatamansi, Mansi, Balchar
Family: Valerianaceae
Potency: Cooling & sweet odorous
Habitat: 3000-5000m
Status: Vulnerable to endangered

***Nardostachys grandiflora (Jatamansi)* Cultivation Steps**

Step 1: Soil Conditions

In natural habitat it mostly grows on inclined slopes where the pH is usually found low from 5-5.5 pH, but it can be easily grown in pH range 5-6.

Step 2: Cultivation & Land Area (1 Nali):

METHOD 1 From Seed

13 gm of seeds and 2200 seedlings.

METHOD 2 From cuttings.

Cutting survival (%): 50-55
Cutting transplantation: During July – August in open fields.

Propagation Means: Seeds, top edge and rhizome cuttings.

Seed sowing
Polyhouse: Inside the Polyhouse during winter months (November and December and during spring months February, March and April.)
Open Field: Open field or nurseries during summer months May and June. To avoid any damage through natural calamities, seeds sowed in open fields or nurseries should be covered with transparent polysheets. It will also help in early germination. Do not sow seeds below 1.0 cm depth.
Germination (%):80-90 under green house and polyhouse condition and 70-80 in open condition.
Seedling survival (%): 50-60%

Step 3: Planting materials

Quality material on subsidy basis (Research Wing of State Forest Departments, research organisations like HAPPRC, HRDI and from registered farmers of Uttarakhand**)**

Step 4: Seedling transplantation

More than 90 days old seeding/ rooted cuttings/ rhizomes in March- April as well as in July-August at 2200 m asl to 3600m asl. Usually shade using green shade net (75%) and slope (30-35^{o}) plays better role for its vegetative and reproductive growth.

Step 5: Space between Plants: 30x30 cm^2

Manure requirement (1Nali): Approximate 3.0 quintals of dry matter. The forest litter is most appropriate for better growth and insect and pest control. Wet FYM is not recommended for growth/MAPs fields.

Step 6: Irrigation

Randomly or regularly day to day basis at the time of plantations and no need of irrigation during monsoon season.

Step 7: Harvesting Time

Since this is a perennial plant and harvesting need to be done after 3 years in vegetatively (rhizome and top edge cuttings) grown crops and after 4-5 years in seeds grown crops. Harvesting of crops preferably done in the month of September or early October.

Step 8: Production (After three years)

22-23 Kg from 1 Nali of land.
Approx. cost of 1Kg of rhizome (Current): Rs.15, 00/Kg

Step 9: Cost benefit analysis of *Nardostachys grandiflora (Jatamansi)*

Seedlings requirement 1 nali of land (no.)	Cost (Rs.) of planting 1nali of land	Cost (Rs.) of cultivation* 1 nail of land for three years	Total investment (Rs.) after three years of cultivation	Approximate production (Kg) of dry tubers 1 nali of land after 03 year	Income from 1 nail of land after 03 years (Rs.)	*Net profit(Rs.) from 1 nali of land after three years
2200	17600 (@Rs. 8/plant)	10,000	27,600	24	36000	8,400

*Approximate income from 1 Nali/ Year = Rs. 5400

Figure 1.Photographs of different stages of cultivation and production of *Nardostachys grandiflora* (A)- Seeds, (B)–seedlings, (C&D)-propagation through top edge Cuttings, (E&F)-Cultivation and (G&H)- harvested rhizomes.

4- *Picrorhiza kurrooa (Kutki)*

The mentioned high altitude medicinal and aromatic plant species (MAP's) needs great concern for boosting their population in natural habitat and it can only be possible/ achieved by means of cultivation. Since, many of them are near to the range of extinction and if they are not highlightedthey will be certainly moved to the list of extinction in next few years. Hence, the following SOP will be helpful to the high altitude farmers for large scale cultivation of the species in their land/villages. For this, the main step is to find the reliable planting material i.e. seeds/ seedlings/cuttings. Since many of the species, like *Nardostachys grandiflora, Angelica glauca, Aconitum heterophyllum* etc., looses their seed viability quickly and needs proper seed storage.

***Picrorhiza kurrooa (Kutki)*- It is** Valiable bitter tonic, antiperiodic,chalagouge, stomatic, laxative.
Active content: Picrotine 1, picrotine 2, kutkin, kurrin, vanillic acid etc.
Scientific Name: *Picrorhiza kurrooa*
Common Name: Kutki, kadwi, kedar Kadwi
Family: Scrophulariaceae
Potency: Cooling & bitter in taste
Habitat: 3000-4000m asl
Status: Rare

***Picrorhiza kurrooa (Kutki*) Cultivation Steps**

Step 1: Soil Conditions

Acidic soil with 5-5.5 pH with adequate water runoff facilities with some slope of 20-30°.

Step 2: Cultivation & Land Area (1 Nali):

METHOD 1 From Seed

13.9 gm of seeds and 2200 seedlings required for 1Nali of land.

Propagation Means: Seeds and stolon cuttings. Stolon cuttings are preferable means in comparison to seeds. Stolon cuttings not only give fast regeneration of plants but also fasten the economic returns to farmers.

METHOD 2 From cuttings.

Cutting: Usually cuttings taken from 1 year old plant is preferable for plantation in the month of July-August or monsoon season. Cuttings 8-10 cm length with more than 5 nodes/internodes or buds can be directly placed in well ploughed soil with an angle of 45˚.
Cutting survival (%): 80-90%during monsoon season.

Seed sowing

Polyhouse: Inside the Polyhouse during winter months (November and December and during spring months February, March and April.)

Open Field: Open field or nurseries during summer months May and June. To avoid any damage through natural calamities, seeds sowed in open fields or nurseries should be covered with transparent polysheets. It will also help in early germination.

Germination (%): 80-90% under irrigated nursery conditions

Seedling survival (%): Usually 50-60%

Step 3: Planting materials

Quality material on subsidy basis (Research Wing of State Forest Departments, research organisations like HAPPRC, HRDI and from registered farmers of Uttarakhand**)**

Step 4: Seedling transplantation

After 60 days of germination/rooting in March-April and July – August at 2000-2500m asl

Step 5: Space between Plants: 30x30 cm^2

Manure requirement (1Nali): Approximate 35 Kgof dry matter. The forest litter is most appropriate for better growth and insect and pest control. Wet FYM is not recommended for growth/MAPs fields.

Step 6: Irrigation

Randomly or regularly day to day basis at the time of plantations and no need of irrigation during monsoon season.

Step 7: Harvesting Time

Since this is a perennial plant and harvesting needs to be done after 3 years in vegetatively (stolon cuttings) grown crops and after 4-5 years in seeds grown crops. Harvesting of crops preferably done in the month of September or early October.

Step 8: Production (After three years)

13-14 Kg tubers from 1 Nali of land.

Approx.Cost of 1 Kg of Stolons or roots (Current): Rs.13,000/Kg

Step 9: Cost benefit analysis of *Picrorhiza kurrooa (Kutki)*

Seedlings requirement 1 nali of land (no.)	Cost (Rs.) of planting 1nali of land	Cost (Rs.) of cultivation* 1 nail of land for three years	Total investment (Rs.) after three years of cultivation	Approximate production (Kg) of dry tubers 1 nali of land after 03 year	Income from 1 nail of land after 03 years (Rs.)	*Net profit(Rs.) from 1 nali of land after three years
2200	2200 (@Rs. 1.0/plant/ cutting)	10000	12,200	22	28600	16,400

*Approximate income from 1 Nali/ Year = Rs. 5400

Figure 1. Photographs of different stages of cultivation and production of *Picrorhiza kurrooa* . (A)-Seeds, (B&C)-Cuttings, (D-E) Cultivations and (F) harvested roots.

5- *Rheum emodi (Archa)*

The mentioned high altitude medicinal and aromatic plant species (MAP's) needs great concern for boosting their population in natural habitat and it can only be possible/ achieved by means of cultivation. Since, many of them are near to the range of extinction and if they are not highlightedthey will be certainly moved to the list of extinction in next few years. Hence, the following SOP will be helpful to the high altitude farmers for large scale cultivation of the species in their land/villages. For this, the main step is to find the reliable planting material i.e. seeds/ seedlings/cuttings. Since many of the species, like *Nardostachys grandiflora, Angelica glauca, Aconitum heterophyllum* etc., looses their seed viability quickly and needs proper seed storage.

***Rheum emodi (Archa)*- It is** Astringent tonic, dyspepsia, healing wounds,cleaning teeth, juice formation etc.
Active content: Emodin, rutin, chrysophanol, and chrysophenic acid etc.
Scientific Name: *Rheum emodi*
Common Name: Gandhini, Revandchini, Archa
Family: Polygonaceae
Potency: Bitter and astringent in taste and odourless
Habitat: 2800-3600m
Status: Rare

***Rheum emodi (Archa)* Cultivation Steps**

Step 1: Soil Conditions

It flourishes well in decomposed soil/ forest litter with pH ranges from 5.5-6.5.

Step 2: Cultivation & Land Area (1 Nali):

115 gm of seeds and 300 seedlings.

Seed sowing:
During winter months seeds are sown inside polyhouse/green house or can also be sown during spring seasons for early growth.
Germination (%):80-90
Seedling survival (%): 60-70%

Step 3: Planting materials

Quality material on subsidy basis (Research Wing of State Forest Departments, research organisations like HAPPRC, HRDI and from registered farmers of Uttarakhand**)**

Step 4: Seedling transplantation

90 days old seedlings can betransplanted in July-August at 2200-2500m.

Step 5: Space between Plants: 75x75 cm^2

Manure requirement (1Nali): At least 3.5 qts, preferably forest litter.

Step 6: Irrigation

Randomly or regularly day to day basis at the time of plantations and no need of irrigation during monsoon season. Plants need frequent irrigation inside the polyhouse and greenhouse condition.

Step 7: Harvesting Time

After 3 years. Harvesting of crops preferably done in the month of September and early October.

Step 8: Production (After three years)

197 Kg from 1 Nali of land.
Approx.Cost of 1 Kg of roots (Current): Rs.250/Kg

Step 9: Cost benefit analysis of *Rheum emodi (Archa)*

Seedlings requirement 1 nali of land (no.)	Cost (Rs.) of planting 1nali of land	Cost (Rs.) of cultivation* 1 nail of land for three years	Total investment (Rs.) after three years of cultivation	Approximate production (Kg) of dry tubers 1 nali of land after 03 year	Income from 1 nail of land after 03 years (Rs.)	*Net profit(Rs.) from 1 nali of land after three years
300	2400 (@ Rs.8/Seedling/ plant)	10,000	12,400	220	55000	42,600

* Approximate income from 1 Nali/ Year =Rs. 14200.

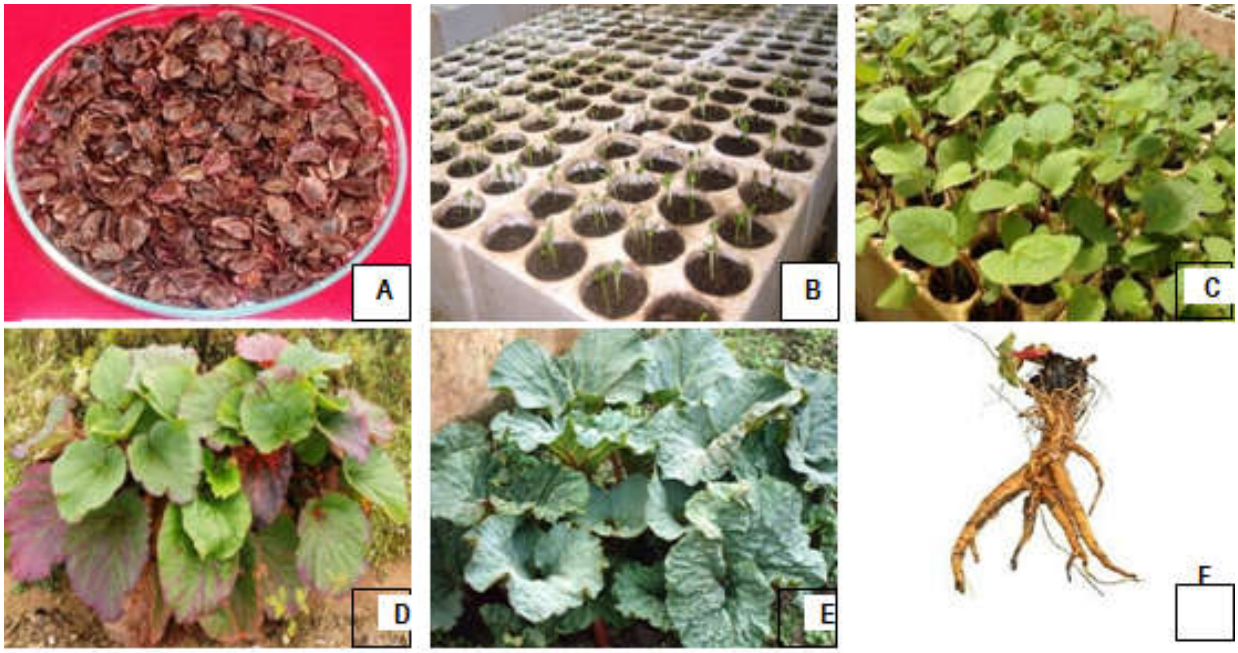


Figure 1. Photographs of different stages of cultivation and production of Rheum emodi. (A)-Seeds, (B&C)-Seedlings, (D-E)-Cultivation and (F)-Harvested roots.