Package of Practices for Organic Production of Crops and Cropping Systems

ICAR-Network Project Organic Farming
SIKKIM

Suggested cropping systems (Based on Testing at Research Farm)

For Rainfed areas
1. Maize (green cobs)-Pahenlo Dal-Buckwheat
2. Maize+Beans- vegetable pea
3. Maize+Beans-Rajmash
4. Maize+Beans-Toria

For Irrigated areas
1. Rice-Vegetable pea-Maize (green cobs)
2. Rice-Fenugreek (leafy vegetable)-Baby corn
3. Rice-Sunflower-\textbf{Dhaincha} (Green Manuring)
4. Rice-Vegetable pea

Details of crops in cropping systems

For rainfed areas

Maize (green cobs)

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Kharif</th>
<th>Rabi</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop</td>
<td>maize</td>
<td>buckwheat</td>
<td>Pahenlo dal</td>
</tr>
<tr>
<td>Fortnight of sowing/planting</td>
<td>April</td>
<td>December</td>
<td>August</td>
</tr>
<tr>
<td>Fortnight of harvesting</td>
<td>July</td>
<td>March</td>
<td>November</td>
</tr>
<tr>
<td>Varieties suitable for organic farming</td>
<td>RCM 1-76 Vivek</td>
<td>Mithey</td>
<td>PD-3</td>
</tr>
<tr>
<td></td>
<td>QPM -9 HQPM-1</td>
<td>PRB-1</td>
<td></td>
</tr>
</tbody>
</table>
### Important features of suitable varieties

<table>
<thead>
<tr>
<th>Parameters</th>
<th>RCM-1-76</th>
<th>Vivek QPM-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (days)</td>
<td>105-110</td>
<td>100-105</td>
</tr>
<tr>
<td>Average yield under organic condition (kg/ha)</td>
<td>6.20 t (green cobs)</td>
<td>7.5 t (green cobs)</td>
</tr>
<tr>
<td>Source(s) of availability</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Suitable regions/districts in the state</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to pest</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to disease</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific tolerance to drought/waterlogging</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

### Cultural practices

<table>
<thead>
<tr>
<th>Seed rate (kg/ha) (not applicable for nursery crops)</th>
<th>20-25 kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-sowing/planting treatment of seed/seedlings (only using organic inputs such as bio-fertilizer, bio-control agents, cow urine, panchagavya, etc.)</td>
<td>Biofertilizer (\textit{Azospirillum} spp.) Phosphobacteria</td>
</tr>
<tr>
<td>- Material</td>
<td>Recommended rate (kg/ha or ltr/ha)</td>
</tr>
<tr>
<td>- Biofertilizer (\textit{Azospirillum} spp.) Phosphobacteria</td>
<td>600 g/ha</td>
</tr>
<tr>
<td>Spacing (row X plant) in cm</td>
<td>50 × 20 cm</td>
</tr>
<tr>
<td>Number of seedling/hill</td>
<td>NA</td>
</tr>
<tr>
<td>Basal application of organic manures including soil</td>
<td>FYM</td>
</tr>
<tr>
<td>- FYM</td>
<td>Quantity/ha</td>
</tr>
<tr>
<td>- Vermicompost</td>
<td>8.0 t/ha</td>
</tr>
<tr>
<td>- Azospirillum spp.</td>
<td>1.0 t/ha</td>
</tr>
<tr>
<td>- PSM</td>
<td>2.0 kg/ha</td>
</tr>
<tr>
<td>- Neem cake</td>
<td>0.5 t/ha</td>
</tr>
<tr>
<td>Top dressing of organic manures (including cow urine/Biodynamic preparation/panchagavya, etc.)</td>
<td>Neem cake</td>
</tr>
<tr>
<td>- Source</td>
<td>Quantity/ha</td>
</tr>
<tr>
<td>- Neem cake</td>
<td>0.5 t/ha</td>
</tr>
<tr>
<td>Irrigation practices</td>
<td>Number of irrigations</td>
</tr>
<tr>
<td>- Most critical stages for irrigation</td>
<td>Days after sowing/planting or stage of crop</td>
</tr>
<tr>
<td>- Depth of irrigation (cm)</td>
<td>-</td>
</tr>
</tbody>
</table>
Crop grown totally under rainfed condition. Therefore no irrigation has been given

<table>
<thead>
<tr>
<th>Weed management</th>
<th>Critical stage of weeding</th>
<th>Recommended practice for organic condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45 days after sowing</td>
<td>Use of weed biomass/ tree leaves mulch between the rows</td>
</tr>
</tbody>
</table>

Organic plant protection practices

<table>
<thead>
<tr>
<th>Name of pest/disease</th>
<th>Recommended organic material/practices used for control</th>
<th>Quantity/ m² area</th>
</tr>
</thead>
</table>

**Diseases:**
- Turcicum leaf blight (Helminthosporium turcicum)
- Maydis leaf blight (Bipolaris maydis)
- Bacterial stalk rot (Erwinia carotovora, Erwinia chrysanthemi)

**Insect pests:**
- Cut worm Stem borer
- Army worm
- Semi-looper and cob borer

Bird damage:
1. Hand picking or trapping of adult moths
2. Crop rotation
3. Change in sowing and harvesting timings
4. Spraying of neem formulations 1500 ppm @3ml/l or spinosad 45SC @ 0.3 ml/l

**Yield**

**Parameters**

| Economic yield (kg/ha) | Average 6.0 t/ha |
Buckwheat (*Rabi*)

Important features of suitable varieties

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mithey</th>
<th>PRB-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (days)</td>
<td>105-110 days</td>
<td>108-115 days</td>
</tr>
<tr>
<td>Average yield under organic condition (kg/ha)</td>
<td>1100 kg</td>
<td>1120 kg</td>
</tr>
<tr>
<td>Source(s) of availability</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Suitable regions/districts in the state</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to pest</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to disease</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific tolerance to drought/waterlogging</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

### Cultural practices

<table>
<thead>
<tr>
<th>Seed rate (kg/ha)</th>
<th>35-40 kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-sowing/planting treatment of seed/seedlings (only using organic inputs such as bio-fertilizer, bio-control agents, cow urine, panchagavya, etc.)</td>
<td>Material Azophos seed treatment+mixed compost+neem cake Or vermicompost</td>
</tr>
<tr>
<td></td>
<td>Recommended rate (kg/ha or l/ha) Azophos @ 800 g/ha 5 t/ha +0.5 t/ha or vermicompost 1.5 t/ha</td>
</tr>
<tr>
<td></td>
<td>Method of application Seed treatment and soil application</td>
</tr>
<tr>
<td>Spacing (row x plant) in cm</td>
<td>30-45cm row to row, 10-15cm plant to plant</td>
</tr>
<tr>
<td>Number of seedling/hill</td>
<td>—</td>
</tr>
<tr>
<td>Basal application of organic manures including soil application of bio-fertilizer, bio-control agents, et. (to be applied before last ploughing)</td>
<td>Source — Quantity/ha</td>
</tr>
<tr>
<td>Top dressing of organic manures (including cow urine/Biodynamic preparation/panchagavya, etc.)</td>
<td>Source — Quantity/ha Days after sowing/planting or stage of crop</td>
</tr>
<tr>
<td>Irrigation practices</td>
<td>Number of irrigations Most critical stages for irrigation Pre-flowering and pod formation stage Depth of irrigation (cm)</td>
</tr>
</tbody>
</table>
**Weed management**

Critical stage of weeding

One weeding and hoeing at 20-25 DAS is helpful for raising a good crop

Recommended practice for organic condition

Crop should be seeded into a fine, firm and weed-free seedbed. Secondly, the seed should be placed into moist soil to ensure quick germination and emergence.

**Organic plant protection practices**

<table>
<thead>
<tr>
<th>Name of pest/disease</th>
<th>Recommended organic material/practices used for control</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diseases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downey mildew</td>
<td>Selection of seeds from disease free plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sowing of healthy seeds and seed treatment with <em>Trichoderma viride</em></td>
<td>4gm/kg of seed</td>
</tr>
<tr>
<td></td>
<td>Soil application of <em>trichoderma viride</em></td>
<td></td>
</tr>
<tr>
<td>Powdery mildew</td>
<td>Sowing of healthy seeds and application of wettable sulfur</td>
<td>0.25%</td>
</tr>
</tbody>
</table>

**Pests**

- Bruchids *(Acanthecelids obtectus)*, grain moth *(Cephitinea spp.)*, cut worm *(Cirphis spp.)*, storage beetles *(Mycetophagus spp.)* and aphids

**Yield**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1125</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic yield (kg/ha)</td>
<td></td>
</tr>
</tbody>
</table>
**Pahenlo dal (Summer)**

**Important features of suitable varieties**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PD-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (days)</td>
<td>115-120 days</td>
</tr>
<tr>
<td>Average yield under organic condition (kg/ha)</td>
<td>650 kg</td>
</tr>
<tr>
<td>Source (s) of availability</td>
<td>—</td>
</tr>
<tr>
<td>Suitable regions/districts in the state</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to pest</td>
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<tr>
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</table>

**Cultural practices**

<table>
<thead>
<tr>
<th>Seed rate (kg/ha) (not applicable for nursery crops)</th>
<th>20-25 kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-sowing/planting treatment of seed/seedlings</td>
<td>Material</td>
</tr>
<tr>
<td>of seed/seedlings (only using organic inputs such as</td>
<td>Recommended rate</td>
</tr>
<tr>
<td>bio-fertilizer, bio-control agents, cow urine,</td>
<td>(kg/ha or lit/ha)</td>
</tr>
<tr>
<td>panchagavya, etc.)</td>
<td>Method of</td>
</tr>
<tr>
<td></td>
<td>application</td>
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<tr>
<td></td>
<td>Seed treatment</td>
</tr>
<tr>
<td></td>
<td>Rhizobium</td>
</tr>
<tr>
<td></td>
<td>400 gram</td>
</tr>
<tr>
<td></td>
<td>PSB (phosphate</td>
</tr>
<tr>
<td></td>
<td>Solubilizing</td>
</tr>
<tr>
<td></td>
<td>Bacteria)</td>
</tr>
<tr>
<td></td>
<td>400 gram</td>
</tr>
<tr>
<td>Spacing (row x plant) in cm</td>
<td>30 x 10 cm</td>
</tr>
<tr>
<td>Number of seedling/hill</td>
<td></td>
</tr>
<tr>
<td>Basal application of organic manures including soil</td>
<td>Source</td>
</tr>
<tr>
<td>application of bio-fertilizer, bio-control agents,</td>
<td>Quantity/ha</td>
</tr>
<tr>
<td>et. (to be applied before last ploughing)</td>
<td>FYM</td>
</tr>
<tr>
<td></td>
<td>5 t/ha</td>
</tr>
<tr>
<td></td>
<td>Vermicompost</td>
</tr>
<tr>
<td></td>
<td>2.5 t/ha</td>
</tr>
<tr>
<td>Irrigation practices</td>
<td>Number of</td>
</tr>
<tr>
<td></td>
<td>irrigations</td>
</tr>
<tr>
<td></td>
<td>Most critical</td>
</tr>
<tr>
<td></td>
<td>stages for irrigation</td>
</tr>
<tr>
<td></td>
<td>Depth of irrigation (cm)</td>
</tr>
<tr>
<td></td>
<td>Pre-flowering stage</td>
</tr>
<tr>
<td>Weed management</td>
<td>Critical stage of weeding</td>
</tr>
<tr>
<td></td>
<td>Recommended practice for organic condition</td>
</tr>
</tbody>
</table>
### Organic Plant Protection Practices

<table>
<thead>
<tr>
<th>Organic plant protection practices</th>
<th>Name of pest/disease</th>
<th>Recommended organic material/practices used for control</th>
<th>Quantity/m² area</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-40DAS</td>
<td>Hand weeding</td>
<td>Farm litter mulch @ 5 t/ha</td>
<td></td>
</tr>
</tbody>
</table>

**Diseases:**
- Anthracnose: Application of wettable sulphur lindemuthianum @0.25%
- Yellow mosaic: Spraying of neem oil
- Rust

**Insect pests:**
- Pod sucking bugs: Spraying of spinosad 45 SC @0.3 ML/L
- Bihar hairy caterpillar: Removal and destruction of early stage larvae

### Yield

**Parameters**

| Economic yield (kg/ha) | 750 |

### Maize+Beans Based Cropping Sequences

#### Land Preparation

- A good seed bed should consist of 5 to 7 cm of fine firm soil that is free from weeds.

- To achieve this fine seedbed, traditional farmer practice is to deep plough immediately after harvest of the kharif/rabi crops. It helps in early sowing of the crop after ploughing the land once or twice followed by one harrowing.

- After harvesting of maize, around 30 per cent residue (maize stalk) should be retained for mulching (conservation agriculture/minimum tillage) in rabi sown crop (Vegetable...
pea), which have the ability to reduce soil temperature, crusting of soil surface, surface evaporation, emergence of weeds, soil erosion, sand-blasting damage to seedlings and improve infiltration rate and finally increased productivity of maize+bean -vegetable pea system.

- Mulching (residue retention of previously harvested crop) has the potential to reduce the risk of crop failure as a result of drought, especially during the winter season.

**Crop (kharif): Maize**

Important features of suitable varieties:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Vivek QPM-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (days)</td>
<td>130-135 days</td>
</tr>
<tr>
<td>Average yield under organic condition (kg/ha)</td>
<td>4200 kg</td>
</tr>
<tr>
<td>Source(s) of availability</td>
<td>—</td>
</tr>
<tr>
<td>Suitable regions/districts in the state</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to pest</td>
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<tr>
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<td>—</td>
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</tbody>
</table>

**Cultural practices**

<table>
<thead>
<tr>
<th>Seed rate (kg/ha) (not applicable for nursery crops)</th>
<th>20-25 kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-sowing/planting treatment of seed/seedlings (only using organic inputs such as bio-fertilizer, bio-control agents, cow urine, panchagavya, etc.)</td>
<td>Material Biofertilizer (Azospirillum spp.) Phospho-bacteria Recommended rate (kg/ha or lit/ha) 600 g/ha</td>
</tr>
<tr>
<td>Spacing (row x plant) in cm</td>
<td>50 × 20 cm</td>
</tr>
<tr>
<td>Number of seedling/hill</td>
<td>NA</td>
</tr>
<tr>
<td>Basal application of organic manures including soil</td>
<td>Source FYM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spacing (row x plant) in cm</th>
<th>50 × 20 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of seedling/hill</td>
<td>NA</td>
</tr>
<tr>
<td>Basal application of organic manures including soil</td>
<td>Source FYM</td>
</tr>
<tr>
<td>Application of bio-fertilizer, bio-control agents, et. (to be applied before last ploughing)</td>
<td>Vermicompost</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Application of Azospirillum spp. PSM</td>
<td>Neem cake</td>
</tr>
<tr>
<td>Top dressing of organic manures (including cow urine/ Biodynamic preparation/ panchagavya, etc.)</td>
<td>Source</td>
</tr>
<tr>
<td>Irrigation practices</td>
<td>Number of irrigations</td>
</tr>
<tr>
<td>Crop grown totally under rainfed condition. Therefore no irrigation has been given</td>
<td></td>
</tr>
<tr>
<td>Weed management</td>
<td>Critical stage of weeding</td>
</tr>
<tr>
<td>Weed management</td>
<td>45 days after sowing</td>
</tr>
<tr>
<td>Organic plant protection practices</td>
<td>Name of pest/ disease</td>
</tr>
<tr>
<td>Diseases:</td>
<td></td>
</tr>
<tr>
<td>Turcicum leaf blight (Helminthosporiumturcicum)</td>
<td></td>
</tr>
<tr>
<td>Maydis leaf blight (Bipolarismaydis)</td>
<td></td>
</tr>
<tr>
<td>Bacterial stalk rot (Erwinia carotovora, Erwinia chrysanthemi)</td>
<td></td>
</tr>
<tr>
<td>Insect pests:</td>
<td></td>
</tr>
<tr>
<td>Cut worm Stem borer Army worm Semi-looper and cob borer Bird damage</td>
<td></td>
</tr>
<tr>
<td>1. Hand picking or trapping of adult months</td>
<td>2. Crop rotation</td>
</tr>
</tbody>
</table>
Yield

**Parameters**

| Economic yield (kg/ha) | 4,100 maize and 1500 kg green pod of cowpea |

Cowpea

**Seed rate:** 35 kg/ha  
**Variety:** Kashi Kanchan  
**Spacing:** 25x10

Rabi crops

<table>
<thead>
<tr>
<th>Cultural practices</th>
<th>Vegetable pea</th>
<th>Rajmash</th>
<th>Toria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation</td>
<td>After harvesting of maize, around 30 per cent residue (maize stalk) should be retained for mulching (conservation agriculture/minimum tillage) in Vegetable pea.</td>
<td>A good seed bed should consist of 5 to 7 cm of fine firm soil that is free from weeds. After harvesting of maize, around 30 per cent residue (maize stalk) should be retained for mulching (conservation agriculture/minimum tillage), which have the ability to reduce soil temperature, crusting of soil surface, surface evaporation, emergence of weeds, soil erosion, sand-blasting damage to seedlings and improve infiltration rate</td>
<td>The land should be well prepared first by 2-3 deep ploughing with soil turning plough, followed by two cross-harrowing after harvesting of maize results in good germination and uniform stand of the crop.</td>
</tr>
<tr>
<td>Organic manure application</td>
<td>Vermicompost or neem cake @ 1.0 t/ha in furrows open for sowing of the seeds.</td>
<td>Apply vermicompost or neem cake @ 1.0 t/ha in furrows open for sowing of the seeds.</td>
<td>Application of mixed compost @ 5 t/ha + vermicompost @ 1.0 t/ha + neem cake @ 1.0 t/ha + dolomite 1.0 t/ha should be applied</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Time of sowing</td>
<td>End of September</td>
<td>End of September</td>
<td>End of September</td>
</tr>
<tr>
<td>Varieties</td>
<td>Kanshi Udai</td>
<td>SKMR-57</td>
<td>M-27, B-9, SYS-1</td>
</tr>
<tr>
<td>Seed rate</td>
<td>100 kg/ha</td>
<td>100kg seed/ha</td>
<td>4 kg seed/ha</td>
</tr>
<tr>
<td>Spacing</td>
<td>30 x 10 cm</td>
<td>30 cm x10</td>
<td>30 cm x 10-15 cm</td>
</tr>
<tr>
<td>Water management</td>
<td>Depending on water availability for good yield applied water at pre-flowering stage</td>
<td>Since Rajmash has been grown as a rainfed crop, hence, proper mulching of maize stalk should be done. If irrigation water is available then apply supplemental irrigation at pre pod formation stage.</td>
<td>Since toria has been grown as a rainfed crop, hence, proper mulching of maize stalk should be done.</td>
</tr>
<tr>
<td>Weed management</td>
<td>The critical period of crop weed competition is 40 days after sowing. One hand weeding, first at 30 DAS</td>
<td>The critical period of crop weed competition is 40 days after sowing. Two hand weeding, first at 15-20 DAS and second at 40-45 DAS should be done to get the optimum yield.</td>
<td>The critical period of crop weed competition is 45 days after sowing. One hand weeding at 15-20 DAS should be done to get the optimum yield. Use of weed biomass/ tree leaves’ mulch between the rows is one of the best alternatives of hand weeding under organic weed management conditions.</td>
</tr>
<tr>
<td>Harvesting</td>
<td>First picking 85-95 days after sowing</td>
<td>85-90 days after sowing</td>
<td>110-115 days after sowing</td>
</tr>
</tbody>
</table>
For Irrigated areas

1. Rice-Vegetable pea-Maize (green cobs)
2. Rice-Fenugreek (leafy vegetable)-Baby corn
3. Rice-Sunflower-Dhaincha (Green Manuring)
4. Rice-Vegetable pea

Land preparation

- The land should be properly prepared with two-three ploughing and uniform levelling with peripheral bund.
- Puddling may be done two-three times to make it weed-free and water retentive.
- Excessive tillage results in degradation of soil quality, causes soil and nutrient loss through erosion during heavy rains and finally leads to yield reduction.
- Organic manures like farmyard manure or composts should be applied about 15 days before transplanting and mixed with the soil during ploughing.

Rice (Kharif)

Important features of suitable varieties

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sasharang</th>
<th>Attey local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (days)</td>
<td>145-155</td>
<td>160-165</td>
</tr>
<tr>
<td>Average yield under organic condition (kg/ha)</td>
<td>4100</td>
<td>2300</td>
</tr>
<tr>
<td>Source (s) of availability</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Suitable regions/districts in the state</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to pest</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific resistance/tolerance to disease</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Specific tolerance to drought/waterlogging</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
### Nursery raising practices (if applicable)

| Area of nursery required for 1 ha | 1000 sq m for dry nursery and wet nursery and 100 sq m for MMN (modified mat nursery) in SRI |
| Nursery raising method | Dry nursery, wet nursery, SRI |
| Bed size (length X breadth in m) | 4-5 cm height and 1-1.5 m in width for dry nursery, keep saturated for few days with water in wet nursery and 4 m wide bed in MMN. |
| Seed sowing rate/m² | 2.5-3.0 in dry, 40-50 in wet and 10 kg/ha in modified SRI |
| Pre-sowing seed/soil treatment (only using organic inputs such as bio-fertilizer, bio-control agents, cow urine, panchagavya, etc.) | Azospirillum 2 kg/ha Phosphate solubilizers 2 kg/ha |
| Source and optimum quantity of organic manures/other nutrient source/m² of nursery | Vermicompost 2 kg Vermicompost |
| Irrigation practices | Manual weeding |
| Organic plant protection practices | Solar seed treatment Seed and seedling treatment with tricoderma |
| Optimum age of nursery (days) | 8-14 days in SRI |

### Cultural practices

| Seed rate (kg/ha) (not applicable for nursery crops) | 60-100 kg/ha for upland condition |
| Pre-sowing/planting treatment of seed/seedlings (only using organic inputs such as bio-fertilizer, bio-control agents, cow urine, panchagavya, etc.) | Material | Recommended rate (kg/ha or lit/ha) | Method of application |
| Azospirillum and phosphate solubilizers | 2kg/ha |
| Azolla | 500kg/ha |
| Azolla is incorporated as green manure before transplanting |
| **Spacing (row × plant) in cm** | 20 × 15 cm |
| **Number of seedling/hill** | 2-3 |
| **Basal application of organic manures including soil** | Source | Quantity/ha |
| **Application of bio-fertilizer, bio-control agents, etc. (to be applied before last ploughing)** | FYM | 15 t/ha |
| | Neem cake | 1.0 t/ha |
| **Top dressing of organic manures (including cow urine, Biodynamic preparation, panchagavya, etc.)** | Source | Quantity/ha | Days after sowing/planting or stage of crop |
| **Irrigation practices** | Number of irrigations | Most critical stages for irrigation | Depth of irrigation (cm) |
| **Weed management** | Critical stage of weeding | Recommended practice for organic condition |
| **Organic plant protection practices** | Name of pest/disease | Recommended organic material/practices used for control | Quantity/ m² area |

**Diseases:**
- Blast
- Brown spot
- Sheath rot
- Sheath blight
- Stem rot
- False smut
- Bacterial leaf blight
- Tungro virus

Deep summer ploughing
Growing tolerant varieties
Crop rotation with oil seeds and pulses
Application of neem cake @ 150kg/ha as basal dose
Spraying neem oilsettig up of light traps
Spray blitox 0.3% at boot leaf stage and 50% at flowering stage.

**Insect pests:**
- Field sanitation,
- Stem borers
- Placement of branches of
(Cnephalocrocis medinalis) Chromoleana odoratum, Schima odoratum, Schima wallichii, Artimisia vulgaris in the field for repelling of insects. Spraying of neem oil 0.03 EC @ 3ml/l at 10 DAT

**Rabi/Summer crops under rice based sequences in irrigated condition**

<table>
<thead>
<tr>
<th>Cultural practices</th>
<th>Vegetable</th>
<th>Fenugreek</th>
<th>Maize green cobs</th>
<th>Baby corn</th>
<th>Sunflower</th>
<th>Dhaincha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation</td>
<td>Zero-tillage</td>
<td>2-3 ploughing</td>
<td>2-3 deep ploughing + 1 tilling</td>
<td>2-3 ploughing + 1 tilling</td>
<td>2-3 ploughing + 1 tilling</td>
<td>One ploughing</td>
</tr>
<tr>
<td>Organic manure application</td>
<td>Vermi-compost @ 1.0 t/ha</td>
<td>FYM @ 10 t/ha or vermi-compost 2 t/ha + neem cake 0.5 t/ha</td>
<td>Mixed compost @ 5 t/ha + vermi-compost @ 1.0 t/ha + neem cake @ 1.0 t/ha + dolomite 1.0 t/ha should be applied</td>
<td>FMY @ 10 t/ha + Vermi-compost @ 2 t/ha</td>
<td>FMY @ 5 t/ha + 1 Poultry Manure + 2 t Vermi-compost/ha</td>
<td>NA</td>
</tr>
<tr>
<td>Time of sowing</td>
<td>November</td>
<td>November</td>
<td>February</td>
<td>February</td>
<td>November</td>
<td>May</td>
</tr>
<tr>
<td>Varieties</td>
<td>Kanshi Udai</td>
<td>Sugandh</td>
<td>HQPM-9</td>
<td>VI-42</td>
<td>DRSH-108</td>
<td>local</td>
</tr>
<tr>
<td>Seed rate</td>
<td>100 kg/ha</td>
<td>40 kg seed/ha</td>
<td>25 kg seed/ha</td>
<td>25 kg/ha</td>
<td>4 kg/ha</td>
<td>45 kg/ha</td>
</tr>
<tr>
<td>Spacing</td>
<td>30×10 cm</td>
<td>20 cm x 10 cm</td>
<td>50 cm x 20 cm</td>
<td>45 cm x 15 cm</td>
<td>60 cm x 30 cm</td>
<td>Broad casting</td>
</tr>
<tr>
<td>Water management</td>
<td>First 45 DAS and second at pod filling stage</td>
<td>Irrigation has been given at 10 interval and just after each cutting</td>
<td>At knee high stage</td>
<td>15-20 DAS and at just at appearance of silking</td>
<td>Three irrigation 1 Bud initiation 2-Flower opening 3- Seed filling</td>
<td>One irrigation</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-------------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Weed management</td>
<td>The critical period of crop weed competition is 40 days after sowing. One hand weeding, first at 30 DAS</td>
<td>Critical crop weed period 30 DAS First weeding</td>
<td>The critical period of crop weed competition is 45 days after sowing. One hand weeding at 15-20 DAS should be done to get the optimum yield. Use of weed biomass/ tree leaves’ mulch between the rows is one of the best alternatives of hand weeding under organic weed management conditions.</td>
<td>Critical crop weed completion period 35 DAS One hand weeding at 20-30 das Weed biomass mulching @ 5 t/ha</td>
<td>Critical crop weed period 30-45 DAS One hand weeding at 30 DAS and mulching of farm litter @ 5 t/ha</td>
<td>NA</td>
</tr>
<tr>
<td>Harvesting</td>
<td>First picking 65-70 DAS First cutting 60 DAS</td>
<td>110-115 days after sowing</td>
<td>First picking started 60 DAS</td>
<td>140 DAS</td>
<td>Incorporation in soil at 60 DAS</td>
<td></td>
</tr>
</tbody>
</table>
## Vegetable cropping systems for low cost plastic tunnels

### 1. Broccoli - spinach - coriander - broccoli - coriander

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/transplanting time</th>
<th>Varieties</th>
<th>Seed rate / ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>First week of May</td>
<td>First week of June</td>
<td>Everest, Aishwarya, TSX-0788 etc</td>
<td>600-700 g</td>
<td>FYM @ 1.5-2.0 kg/m², neem cake @ 200 g/m² and dolomite @ 200 g/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g</td>
</tr>
<tr>
<td>Spinach</td>
<td>-</td>
<td>Third week of September</td>
<td>All Green, Pusa Jyoti etc</td>
<td>15 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 7-10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Leaf should be cut when attains marketable size or at 6-9” height plant should be uprooted.</td>
</tr>
<tr>
<td>Coriander</td>
<td>-</td>
<td>Third week of November</td>
<td>Pant Haritma, Super Midori, Khushboo, Rachna etc</td>
<td>25-30 kg</td>
<td>FYM @ 1.5-2.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 7-10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Harvesting should be done at 6-7” height and whole plant should be uprooted.</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Second week of December</td>
<td>Third week of January</td>
<td>Everest, Aishwarya TSX-0788 etc</td>
<td>600-700 g</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g</td>
</tr>
<tr>
<td>Coriander</td>
<td>-</td>
<td>First week of May</td>
<td>Pant Haritma, Super Midori, Khushboo, Rachna etc</td>
<td>25-30 kg</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Two manual weeding at 17 days interval.</td>
<td>Haresting should be done at 6-7” height and whole plant should be uprooted.</td>
<td></td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and spinach.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnants, stubble, debris etc. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor of the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm etc.
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval. Spraying of Bacillus thuringiensis @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Broccoli

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2).
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Sanitize tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
Drench with copper oxychloride @ 0.25 per cent.

Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (*Rhizoctonia solani)*

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (*Xanthomonas campestris pv. campestris)*

- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

**Spinach**: Major diseases have not been reported in spinach under Sikkim conditions.

**Coriander**

**Powdery mildew (*Erysiphe polygoni)*

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.
2. Broccoli - coriander - cabbage - radish - coriander

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>First week of May</td>
<td>First week of June</td>
<td>Everest, Aishwarya, TSX-0788, etc.</td>
<td>600 - 700 g</td>
<td>FYM @ 1.5-2.0 kg/m², neem cake @ 200 g/m² and dolomite @ 200 g/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g</td>
</tr>
<tr>
<td>Coriander</td>
<td>-</td>
<td>Third week of September</td>
<td>Pant Haritma, Super Midori, Khushboo, Rachna etc.</td>
<td>25-30 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 7-10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Harvesting should be done at 6-7'' height and whole plant should be uprooted.</td>
</tr>
<tr>
<td>Cabbage</td>
<td>First week of October</td>
<td>Third week of November</td>
<td>Rare Ball, Magic Ball, BC-76, Golden Acre, Pragati etc.</td>
<td>500 - 600 g</td>
<td>FYM @ 1.5-2.0 kg/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>40 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvesting should be done when head size: 15-20 cm diameter and weight: 1.5-1.5 kg</td>
</tr>
<tr>
<td>Radish</td>
<td>-</td>
<td>First week of March</td>
<td>Pusa Chetri, Chinese Pink etc.</td>
<td>8-10 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>20 cm row to row, 5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Light irrigation may be given to facilitate lifting of roots.</td>
</tr>
<tr>
<td>Coriander</td>
<td>-</td>
<td>First week of May</td>
<td>Pant Haritma, Super Midori, Khushboo, Rachna etc.</td>
<td>25-30 kg</td>
<td></td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Two manual weeding at 7 days interval.</td>
<td>Harvesting should be done at 6-7'' height and whole plant should be uprooted.</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and radish.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli and cabbage.
- Remove and destroy all the remnants, stubble, debris etc. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm etc.
- Flood the field to check the infestation of red ant and cut worm.
- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval.
- Spraying Bacillus thuringiensis @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Broccoli and cabbage

Club root (Plasmodiophora brassicae)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Plant cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2).
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices since the spores are easily transported through water or wind.
- Sanitize tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
Drench with copper oxychloride @ 0.25 per cent.
Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (*Rhizoctonia solani*)**
- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (*Xanthomonas campestris pv. campestris*)**
- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
- Use resistant varieties of cabbage like Cabaret, Defender, Gladiator, Pusa Mukta.

**Radish:** Major diseases have not been reported under Sikkim conditions.

**Coriander**

**Powdery mildew (*Erysiphe polygoni*)**
- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.
### 3. Coriander - radish - fenugreek - spinach - coriander

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coriander</td>
<td>-</td>
<td>First week of June</td>
<td>Pant Haritma, Super Midori, Khushboo, Rachna</td>
<td>25-30 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² and dolomite @ 200 g/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Two manual weeding at 7 days interval.</td>
<td>Harvesting should be done at 6-7” height and whole plant should be uprooted.</td>
</tr>
<tr>
<td>Radish</td>
<td>-</td>
<td>Third week of July</td>
<td>Pusa Chetki, Chinese Pink etc.</td>
<td>8-10 kg</td>
<td>FYM @ 1.5 -2.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>20 cm row to row, 5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Light irrigation may be given to facilitate harvest of roots.</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>-</td>
<td>First week of October</td>
<td>Local, Pusa Kasuri, Prabha, Sag Kalmi etc.</td>
<td>30-35 kg</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Harvesting should be done at 6-7” height and whole plant should be uprooted.</td>
<td></td>
</tr>
<tr>
<td>Spinach</td>
<td>-</td>
<td>First week of January</td>
<td>All Green, Pusa Jyoti etc.</td>
<td>15 kg</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 7-10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Leaf should be cut when a plant is marketable size or at 6-9” height plant should be uprooted.</td>
<td></td>
</tr>
<tr>
<td>Coriander</td>
<td>-</td>
<td>First week of April</td>
<td>Pant Haritma, Super Midori, Khushboo, Rachna</td>
<td>25-30 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Two manual weeding at 7 days interval.</td>
<td>Harvesting should be done at 6-7” height and whole plant should be uprooted.</td>
</tr>
</tbody>
</table>
Crop protection

**Insect pests management:** Insect pests that cause economic damage have not been reported under Sikkim conditions.

**Disease management**

**Coriander**

**Powdery mildew (Erysiphe polygoni)**

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.

**Fenugreek**

**Powdery mildew (Erysiphe polygoni and Leveillula taurica)**

- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

**Radish:** Major diseases have not been reported under Sikkim conditions.

**Spinach:** Major diseases have not been reported under Sikkim conditions.
### 4. Cabbage - Raya sâg - broccoli - coriander

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>First week of May</td>
<td>First week of June</td>
<td>Golden Acre, Rare Ball, Magic Ball, BC-76, Pragati etc.</td>
<td>500 - 600 g</td>
<td>FYM @ 1.5 -2.0 kg/m², neem cake @ 200 g/m² and dolomite @ 200 g/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>40 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Harvesting should be done when head size: 15-20 cm diameter and weight: 1-1.5 kg</td>
</tr>
<tr>
<td>Raya sâg</td>
<td>Fourth week of August</td>
<td>Fourth week of September</td>
<td>Green leaf or purple leaf type</td>
<td>600 - 700 g</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Multiple leaf cut should be taken when attains marketable size or at 9-12&quot; length.</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Fourth week of November</td>
<td>First week of January</td>
<td>Everest, Aishwarya, TS X-078, etc.</td>
<td>600 - 700 g</td>
<td>FYM @ 1.5 -2.0 kg/m², neem cake @ 200 g/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g</td>
</tr>
<tr>
<td>Coriander</td>
<td>-</td>
<td>Fourth week of April</td>
<td>Pant Haritma, Super Midori, Khushboo, Rachna</td>
<td>25-30 kg</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Two manual weeding at 7 days interval.</td>
<td>Harvesting should be done at 6-7&quot; height and whole plant should be uprooted.</td>
<td></td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and Raya sâg.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of cabbage and broccoli.
- Remove and destroy all the remnants, stubble, debris etc. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm etc.
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval.
- Spraying *Bacillus thuringiensis* @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Cabbage and Broccoli

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
Follow soil conservation practices as the spores are easily transported through water or wind.

- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (Rhizoctonia solani)**

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (Xanthomonas campestris pv. campestris)**

- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25%.
- Provide drainage and free air movement to dry the moisture present on the plants.
Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
Use resistant varieties of cabbage viz., Cabaret, Defender, Gladiator, Pusa Mukta.

**Raya sâg**

**Club root (**Plasmodiophora brassicae**)**
- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Coriander**

**Powdery mildew (**Erysiphe polygoni**)**
- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.
5. Cabbage - spinach - broccoli - coriander

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>First week of May</td>
<td>First week of June</td>
<td>Golden Acre, Rare Ball, Magic Ball, BC-76, Pragati etc.</td>
<td>500 - 600 g</td>
<td>FYM @ 1.5 - 2.0 kg/m², neem cake @ 200 g/m² and dolomite @ 200 g/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>40 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Harvesting should be done when head size: 15-20 cm diameter and weight: 1-1.5 kg</td>
</tr>
<tr>
<td>Spinach</td>
<td>-</td>
<td>Fourth week of September</td>
<td>All Green, Pusa Jyoti etc.</td>
<td>15 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 7-10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Leaf should be cut when attains marketable size or at 6-9' height plant should be uprooted.</td>
</tr>
<tr>
<td>Broccoli</td>
<td>First week of November</td>
<td>Second week of December</td>
<td>Everest, Ashwarya, TS X-0788, etc.</td>
<td>600 - 700 g</td>
<td>FYM @ 1.5 - 2.0 kg/m², neem cake @ 200 g/m² and dolomite @ 200 g/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g</td>
</tr>
<tr>
<td>Coriander</td>
<td>-</td>
<td>Second week of April</td>
<td>Pant Hritma, Super Midori, Khushboo, Ra chna</td>
<td>25-30 kg</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Two manual weeding at 7 days interval.</td>
<td>Harvesting should be done at 6-7'' height and whole plant should be uprooted.</td>
<td></td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management
- No major insect pests have been recorded in coriander and spinach.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnants, stubble, debris etc. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm etc.
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval. Spraying of Bacillus thuringiensis @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Cabbage and broccoli

Club root (Plasmodiophora brassicae)
- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Plant cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with Trichoderma viride @ 4 gm/kg of seeds.
- Drench with copper oxycholoride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (*Rhizoctonia solani*)**
- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (*Xanthomonas campestris* pv. *campestris*)**
- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.

**Spinach:** Major diseases have not been reported in spinach under Sikkim conditions.

**Coriander**

**Powdery mildew (*Erysiphe polygoni*)**
- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.
### Crop Nursery Sowing - transplanting time

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coriander</td>
<td>Plant</td>
<td>First week of June</td>
<td>Pant, Haritma, Super Midori, Khushboo, Rachna</td>
<td>25 - 30 kg</td>
<td>Vermicompost at 0.5-1.0 kg and FYM at 1.5 - 2.0 kg, Neem cake @ 200 g/m² at the time of bed preparation</td>
<td>15-20 cm row to row, 5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Harvesting should be done at 6-7'' height and whole plant should be uprooted.</td>
</tr>
<tr>
<td>Radish</td>
<td>Plant</td>
<td>Second week of July</td>
<td>Pusa Chetki, Chinese Pink</td>
<td>8-10 kg</td>
<td>FYM @ 1.5 - 2.0 kg, Neem cake @ 200 g/m², Light irrigation before harvesting of roots.</td>
<td>20 cm row to row, 5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Harvesting should be done at 6-8'' height, approximate head size: 15-20 cm diameter, weight: 500 g to 1 kg.</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>Plant</td>
<td>Fourth week of September</td>
<td>Local, Pusa Kasuri, Prabha, Sag Kalmi etc.</td>
<td>30 - 35 kg</td>
<td>FYM @ 1.5 - 2.0 kg, Neem cake @ 200 g/m² at the time of bed preparation</td>
<td>15-20 cm row to row, 5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvesting should be done at 6-8'' height, approximate head size: 15-20 cm diameter, weight: 500 g to 1 kg.</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>Plant</td>
<td>First week of November</td>
<td>Suhasini, Snow Ball, Sumedha, Shalaka, Shalaka Kaik, etc.</td>
<td>400 - 500 g</td>
<td>Vermicompost @ 0.5-1.0 kg at the time of bed preparation</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Harvesting should be done at 6-8'' height, approximate head size: 15-20 cm diameter, weight: 500 g to 1 kg.</td>
</tr>
<tr>
<td>Pakchoi</td>
<td>Plant</td>
<td>First week of March</td>
<td>Shuko</td>
<td>400 - 500 g</td>
<td>Vermicompost @ 0.5-1.0 kg at the time of bed preparation</td>
<td>30 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Harvesting should be done at 6-8'' height, approximate plant size: 15-20 cm height, weight: 1 kg.</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- No major insect pests have been recorded in coriander and spinach.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnants, stubble, debris etc. after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm etc.
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval. Spraying of Bacillus thuringiensis @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Coriander

Powdery mildew (*Erysiphe polygoni*)

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
Spray neem seed kernel extract @ 5 per cent.

**Radish:** Major diseases have not been found under Sikkim conditions.

**Fenugreek**

**Powdery mildew (Erysiphe polygoni and Leveillula taurica)**

- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

**Cauliflower and Pakchoi**

**Club root (Plasmodiophora brassicae)**

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and removal of infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (Rhizoctonia solani)**
- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (Xanthomonas campestris pv. campestris)**
- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz*., COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
# Vegetable cropping sequence for low cost plastic rain shelter

## 1. Tomato - tomato - pea

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>First week of March</td>
<td>First week of April</td>
<td>Pusa Ruby, Punjab Chuhara, Romeo, Jessica, Epoch</td>
<td>400 - 500 g</td>
<td>FYM @ 4-5 kg/m², neem cake @ 200 g/m² and diamite @ 200 g/m² at the time of bed preparation.</td>
<td>Planting should be in small pits.</td>
<td>75 cm row to row, 60 cm plant to plant.</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10 days interval. Basin of plants should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.</td>
<td>Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.</td>
</tr>
<tr>
<td>Tomato</td>
<td>Last week of June</td>
<td>Last week of July</td>
<td>Pusa Ruby, Punjab Chuhara, Romeo, Jessica, Epoch</td>
<td>400 - 500 g</td>
<td>FYM @ 4-5 kg/m², neem cake @ 200 g/m² at the time of bed preparation. Seeding root dip with Azospirillum + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m² after two months of transplanting.</td>
<td>Planting should be in small pits.</td>
<td>75 cm row to row, 60 cm plant to plant.</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10 days interval. Basin of plants should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.</td>
<td>Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.</td>
</tr>
<tr>
<td>Pea</td>
<td>-</td>
<td>Third week of November</td>
<td>TSX-10, Pant Sabzi Matar-3, Pusa Pragati, VRP-5, VRP-6, Dentame etc.</td>
<td>100 - 125 kg</td>
<td>FYM @ 1.5-2.0 kg/m³ at the time of bed preparation. Sowing should be done in rows either on ridges, furrows or flat land.</td>
<td>Sowing should be done in rows either on ridges, furrows or flat land.</td>
<td>30 cm x 30 cm and for Dentame 45 cm row to row, 30 cm plant to plant.</td>
<td>Soil kept moist till germination and then irrigate at flowering and pod filling stage.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Multiple harvest of mature green pods with pedicel and minimum disturbance to the plants.</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- White fly, aphids and fruit borer cause economic damage in tomato.
- Use petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato and aphids in pea.
- Regularly monitor, collect and destroy larvae for controlling fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer and pod borer in pea.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

Disease management

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
• When the foliage is wet working in the field should be avoided.
• Use resistant varieties like Arka Rakshak, Arka Samrat.
• Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

Late blight (*Phytophthora infestans*)
• Remove infected plant debris after harvest.
• Crop rotation with non-solanaceous crops.
• Provide sufficient drainage.
• Maintain optimum spacing to allow free air circulation.
• Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

Bacterial wilt (*Pseudomonas solanacearum*)
• Field sanitation and remove infected plants immediately after the appearance of the symptom.
• Crop rotation with non-solanaceous crops.
• Spray copper fungicide Bordeaux mixture @ 1% (10 g CuSO₄ + 10 g lime + 1 l water) or COC @ 0.25 per cent.
• Raise soil pH with dolomite application @ 200 gm/m² and increase the calcium content in the soil.
• Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.
• Apply plant resistance inducer.
• Incorporate *Brassica* spp. at flowering stage as manure.
• Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 l of water) to drench the soil 3 times i.e., at 15, 30 and 45 days after transplanting.
• Flood the field one or two weeks before planting.
• Control root knot nematode to avoid plant injury.
• Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.
Tomato mosaic virus
- Use disease-free seeds.
- Avoid smoking in the field.
- Wash hands with soap and water before and after handling infected plants.
- Avoid the soil in which the previous crop was infected.

Tomato leaf curl (*Tomato leaf curl virus*)
- Remove and destroy infected plants.
- Use yellow sticky traps to monitor and control white flies.
- Apply petroleum oil-based agro spray @ 7 ml/l.
- Remove alternate or collateral hosts.

Tomato spotted wilt virus
- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew
- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Pea

Wilt and Root rot (*Fusarium oxysporum* and *Rhizoctonia solani*)
- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.

● Drench soil with copper oxychloride @ 0.25 per cent.

● Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

**Powdery mildew (Erysiphe polygoni)**

● Late planting should be avoided.

● Remove and destroy plants after harvest.

● The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.

● Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.

● Varieties maturing in January usually escape the maximum intensity of the disease.

● Dusting sulphur @ 25 kg/ha is also recommended.


**Rust (Uromyces fabae)**

● The affected plant trash should be burnt after harvest.

● Follow suitable crop-rotation with non-leguminous crops.

● Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

● Early sowing in the month of October.

● Use resistant varieties *viz.*, Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.
## 2. Bitter gourd/Sponge gourd/Bottle gourd - tomato - pea

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitter gourd/Sponge gourd/Bottle gourd</td>
<td>First week of March</td>
<td>Transplanting first week of April or direct sown in April.</td>
<td><strong>Bitter gourd:</strong> Pusa Vishesh, Arka Harit, Sapan etc.</td>
<td>4.5 kg for all the crops</td>
<td>Vermicompost @ 0.5-1.0 kg/m² and dolomite @ 200 g/m² at the time of bed preparation.</td>
<td><strong>Bitter gourd:</strong> 150 cm x 100 cm</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings or soil is kept moist till germination for direct sowing. Later, irrigate at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use. Staking should be done with bamboo sticks and light pruning should be carried out to remove excessive growth.</td>
<td>Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully from the vine without uprooting or injuring them.</td>
<td></td>
</tr>
<tr>
<td>Sponge gourd</td>
<td></td>
<td></td>
<td><strong>Sponge gourd:</strong> Pusa Chikni, Pusa Nasdar, Aneeta etc.</td>
<td></td>
<td></td>
<td><strong>Sponge gourd:</strong> 150 cm x 100 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottle gourd</td>
<td></td>
<td></td>
<td><strong>Bottle gourd:</strong> Pusa Summer Prolific Long, Pusa Meghdut, Pusa Summer Prolific Round etc.</td>
<td></td>
<td></td>
<td><strong>Bottle gourd:</strong> 200 cm x 150 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td>Last week of June</td>
<td>Last week of July</td>
<td>Pusa Ruby, Punjab Chuhara, Romeo, Jessica, Epoch, Lakshman, Megha Tomato-2, Megha Tomato-3, etc.</td>
<td>400-500 g</td>
<td>FYM @ 4-5 kg/m², neem cake @ 200 g/m² at the time of bed preparation. Seedling root dip with Azospirillum + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m² after two months of transplanting.</td>
<td>Planting should be in small pits.</td>
<td>75 cm row to row, 60 cm plant to plant.</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.</td>
<td>Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.</td>
</tr>
<tr>
<td>Pea</td>
<td>Third week of November</td>
<td></td>
<td>TSX-10, Pant Sabzi Matar-3, Pusa Pragati, VPR-5, VPR-6, Dentame etc.</td>
<td>100 - 125 kg</td>
<td>FYM @ 1.5 - 2.0 kg/m² at the time of bed preparation.</td>
<td>Sowing should be done in rows either on ridges, furrows or flat land.</td>
<td>30 cm x 30 cm for Dentame; Others 45 cm row to row, 30 cm plant to plant.</td>
<td>Soil kept moist till germination and then irrigate at flowering and pod filling stage.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- Fruit fly is the major problem in cucurbits like bottle gourd, sponge gourd, bitter gourd etc.
- Collect fallen infested fruits and destroy the maggots that remain inside fruits for management of fruit fly.
- Install methyl eugenol based para-pheromone traps @ 16-20 traps/ha.
- White fly, aphids and fruit borer cause economic damage in tomato.
- Use petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato and aphids in pea.
- Regularly monitor, collect and destroy larvae to control fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer and pod borer in pea.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

Disease management

Bitter gourd, Sponge gourd and Bottle gourd

Powdery mildew (Podosphaera xanthii and Erysiphe cichoracearum)

- Grow resistant varieties when available (cucumber, muskmelon, and pumpkin).
- Spray wettable sulphur @ 0.25 per cent or neem oil @ 3 per cent or petroleum oil-based agro spray @ 0.7 per cent at the very appearance of the disease.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to powdery mildew.

Downy mildew (Pseudoperonospora cubensis)

- Use resistant cultivars when possible (primarily, cucumber).
● Overhead irrigation should be avoided.

● Preventive spraying with copper oxychloride @ 0.25 per cent.

● Planting early may help to avoid conditions conducive to the disease later in the season.

● Use of bed system with wide spacing with good drainage and air movement and exposure to sun helps to check disease development.

● Bottle gourd variety, N. Shishir (NDBG-202) is resistant to Downy mildew.

● Bitter gourd variety, Phule Green Gold tolerant to Downy mildew.

**Choanephora wet rot (**_Choanephora cucurbitarum_**)

● Plant on raised beds.

● Fruit injury should be prevented.

● Plastic mulches or trellising should be done to avoid direct contact of fruits with soil.

● Harvest fruits at proper stage of maturity.

**Fruit rot (**_Pythium aphanidermatum_**)

● Drench soil with copper oxychloride @ 0.25 per cent.

● Fruits should be kept away from soil.

**Anthracnose (**_Colletotrichum orbiculare_**)

● Sow pathogen-free seed of resistant varieties.

● Crop rotations with unrelated crops for at least two years.

● Good sanitation practices, such as cleaning up crop debris at the end of the growing season should be followed.

● Avoid overhead irrigation.

● Spray copper oxychloride @ 0.25 per cent.

● Bottle gourd variety, N. Shishir (NDBG-202) is resistant to anthracnose.
Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

**Early blight (*Alternaria solani*)**

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

**Late blight (*Phytophthora infestans*)**

- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceous crops.
● Provide sufficient drainage.

● Maintain optimum spacing to allow free air circulation.

● Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

**Bacterial wilt** (*Pseudomonas solanacearum*)

● Field sanitation and remove infected plants immediately after the appearance of the symptom.

● Crop rotation with non-solanaceous crops.

● Spray copper fungicide Bordeaux mixture @ 1% (10 g CuSO₄ + 10 g lime + 1 l water) or COC @ 0.25 per cent.

● Raise soil pH with dolomite application @ 200 gm/m² and increase the calcium content in the soil.

● Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.

● Apply plant resistance inducer.

● Incorporate *Brassica* spp. at flowering stage as manure.

● Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 l of water) to drench the soil 3 times *i.e.*, at 15, 30 and 45 days after transplanting.

● Flood the field one or two weeks before planting.

● Control root knot nematode to avoid plant injury.

● Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.


**Tomato mosaic virus**

● Use disease-free seeds.

● Avoid smoking in the field.
• Wash hands with soap and water before and after handling infected plants.
• Avoid the soil in which the previous crop was infected.

**Tomato leaf curl (Tomato leaf curl virus)**
• Remove and destroy infected plants.
• Use yellow sticky traps to monitor and control white flies.
• Apply petroleum oil-based agro spray @ 7 ml/l.
• Remove alternate or collateral hosts.
• Use resistant varieties viz., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.

**Tomato spotted wilt virus**
• Remove crop debris, weeds and other source of thrips at the end of each crop season.
• Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
• Regularly monitor the tomato field with yellow sticky traps.
• Remove and destroy infected plants.

**Powdery mildew**
• Apply horticultural oil @ 0.7 per cent.
• Improve air circulation by thinning and pruning.
• Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

**Pea**

**Wilt and Root rot (Fusarium oxysporum and Rhizoctonia solani)**
• Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.
- Drench soil with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

**Powdery mildew (Erysiphe polygoni)**

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.

**Rust (Uromyces fabae)**

- The affected plant trash should be burnt after harvest.
- Follow suitable crop-rotation with non-leguminous crops.
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
- Early sowing in the month of October.
- Use resistant varieties *viz.*, Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.
3. Bitter gourd/Sponge gourd/Bottle gourd - capsicum - pea

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<th>Crop</th>
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<th>Varieties</th>
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<tr>
<td>Bitter gourd/ Sponge gourd/ Bottle gourd</td>
<td>First week of March</td>
<td>Transplanting first week of April or direct sown in April</td>
<td>Bitter gourd: Pusa Vishes, Arka Harit, Sapan etc. Sponge gourd: Pusa Chikini, Pusa Nasdar, Aneeta etc. Bottle gourd: Pusa Summer Prolific Long, Pusa Naveen, Pusa Meghdut, Pusa Summer Prolific Round etc.</td>
<td>4-5 kg for all the crops</td>
<td>Vermicompost @ 0.5-1.0 kg/m² and dolomite @ 200 g/m³ at the time of bed preparation.</td>
<td>Planting/ sowing should be in small pits.</td>
<td>Bitter gourd: 150 cm x 100 cm</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings or soil is kept moist till germination for direct sowing. Later irrigate at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use. Staking should be done with bamboo sticks and light pruning should be carried out to remove excessive growth.</td>
<td>Tender green, medium-sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully from the vine without uprooting or injuring them.</td>
</tr>
<tr>
<td>Capsicum</td>
<td>Last week of June</td>
<td>Last week of July</td>
<td>California Wonder, Pusa Deepthi, Bharat, Indra, Orebell, Green Gold etc.</td>
<td>1.0 - 1.5 kg</td>
<td>FYM @ 1.5-2.0 kg/m² at the time of bed preparation and vermicompost @ 0.5-1.0 kg/m² 60 days after transplanting.</td>
<td>Planting should be in small pits.</td>
<td>60 cm row to row, 50 cm plant to plant.</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings. Later irrigate at 15-20 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use.</td>
<td>Tender green, medium-sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully without damaging the plant.</td>
</tr>
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<td>Pea</td>
<td>Third week of November</td>
<td></td>
<td>TSX-10, Pant Sabzi Matar-3 Pusa Pragati, VRP-5, VRP-6, Dentame etc.</td>
<td>100 - 125 kg</td>
<td>FYM @ 1.5-2.0 kg/m² at the time of bed preparation.</td>
<td>Sowing should be done in rows either on ridges, furrows or flat land. Dentame 45 cm row to row, 30 cm plant to plant. Others 30 cm x30 cm</td>
<td>Soil kept moist till germination and then irrigate at flowering and pod filling stage.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.</td>
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Crop protection

Insect pests management

- Fruit fly is the major problem in cucurbits like bottle gourd, sponge gourd, bitter gourd etc.
- Collect fallen infested fruits and destroy the maggots that remain inside fruits for management of fruit fly.
- Install methyl eugenol based para-pheromone traps @ 16-20 traps/ha.
- White fly, aphids and fruit borer cause economic damage in tomato.
- Apply petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato and aphids in pea.
- Regularly monitor, collect and destroy larvae for controlling fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control tomato fruit borer and pod borer in pea.
- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

Disease management

Bitter gourd, Sponge gourd and Bottle gourd

Powdery mildew (*Podosphaera xanthii* and *Erysiphe cichoracearum*)

- Grow resistant varieties when available (cucumber, muskmelon, and pumpkin).
- Spray wettable sulphur @ 0.25 per cent or neem oil @ 3 per cent or petroleum oil-based agro spray @ 0.7 per cent at the very appearance of the disease.
- Bottle gourd variety, N. Shishir (NDBG-202) is resistant to powdery mildew.

Downy mildew (*Pseudoperonospora cubensis*)

- Use resistant cultivars when possible (primarily, cucumber).
- Overhead irrigation should be avoided.
● Preventive spraying with copper oxychloride @ 0.25 per cent.

● Planting early may help to avoid conditions conducive to the disease later in the season.

● Use of bed system with wide spacing with good drainage and air movement and exposure to sun helps to check disease development.

● Bottle gourd variety, N. Shishir (NDBG-202) is resistant to Downy mildew.

● Bitter gourd variety, Phule Green Gold tolerant to Downy mildew

**Choanephora wet rot (Choanephora cucurbitarum)**

● Plant on raised beds.

● Fruit injury should be prevented.

● Plastic mulches or trellising should be done to avoid direct contact of fruits with soil.

● Harvest fruits at proper stage of maturity.

**Fruit rot (Pythium aphanidermatum)**

● Drench soil with copper oxychloride @ 0.25 per cent.

● Fruits should be kept away from soil.

**Anthracnose (Colletotrichum orbiculare)**

● Sow pathogen-free seed of resistant varieties.

● Crop rotations with unrelated crops for at least two years.

● Good sanitation practices, such as cleaning up crop debris at the end of the growing season should be followed.

● Avoid overhead irrigation.

● Spray copper oxychloride @ 0.25 per cent.

● Bottle gourd variety, N. Shishir (NDBG-202) is resistant to anthracnose.
Capsicum

**Anthracnose (Colletotrichum capsici)**

- Use disease-free seeds.
- Collect and destroy infected plant debris.
- Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.
- Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.
- Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.

**Cercospora leaf spot (Cercospora capsici)**

- Remove and burn crop debris.
- Spray copper oxychloride @ 0.25 per cent.
- Adequate spacing should be given to avoid leaf wetness and improve air circulation.

**Damping off (Pythium spp.)**

- Destroy plant debris after harvest.
- Sowing seed on raised beds of 6-8" high (15 cm).
- Use low seed rate of 650 g/cent.
- Crop rotation with non-host crops like mustard.
- Apply well-decomposed FYM.
- Treat nursery soil with *Trichoderma viride* @ 2 per cent.
- Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.
- Water stagnation should be avoided
- Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.

**Phytophthora blight (*Phytophthora capsici*)**
- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.
- Overhead irrigation should be avoided.
- Remove and destroy the infected plant as soon as symptoms appears.
- Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.

**Chilli mosaic (*Chilli mosaic virus*)**
- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

**Leaf curl (*Gemini virus*)**
- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

**Pea**

**Wilt and Root rot (*Fusarium oxysporum and Rhizoctonia solani*)**
- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.
- Drench soil with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

**Powdery mildew (Erysiphe polygoni)**

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.

**Rust (Uromyces fabae)**

- The affected plant trash should be burnt after harvest.
- Follow suitable crop-rotation with non-leguminous crops.
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
- Early sowing in the month of October.
- Use resistant varieties viz., Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.
## Vegetable cropping sequence for low cost polyhouse

### 1. Cucumber - tomato - cabbage (cole crops)

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<tr>
<th>Crop</th>
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</tr>
</thead>
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<tr>
<td>Cucumber</td>
<td></td>
<td>First week of April</td>
<td>Sikkim local,</td>
<td>3-4 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² and dolomite @ 200 g/m² at the time of bed preparation.</td>
<td>Sowing should be done in rows on ridges or on raised bed.</td>
<td>150 cm row to row; 100 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation. Excessive watering should be avoided.</td>
<td>Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking should be done with bamboo sticks and light pruning should be done to remove excessive growth.</td>
<td>Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully from the vine without injuring them.</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>Last week of June</td>
<td>Last week of July</td>
<td>All Rounder,</td>
<td>400 - 500 g</td>
<td>FYM @ 4-5 kg/m² and neem cake @ 200 g/m² at the time of bed preparation. Seedling root dip with Azotobacter + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m² after two months of transplanting.</td>
<td>Planting should be done in rows on raised bed.</td>
<td>100 cm row to row; 75 cm plant to plant</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.</td>
<td>Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Second week of October</td>
<td>Third week of November</td>
<td>Rare Ball, Magic Ball, BC-76, Golden Acre, Pragati etc.</td>
<td>500 - 600 g</td>
<td>FYM @ 1.5-2.0 kg/m² and neem cake @ 200 g/m² at the time of bed preparation. Planting should be done in small pits in rows.</td>
<td>Planting should be done in small pits in rows.</td>
<td>40 cm row to row; 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvesting should be done when head size: 15-20 cm diameter and weight: 1-1.5 kg</td>
</tr>
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</table>
Crop protection

Insect pests management

- Fruit fly is the major problem in cucumber.
- Collect fallen infested fruits and destroy the maggots that remain inside the fruits for management of fruit fly.
- Install methyl eugenol based para-pheromone traps @ 16-20 traps/ha.
- White fly, aphids and fruit borer cause economic damage in tomato. Use petroleum-oil based ago spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato.
- Regularly monitor, collect and destroy the larvae for controlling fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer.
- Installing pheromone trap for mass trapping adult of fruit borers is highly effective.
- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.
- Remove and destroy all the remnant stubble, debris *etc.* after the harvest of the preceding crop.
- Apply well-decomposed FYM.
- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm *etc.*
- Flood the field to check the infestation of red ant and cutworm.
- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.
- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.
Disease management

Cucumber

Fruit rot (*Pythium aphanidermatum*)
- Drench soil with copper oxychloride @ 0.25 per cent.
- Fruits should be kept away from soil.

Anthracnose (*Colletotrichum orbiculare*)
- Use pathogen-free seed of resistant varieties.
- Crop rotations with unrelated crops for at least 2 years.
- Good sanitation practices, such as cleaning up crop debris at the end of the growing season should be followed.
- Avoid overhead irrigation.
- Spray copper oxychloride @ 0.25 per cent.

Tomato

Damping off (*Pythium aphanidermatum*)
- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)
- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
Air circulation should be improved by adopting proper spacing in the field.

Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.

Irrigation should be given early in the day to promote rapid drying of foliage.

Healthy plants with adequate nutrition are less susceptible to the disease.

Minimize plant injury and the spread of spores by controlling feeding by insects.

When the foliage is wet working in the field should be avoided.

Use resistant varieties like Arka Rakshak, Arka Samrat.

Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

**Late blight (Phytophthora infestans)**

Remove infected plant debris after harvest.

Crop rotation with non-solanaceous crops.

Provide sufficient drainage.

Maintain optimum spacing to allow free air circulation.

Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

**Bacterial wilt (Pseudomonas solanacearum)**

Field sanitation and remove infected plants immediately after the appearance of the symptom.

Crop rotation with non-solanaceous crops.

Spray copper fungicide Bordeaux mixture @ 1% (10 g CuSO₄ + 10 g lime + 1 l water) or COC @ 0.25 per cent.

Raise soil pH with dolomite application @ 200 gm/m² and increase the calcium content in the soil.
Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.

Apply plant resistance inducer.

Incorporate *Brassica* spp. at flowering stage as manure.

Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 l of water) to drench the soil 3 times *i.e.*, at 15, 30 and 45 days after transplanting.

Flood the field one or two weeks before planting.

Control root knot nematode to avoid plant injury.

Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.


**Tomato mosaic virus**

Use disease-free seeds.

Avoid smoking in the field.

Wash hands with soap and water before and after handling infected plants.

Avoid the soil in which the previous crop was infected.

**Tomato leaf curl (Tomato leaf curl virus)**

Remove and destroy infected plants.

Use yellow sticky traps to monitor and control white flies.

Apply petroleum oil-based agro spray @ 7 ml/l.

Remove alternate or collateral hosts.

Tomato spotted wilt virus

- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew (*Erysiphe polygoni*)

- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Cabbage

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drenching with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (*Rhizoctonia solani*)**
- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (*Xanthomonas campestris pv. campestris*)**
- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides *viz.*, COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
## 2. Capsicum - Tomato - Broccoli (Cole Crops)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capsicum</td>
<td>First week of March</td>
<td>First week of April</td>
<td>California Wonder, Pusa Deepti, Bharat, Indra, Orebelle, Green Gold etc.</td>
<td>1.0-1.5 kg</td>
<td>FYM @ 1.5-2.0 kg/m² and dolomite @ 200 g/m² at the time of bed preparation and vermicompost @ 0.5-1.0 kg/m² 60 days after transplanting.</td>
<td>Planting should be in rows in small pits.</td>
<td>60 cm row to row, 50 cm plant to plant.</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings. Later, irrigate at 15-20 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use.</td>
<td>Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully without damaging the plant.</td>
</tr>
<tr>
<td>Tomato</td>
<td>Last week of June</td>
<td>Last week of July</td>
<td>All Rounder, Avinash, Naveen, Avatar, Megha Tomato-2, Megha Tomato-3, Lakshman etc</td>
<td>400-500 g</td>
<td>FYM @ 4-5 kg/m², neem cake @ 200 g/m² at the time of bed preparation. Seedling root dip with Azospirillum + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m² after two months of transplanting.</td>
<td>Planting should be in small pits.</td>
<td>100 cm row to row, 75 cm plant to plant.</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.</td>
<td>Tomatoes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Second week of October</td>
<td>Third week of November</td>
<td>Everest, Aishwarya TSX-0788 etc.</td>
<td>600-700 g</td>
<td>FYM @ 1.5-2.0 kg/m², neem cake @ 200 g/m² at the time of bed preparation</td>
<td>Planting should be in small pits.</td>
<td>45 cm row to row, 30 cm plant to plant.</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvest before buds open and bud cluster should be compact. Approx. head size: 15-20 cm diameter, weight: 250-600 g</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- White fly, aphids and fruit borer cause economic damage in tomato. Use petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato.

- Regularly monitor, collect and destroy larvae for fruit borer.

- Spray Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer.

- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.

- Remove and destroy all the remnant stubble, debris etc. after the harvest of the preceding crop.

- Apply well-decomposed FYM.

- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm etc.

- Flood the field to check the infestation of red ant and cutworm.

- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cut worm.

- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval. Spraying of *Bacillus thuringiensis* @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth.

Disease management

Capsicum

**Anthracnose (Colletotrichum capsici)**

- Use disease-free seeds.
Collect and destroy infected plant debris.

Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.

Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.

Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.

Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.

**Cercospora leaf spot (**Cercospora capsici**i)**

Remove and burn crop debris.

Spray copper oxychloride @ 0.25 per cent.

Adequate spacing should be given to avoid leaf wetness and improve air circulation.

**Damping off (**Pythium spp.**)**

Destroy plant debris after harvest.

Sowing seed on raised beds of 6-8" high (15 cm).

Use low seed rate of 650 g/cent.

Crop rotation with non-host crops like mustard.

Apply well-decomposed FYM.

Treat nursery soil with *Trichoderma viride* @ 2 per cent.

Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.

Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.

Water stagnation should be avoided

Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.
Phytophthora blight (*Phytophthora capsici*)

- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.
- Overhead irrigation should be avoided.
- Remove and destroy the infected plant as soon as symptoms appear.
- Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.

Chilli mosaic (*Chilli mosaic virus*)

- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

Leaf curl (*Gemini virus*)

- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
- Provide sufficient drainage to avoid water stagnation.
- Crop rotation with non-solanaceous crops.

Early blight (*Alternaria solani*)

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

**Late blight (Phytophthora infestans)**
- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceaous crops.
- Provide sufficient drainage.
- Maintain optimum spacing to allow free air circulation.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

**Bacterial wilt (Pseudomonas solanacearum)**
- Field sanitation and remove infected plants immediately after the appearance of the symptom.
- Crop rotation with non-solanaceous crops.
- Spray copper fungicide Bordeaux mixture @ 1% (10 g CuSO₄ + 10 g lime + 1 l water) or COC @ 0.25 per cent.
• Raise soil pH with dolomite application @ 200 gm/m² and increase the calcium content in the soil.

• Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.

• Apply plant resistance inducer.

• Incorporate Brassica spp. at flowering stage as manure.

• Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 l of water) to drench the soil 3 times i.e., at 15, 30 and 45 days after transplanting.

• Flood the field one or two weeks before planting.

• Control root knot nematode to avoid plant injury.

• Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.


**Tomato mosaic virus**

• Use disease-free seeds.

• Avoid smoking in the field.

• Wash hands with soap and water before and after handling infected plants.

• Avoid the soil in which the previous crop was infected.

**Tomato leaf curl (Tomato leaf curl virus)**

• Remove and destroy infected plants.

• Use yellow sticky traps to monitor and control white flies.

• Apply petroleum oil-based agro spray @ 7 ml/l.

• Remove alternate or collateral hosts.

• Use resistant varieties viz., Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.
Tomato spotted wilt virus

- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew (*Erysiphe polygoni*)

- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Broccoli

Club root (*Plasmodiophora brassicae*)

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
- Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.
- Drench with copper oxychloride @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (Rhizoctonia solani)**
- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (Xanthomonas campestris pv. campestris)**
- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides viz., COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
### 3. Tomato - capsicum - cauliflower (cole crops)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>First week of March</td>
<td>First week of April</td>
<td>All Rounder, Avinash, Naveen, Avatar, Megha Tomato-2, Megha Tomato-3, Lakshman etc.</td>
<td>400 - 500 g</td>
<td>FYM @ 4-5 kg/m², neem cake @ 200 g/m² and dolomite @ 200 g/m² at the time of bed preparation. Seedling root dip with Azospirillum + PSB (20 %) for 15 minutes. Apply vermicompost @ 0.5-1.0 kg/m² after two months of transplanting.</td>
<td>Planting should be done in rows on raised bed.</td>
<td>100 cm row to row, 75 cm plant to plant</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings and then at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10 days interval. Basin of plant should always be cleaned for better nutrient use. Staking of plants should be done with bamboo sticks.</td>
<td>Toma toes are harvested at mature green stage at four days interval for distant market and pink to light red stage for local market.</td>
</tr>
<tr>
<td>Capsicum</td>
<td>Last week of June</td>
<td>Last week of July</td>
<td>California Wonder, Pusa Deepi, Bharat, Indra, Orebelle, Green Gold etc.</td>
<td>1.0 - 1.5 kg</td>
<td>FYM @ 1.5-2.0 kg/m² and neem cake @ 200 g/m² at the time of bed preparation and vermicompost @ 0.5-1.0 kg/m² 60 days after transplanting.</td>
<td>Planting should be in rows in small pits.</td>
<td>60 cm row to row, 50 cm plant to plant</td>
<td>Manual irrigation at 3-5 days interval for initial establishment of seedlings. Later irrigation at 15-20 days interval or by drip irrigation.</td>
<td>Three manual weeding at 10-15 days interval. Basin of plant should always be cleaned for better nutrient use.</td>
<td>Tender green, medium sized fruits should be harvested at intervals of 3 to 4 days. Fruits should be removed carefully without damaging the plant.</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>Second week of October</td>
<td>Third week of November</td>
<td>Suhasini, Snow Ball, Sumedha, Shalakha, Pusa Katki etc.</td>
<td>400 - 500 g</td>
<td>FYM @ 1.5-2.0 kg/m² and neem cake @ 200 g/m² at the time of bed preparation.</td>
<td>Planting should be in small pits.</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>Manual irrigation at 10-15 days interval or by drip irrigation.</td>
<td>Three manual weeding at 15 days interval.</td>
<td>Harvest curd at compact stage. Approx. head size: 15-20 cm diameter, weight: 500 g to 1.0 kg</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- White fly, aphids and fruit borer cause economic damage in tomato. Use petroleum-oil based agro spray @ 10 ml/l and second spray at 20 days interval to control whitefly and aphids in tomato.

- Regularly monitor, collect and destroy larvae for fruit borer.

- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of tomato fruit borer.

- Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.

- Red ant, cut worm, semi-looper, cabbage butterfly and Diamond back moth are some important pests of broccoli.

- Remove and destroy all the remnant stubble, debris etc. after the harvest of the preceding crop.

- Apply well-decomposed FYM.

- Frequently monitor the field, hand-pick and destroy the larvae of cabbage butterfly, semi-looper, Diamond back moth, cutworm etc.

- Flood the field to check the infestation of red ant and cutworm.

- Apply mixture of water, cow urine and neem oil (8 l + 2 l + 50 ml) @ 100 ml/plant at weekly interval starting from 15 DAT to manage red ant and cutworm.

- If pest population becomes severe, spray neem formulation 1500 ppm @ 3 ml/l and second spray at 15 days interval. Spraying of Bacillus thuringiensis @ 2 g/l checks the population of cutworm, semi-looper and Diamond back moth

Disease management

Tomato

Damping off (*Pythium aphanidermatum*)

- Seed treatment with *Trichoderma viride* @ 4 g/kg seeds.
Provide sufficient drainage to avoid water stagnation.

Crop rotation with non-solanaceous crops.

**Early blight (*Alternaria solani*)**

- Use clean seed for healthy plants.
- Remove and burn crop residues at the end of the season.
- Deep ploughing to expose the disease inoculum to the sun.
- Crop rotation with non-susceptible crops at least for three years.
- Air circulation should be improved by adopting proper spacing in the field.
- Orientation of rows in the direction of prevailing winds, avoid shaded areas, and also avoid wind barriers.
- Irrigation should be given early in the day to promote rapid drying of foliage.
- Healthy plants with adequate nutrition are less susceptible to the disease.
- Minimize plant injury and the spread of spores by controlling feeding by insects.
- When the foliage is wet working in the field should be avoided.
- Use resistant varieties like Arka Rakshak, Arka Samrat.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent at 10 to 15 days interval.

**Late blight (*Phytophthora infestans*)**

- Remove infected plant debris after harvest.
- Crop rotation with non-solanaceous crops.
- Provide sufficient drainage.
- Maintain optimum spacing to allow free air circulation.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.
Bacterial wilt (*Pseudomonas solanacearum*)

- Field sanitation and remove infected plants immediately after the appearance of the symptom.
- Crop rotation with non-solanaceous crops.
- Spray copper fungicide Bordeaux mixture @ 1% (10 g CuSO$_4$ + 10 g lime + 1 l water) or COC @ 0.25 per cent.
- Raise soil pH with dolomite application @ 200 gm/m$^2$ and increase the calcium content in the soil.
- Maintain pH of 6.2-6.5 which is ideal for growing tomatoes.
- Apply plant resistance inducer.
- Incorporate *Brassica* spp. at flowering stage as manure.
- Apply asafoetida-turmeric powder mixture (1 g asafoetida + 5 g turmeric powder in 10 l of water) to drench the soil 3 times i.e., at 15, 30 and 45 days after transplanting.
- Flood the field one or two weeks before planting.
- Control root knot nematode to avoid plant injury.
- Drench with copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

**Tomato mosaic virus**

- Use disease-free seeds.
- Avoid smoking in the field.
- Wash hands with soap and water before and after handling infected plants.
- Avoid the soil in which the previous crop was infected.
Tomato leaf curl (*Tomato leaf curl virus*)
- Remove and destroy infected plants.
- Use yellow sticky traps to monitor and control white flies.
- Apply petroleum oil-based agro spray @ 7 ml/l.
- Remove alternate or collateral hosts.
- Use resistant varieties *viz.*, Arka Shreshta, Arka Samrat, Arka Rakshak, Arka Ananya, Kashi Amrit, Shaktiman, Ananya, Vaibhav, Uttam, NS-510, 524, 534.

Tomato spotted wilt virus
- Remove crop debris, weeds and other source of thrips at the end of each crop season.
- Plough and keep the field fallow for 2-3 weeks before planting to allow the thrips to emerge and disperse.
- Regularly monitor the tomato field with yellow sticky traps.
- Remove and destroy infected plants.

Powdery mildew (*Erysiphe polygoni*)
- Apply horticultural oil @ 0.7 per cent.
- Improve air circulation by thinning and pruning.
- Do not fertilize until the problem is corrected. Powdery mildew favors young, succulent growth.

Capsicum

**Anthracnose (*Colletotrichum capsici*)**
- Use disease-free seeds.
- Collect and destroy infected plant debris.
- Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.
Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.

Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.

Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.

**Cercospora leaf spot (Cercospora capsici)**

- Remove and burn crop debris.
- Spray copper oxychloride @ 0.25 per cent.
- Adequate spacing should be given to avoid leaf wetness and improve air circulation.

**Damping off (Pythium spp.)**

- Destroy plant debris after harvest.
- Sowing seed on raised beds of 6-8" high (15 cm).
- Use low seed rate of 650 g/cent.
- Crop rotation with non-host crops like mustard.
- Apply well-decomposed FYM.
- Treat nursery soil with *Trichoderma viride* @ 2 per cent.
- Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.
- Water stagnation should be avoided
- Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.

**Phytophthora blight (Phytophthora capsici)**

- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.
Overhead irrigation should be avoided.

Remove and destroy the infected plant as soon as symptoms appear.

Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.

**Chilli mosaic (Chilli mosaic virus)**

- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

**Leaf curl (Gemini virus)**

- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

**Cauliflower**

**Club root (Plasmodiophora brassicae)**

- Crop rotation with non-host crops like pulses for minimum of four years.
- Field sanitation and remove infected plants.
- Planting cabbage and other susceptible cruciferous crops in well-drained fields that have pH slightly above neutral (usually about pH 7.2)
- Arrest flow of water from infected field to other field.
- Avoid excess irrigation.
- Follow soil conservation practices as the spores are easily transported through water or wind.
- Clean tools and farm implements used on infected plants.
- Apply dolomite @ 2 t/ha to reduce the soil acidity and increase pH to 7.2 (6 weeks before planting @ 2.5 t/ha).
Treat the seeds with *Trichoderma viride* @ 4 gm/kg of seeds.

Drench with copper oxychloride @ 0.25 per cent.

Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seeds, followed by seedling dip @ 5 g/l and soil application @ 2.5 kg/ha along with 50 kg FYM before planting.

**Wiry stem/Damping off (Rhizoctonia solani)**

- Remove infected plants and burn them.
- Crop rotation with French bean and green peas.
- Apply well-decomposed FYM.
- Destroy plant debris after harvest.
- Treat the nursery soil with *Trichoderma viride* @ 2 per cent.

**Black rot of crucifers (Xanthomonas campestris pv. campestris)**

- Use certified seeds.
- Hot water treatment of seeds at 50°C for 30 min.
- Deep ploughing to bury the crop residue.
- Crop rotation with French bean and green peas.
- Intercultural operations should be avoided when plants are wet.
- Control cruciferous weeds in and around the field.
- Apply copper-based fungicides viz., COC @ 0.25 per cent.
- Provide drainage and free air movement to dry the moisture present on the plants.
- Control cabbage worms, cut worms and root maggots to prevent injury to the crop plants.
### Vegetable cropping sequence for open condition

#### 1. Okra - pea - spinach (leafy vegetables)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okra</td>
<td>Third week of March</td>
<td>Transplant in third week of April or direct sowing in April</td>
<td>Pusa Sawani, Pusa Maik mali, Parbhani, Kranti, Arka Anamika, Bhindi No. 10, Sikkim Local-1 etc.</td>
<td>15 - 20 kg</td>
<td>FYM @ 1.5-2.0 kg/m² mixed with biofertilizer Azospirillum @ 2 kg/ha and dolomite @ 200 g/m² at the time of bed preparation.</td>
<td>Planting / sowing should be done in rows either on ridges or on raised bed. Seed should be treated with Trichoderma viride @ 1 g/kg seed</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>If no rain then manual irrigation at 3-5 days interval for establishment of seedlings or soil should be kept moist till direct sown seed germinates.</td>
<td>Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval.</td>
<td>Regular picking of pods increases the yield. Pods are harvested at about 10 cm length. Delay in harvesting causes fibrous and matured fruits which get lower price in market.</td>
</tr>
<tr>
<td>Pea</td>
<td>First week of November</td>
<td>TSX-10, Pust Sabal Matar-3, Pusa Pragati, VRP-5, VRP-6, Dentame etc.</td>
<td>100 - 125 kg</td>
<td>FYM @ 1.5-2.0 kg/m² at the time of bed preparation.</td>
<td>Sowing should be done in rows either on ridges, furrows or flat land.</td>
<td>30 cm x 30 cm; and for Dentame 45 cm row-row, 30 cm plant to plant.</td>
<td>Soil kept moist till germination and then irrigate at flowering and pod filling stage.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.</td>
<td></td>
</tr>
<tr>
<td>Spinach</td>
<td>Third week of February</td>
<td>All Green, Pusa Jyoti etc.</td>
<td>15 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m² at the time of bed preparation</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 7-10 days interval.</td>
<td>Three manual weeding at 10 days interval.</td>
<td>Leaf should be cut when attains marketable size or at 6-9&quot; height plant should be uprooted.</td>
<td></td>
</tr>
</tbody>
</table>
### 2. Red cherry pepper (dalley) + fenugreek/coriander/spinach (as intercrops)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red cherry pepper</td>
<td>First week of March</td>
<td>Third week of April</td>
<td>Red cherry pepper (dalley)</td>
<td>1.0 - 1.5kg</td>
<td>FYM @ 2-2.5 kg/m² mixed with neem cake @ 2 kg/m² and biofertilizer Azospirillum @ 2 kg/ha and dolomite @ 200 gm² should be applied at the time of planting.</td>
<td>Planting should be done in rows either on ridges or on raised bed. Seedlings root dip with Azospirillum + PSB (20 %) for 15 minutes before planting.</td>
<td>100 cm x 100 cm</td>
<td>If no rain then manual irrigation at 3-5 days interval for establishment of seedlings. Later on crop should be rainfed.</td>
<td>Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval. Mulching with chilai, titepati or plastics is beneficial for weed and disease control.</td>
<td>First picking should be done at green stage to stimulate further flush of flowers and fruit set. Chilli for vegetable purposes is generally harvested at fully grown green stage whereas for dried chilli fruits at ripe stages are ideal.</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>Third week of April</td>
<td></td>
<td>Local, Pusa Kasuri, Prabha, Sag Kalmi etc.</td>
<td>20-25 kg</td>
<td>Not required</td>
<td>Sowing should be done in two rows in between the rows of Red cherry pepper (dalley) plants</td>
<td>15 cm row to row, 3-5 cm plant to plant</td>
<td>If no rain then manual irrigation at 10 days interval.</td>
<td>Manual weeding as per requirement.</td>
<td>Harvesting should be done at 6-7’ height and whole plant should be uprooted.</td>
</tr>
<tr>
<td>Coriander</td>
<td>First week of August</td>
<td></td>
<td>Pant Ha’ritma, Super Midori, Rachna etc.</td>
<td>20-25 kg</td>
<td>Vermicompost @ 0.5-1.0 kg/m²</td>
<td>Sowing should be done in two rows in between the rows of Red cherry pepper (dalley) plants</td>
<td>15 cm row to row, 3-5 cm plant to plant</td>
<td>Rainfed crop</td>
<td>Manual weeding as per requirement.</td>
<td>Harvesting should be done at 6-7’ height and whole plant should be uprooted.</td>
</tr>
<tr>
<td>Spinach</td>
<td>First week of December</td>
<td></td>
<td>All Green, Pusa a Jyoti etc.</td>
<td>10 kg</td>
<td>Not required</td>
<td>Sowing should be done in two rows in between the rows of Red cherry pepper (dalley) plants</td>
<td>15 cm row to row, 3-5 cm plant to plant</td>
<td>If no rain then manual irrigation at 10 days interval.</td>
<td>Manual weeding as per requirement.</td>
<td>Leaf should be cut when attains marketable size or at 6-9’ height plant should be uprooted.</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- Shoot and fruit borer, Jassids, white fly, aphids and Blister beetle are some important pests of okra.
- Install pheromone traps @ 16-20 traps/ha for trapping of *Earias vittella* moths. Replace the lures at 20-25 days interval.
- Two to three sprays of petroleum-oil based agro spray @ 10 ml/l or neem oil (1500 ppm) @ 3 ml/l for management of leaf hopper, white fly, aphids etc. in okra and aphids in pea.
- Blister beetle can be managed by manual collection and destruction and spraying of neem-based formulation @ 3 ml/l or *Beauveria bassiana* @ 5 g/l at the time of flowering.
- Wood ash can also be used to repel the insect.
- White fly, aphids, tea mosquito bug and fruit borer cause economic damage in chilli.
- Use petroleum-oil based agro spray @ 10 ml/l or neem oil (1500 ppm) @ 3 ml/l and second spray at 20 days interval to control whitefly, aphids, tea mosquito bug in Red cherry pepper (dalley).
- Regularly monitor, collect and destroy larvae of fruit borer.
- Spraying Spinosad 45 SC @ 0.3 ml/l and second spray at 20 days interval is effective to control of fruit borer. Installation of pheromone trap for mass trapping of adult of fruit borers is highly effective.
- No major insect pests problem reported in fenugreek, spinach and coriander.

Disease management

Okra

**Yellow Vein Mosaic (Yellow vein mosaic virus)**

- Grow tolerant varieties like Pusa A-4, Arka Abhay, Arka Anamika, Hisar Naveen.
- Grow tolerant varieties like Varsha Uphar, Hisar Unnat, HBH-142 (F1 hybrid), and Azad Bhindi.
The early sown crop is less affected as compared to July sown.

Remove and destroy infected plants.

Use neem oil @ 3 per cent or NSKE @ 5 per cent or petroleum oil-based agro spray @ 7 ml per l of water to control the vector.

**Powdery mildew (Erysiphe polygoni)**

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. The first spray is done after the appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Application of finely ground sulphur @ 30 kg/ha is also found effective.

**Pea**

**Wilt and Root rot (Fusarium oxysporum and Rhizoctonia solani)**

- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.
- Drench soil with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

**Powdery mildew (Erysiphe polygoni)**

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
• Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.

• Varieties maturing in January usually escape the maximum intensity of the disease.

• Dusting sulphur @ 25 kg/ha is also recommended.


Rust (*Uromyces fabae*)

• The affected plant trash should be burnt after harvest.

• Follow suitable crop-rotation with non-leguminous crops.

• Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

• Early sowing in the month of October.

• Use resistant varieties viz., Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.

Red cherry pepper (*Dalley* chillies)

Anthracnose (*Colletotrichum capsici*)

• Use disease-free seeds.

• Collect and destroy infected plant debris.

• Apply Bordeaux mixture @ 1 per cent at 20 days interval commencing from one month after transplanting.

• Spray copper oxychloride @ 2.5 per cent thrice at 15 days interval starting from observing the die-back symptoms.

• Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 2 per cent.

• Use of plant extracts like sweet flag, tulsi and neem oil are reported to control the disease.
Cercospora leaf spot (*Cercospora capsici*)

- Remove and burn crop debris.
- Spray copper oxychloride @ 0.25 per cent.
- Adequate spacing should be given to avoid leaf wetness and improve air circulation.

Damping off (*Pythium spp.*)

- Destroy plant debris after harvest.
- Sowing seed on raised beds of 6-8" high (15 cm).
- Use low seed rate of 650 g/cent.
- Crop rotation with non-host crops like mustard.
- Apply well-decomposed FYM.
- Treat nursery soil with *Trichoderma viride* @ 2 per cent.
- Seed treatment with *Trichoderma viride* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed 24 hours before sowing.
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM.
- Water stagnation should be avoided
- Drench with copper oxychloride @ 2.5 g/lit or Bordeaux mixture @ 1 per cent.

Phytophthora blight (*Phytophthora capsici*)

- Poorly-drained soil and excess watering should be avoided.
- Mulch the soil to avoid direct contact of fruits with soil.
- Overhead irrigation should be avoided.
- Remove and destroy the infected plant as soon as symptoms appears.
- Crop rotation with non-solanaceous crops like cereals, oilseeds and pulses.
Chilli mosaic (*Chilli mosaic virus*)
- Remove and destroy affected plants.
- Use virus-free seedlings.
- Growing barrier crops like maize (2-3 rows) around chillies to reduce the disease incidence.

Leaf curl (*Gemini virus*)
- Remove and destroy affected plants.
- Use neem oil or NSKE @ 0.3 per cent and @ 5 per cent, respectively to control aphids.

Fenugreek

Powdery mildew (*Erysiphe polygoni* and *Leveillula taurica*)
- Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.

Coriander

Powdery mildew (*Erysiphe polygoni*)
- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extracts @ 5 per cent.

**Spinach:** Major diseases have not been found in spinach under Sikkim conditions.
### 3. Okra - garlic

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okra</td>
<td>Transplant in third week of March</td>
<td>April or direct sowing in April</td>
<td>Pusa Sawani, Pusa Makhmal, Parbhani Kranti, Arka Anamika, Bhindi No. 10, Sikkim Local-1 etc.</td>
<td>15 - 20 kg</td>
<td>FYM @ 1.5 - 2.0 kg/m² mixed with biofertilizer Azospirillum @ 2 kg/ha and dolomite @ 200 g/m² at the time of bed preparation.</td>
<td>Planting/ sowing should be done in rows either on ridges or on raised beds. Seed should be treated with Trichoderma viride @ 1 g/kg seed</td>
<td>45 cm row to row, 30 cm plant to plant</td>
<td>If no rain then manual irrigation at 3-5 days interval for establishment of seedlings or soil should be kept moist till seed germinates for direct sowing.</td>
<td>Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval.</td>
<td>Regular picking of pods increases the yield. Pods are harvested at about 10 cm in size. Delay in harvesting causes fibrous and matured fruits which get lower price in market.</td>
</tr>
<tr>
<td>Garlic</td>
<td>First week of November</td>
<td></td>
<td>Agrifound White, Agrifound Parvati, Yamuna Sated, VL Garlic-1, VL Lahsun-2, Sikkim Local garlic</td>
<td>300 - 500 kg</td>
<td>FYM @ 1.5 - 2.0 kg/m² at the time of planting and vermicompost @ 0.5-1.0 kg/m² 60 days after planting.</td>
<td>Planting/ sowing should be done in rows either on ridges or on raised beds.</td>
<td>15 cm row to row, 10 cm plant to plant</td>
<td>Light irrigation at 7-10 days interval. Over watering should be avoided.</td>
<td>Manual weeding should be done at 10-15 days interval.</td>
<td></td>
</tr>
</tbody>
</table>
### 4. Ginger - pea

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties/ cultivars</th>
<th>Seed rate/ ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginger</td>
<td>-</td>
<td>First week of March</td>
<td>Bhaise, Gorubathane, Majhauley etc.</td>
<td>2.0 - 2.5 tonnes</td>
<td>FYM @ 4-5 kg/m² mixed with neem cake @ 2 kg/m² biofertilizer + Azospirillum + PSB @ 5-6 kg/ha and dolomite @ 200 g/m² at the time of planting should be applied in rows.</td>
<td>Healthy medium or small size (40-50 g) rhizomes with two good buds treated with hot water (50°C) and Trichoderma viride @ 2 g/kg rhizome for 30 minutes should be used for planting in rows on raised bed.</td>
<td>30-45 cm row to row and 15-20 cm plant to plant.</td>
<td>Generally irrigation is not required, however, proper drainage should be maintained and avoid waterlogging conditions.</td>
<td>2-3 manual weeding before manuring and first mulching with chilum or têpati at 40-45 days and second at 90 days after planting. Maize should not be grown as an intercrop.</td>
<td>Healthy plants should be selected for seed purpose rhizome and should be harvested first before harvesting rest of the crop.</td>
</tr>
<tr>
<td>Pea</td>
<td>-</td>
<td>Third/fourth week of November</td>
<td>TSX-10, Pant Sabzi Matar-3, Pusa Pragati, VRP-5, VRP-6, Dentame etc.</td>
<td>100 - 125 kg</td>
<td>FYM @ 1.5 - 2.0 kg/m² at the time of bed preparation.</td>
<td>Sowing should be done in rows either on ridges, furrows or flat land.</td>
<td>Dentame 45 cm row to row, 30 cm plant to plant and for others 30 cm x 30 cm</td>
<td>Soil kept moist till germination and then irrigate at flowering and pod filling stage.</td>
<td>Three manual weeding at 10-15 days interval.</td>
<td>Multiple harvesting of mature green pods with pedicel and minimum disturbance to the plants.</td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- Shoot and fruit borer, Jassids, white fly, aphids and Blister beetle are some important pests of okra.
- Install pheromone traps @ 16-20 traps/ha for trapping of *Earias vittella* moths. Replace the lures at 20-25 days interval.
- Give two to three sprays of petroleum-oil based agro spray @ 10 ml/l or neem oil (1500 ppm) @ 3 ml/l for management of leaf hopper, white fly, aphids *etc.* in okra and aphids in pea.
- Blister beetle can be managed by manual collection and destruction and spraying of neem-based formulation @ 3 ml/l or *Beauveria bassiana* @ 5 g/l at the time of flowering.
- Wood ash can also be used to repel the insect.
- No insect pests cause economic damage in garlic.
- In ginger, shoot borer and white grub are major problems.
- Spray neem oil (1500 ppm) @ 3 ml/l at 20 days interval for management of shoot borer and apply *Beauveria bassiana* or *Metarhizium anisopliae* @ 5 kg/ha during field preparation for management of white grub.

Disease management

Okra

Yellow Vein Mosaic (*Yellow vein mosaic virus*)

- Grow tolerant varieties like Pusa A-4, Arka Abhay, Arka Anamika, Hisar Naveen.
- Grow tolerant varieties like Varsha Uphar, Hisar Unnat, HBH-142 (F1 hybrid), and Azad Bhindi.
- The early sown crop is less affected as compared to July sown.
- Remove and destroy infected plants.
Use neem oil @ 3 per cent or NSKE @ 5 per cent or petroleum oil-based agro spray @ 7 ml per l of water to control the vector.

**Powdery mildew (Erysiphe polygoni)**

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. The first spray is done after the appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Application of finely ground sulphur @ 30 kg/ha is also found effective.

**Garlic**

**Damping off (Pythium spp., Phytophthora spp., Rhizoctonia solani, Fusarium spp.)**

- Healthy seed should be selected for sowing.
- The seed should be treated with *Trichoderma viride* @ 4 g/kg of seed before sowing.
- Continuous raising of nursery in the same plot should be avoided.
- Application of bio-control agent *Trichoderma viride* in soil @ 1.2 kg/ha is also found effective to control damping-off to considerable extent.

**Purple blotch (Alternaria porri)**

- Lowering the density of transplanted crops.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent.
- Tolerant varieties viz., Yamuna Safed (G-1), Yamuna Safed-5 (G-189), Pant Lohit.

**Stemphylium blight (Stemphylium vesicarium)**

- Lowering the density of transplanted crops.
- Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 0.1 per cent.
Tolerant varieties viz., Yamuna Safed (G-1), Yamuna Safed-5 (G-189).

**White rot (Sclerotium cepivorum)**

- Seedling dip in *Trichoderma viride*.
- Soil application of *Trichoderma viride* @ 2.5 kg in 50 kg well rotten FYM for 1 ha land.

**Powdery mildew (Leveillula taurica)**

- Spray wettable sulphur solution @ 0.2 per cent.

**Pea**

**Wilt and Root rot (Fusarium oxysporum and Rhizoctonia solani)**

- Early sowing should be avoided to escape from high humidity and high temperature which are congenial for the disease.
- Soil drenching with copper oxychloride @ 0.25 per cent.
- Crop rotation of at least 2-3 years with suitable non-leguminous crops should be followed.

**Powdery mildew (Erysiphe polygoni)**

- Late planting should be avoided.
- Remove and destroy plants after harvest.
- The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. Give the first spray after appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.
- Spraying 10 per cent milk dilution at 10 days interval is effective with modification of pH conditions.
- Varieties maturing in January usually escape the maximum intensity of the disease.
- Dusting sulphur @ 25 kg/ha is also recommended.

Rust (*Uromyces fabae*)

• The affected plant trash should be burnt after harvest.
• Follow suitable crop-rotation with non-leguminous crops.
• Dust sulphur @ 25 kg/ha or spray wettable sulphur @ 0.25 per cent.
• Early sowing in the month of October.
• Use resistant varieties viz., Arka Ajit, Arka Karthik and Arka Sampoorna and moderately resistant, Arka Apoorva.

Ginger

Soft rot (*Pythium aphanidermatum, P. myriotylum and P. vexans*)

• Use disease-free, healthy rhizome for planting.
• Hot water treatment of rhizome at 50°C for 30 min. followed by treatment of the rhizome with *Trichoderma viride* (5 g/lit. water).
• Provide good drainage.
• Apply FYM and other organic manure to increase the population of beneficial microorganisms.
• Bio-fumigation with residues of cruciferous crops like mustard, toria, and rapeseed.
• Apply neem cake @ 2.5 quintals along with *Trichoderma viride* @ 2.5 kg per ha, respectively at the time of planting.
• Immediate removal of the infected plants and drenching with COC @ 0.3 per cent.
• Allow at least three years between the ginger crops planted on the same land.
• Drench with Bordeaux mixture @ 1 per cent or COC @ 0.3 per cent for effective control of the disease.
Bacterial wilt (*Ralstonia solanacearum*)

- Select disease-free or healthy seed rhizomes for sowing.
- Apply FYM and other organic manure to increase the population of beneficial microorganisms.
- Flood the field 2 or 3 weeks before sowing of ginger rhizome.
- Rotation of ginger crop with non-host crops like rice, wheat, maize or green manure crops.
- Solarization of seed rhizomes inside polythene for 2 hours.
- Biofumigation by growing mustard crop and incorporating the crop residues into the field at the flowering stage can also suppress the pathogen.
- Control insects and nematodes by suitable organic pesticides because they serve as carriers of the pathogen and spread to healthy plants while feeding.
- Soil amendment with dolomite to increase the pH of the soil.
- Apply bleaching powder @ 25 kg per ha.
- Provide good drainage since water stagnation predisposes the plant to infection.
- Once the disease is noticed in the field all beds should be drenched with Bordeaux mixture @ 1 per cent.

**Dry rot/yellows/Fusarium wilt (*Fusarium spp.*)**

- Select disease free and healthy rhizome for planting.
- Crop rotation with non-host crops.
- Seed treatment (5 g/1 litre of water) and soil application of *Trichoderma viride* or *T. harzianum* @ 2.5 kg mixed with 50 kg of well rotten FYM for 1 ha.
5. Okra - potato - coriander (leafy vegetables)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nursery sowing</th>
<th>Sowing/ transplanting time</th>
<th>Varieties</th>
<th>Seed rate/ ha</th>
<th>Nutrient management</th>
<th>Method of planting</th>
<th>Spacing (cm)</th>
<th>Water management</th>
<th>Intercultural operation</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okra</td>
<td>Third week of March</td>
<td>Transplant in third week of April or direct sowing in April.</td>
<td>Pusa Sawani, Pusa Makhmali, Parbhani Kranti, Arka Anamika, Bhindi No. 10, Sikkim Local-1 etc.</td>
<td>15 - 20 kg</td>
<td>FYM @ 1.5 - 2.0 kg/m² mixed with biofertilizer Azospirillum @ 2 kg/ha and dolomite @ 200 g/m² at the time of bed preparation.</td>
<td>Planting / sowing should be done in rows either on ridges or on raised beds. Seed should be treated with Trichoderma viride @ 1 g/kg seed.</td>
<td>45 cm row to row, 30 cm plant to plant.</td>
<td>If no rain then manual irrigation at 3-5 days interval for establishment of seedlings or soil should be kept moist till direct seed own germinates.</td>
<td>Crop should be weed free for full season. Manual weeding should be done at 10-15 days interval.</td>
<td>Regular picking of pods increases the yield. Pods are harvested at about 10 cm in size. Delay in harvesting causes fibrous and matured fruits which gets lower price in market.</td>
</tr>
<tr>
<td>Potato</td>
<td>First week of November</td>
<td>Healthy medium or small size sprouted tubers should be used for planting in rows either on ridges or on raised beds.</td>
<td>Healthy medium or small size sprouted tubers should be used for planting in rows either on ridges or on raised beds.</td>
<td>60 cm row to row, 30 cm tuber to tuber</td>
<td>Soil should be kept moist with frequent irrigation in furrows up to 2/3rd height of ridges. Heavy irrigation should be avoided.</td>
<td>Three manual weeding at 10-15 days interval. Deep cultivation is avoided. Earthing up should be done when plants are 15-20 cm tall.</td>
<td>Crop should be harvested 15 days after cutting the haulms when tuber skin is hard enough to withstand handling during harvest and transport from field to store.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coriander</td>
<td>Second week of March</td>
<td>Sowing should be in rows.</td>
<td>Sowing should be in rows.</td>
<td>15-20 cm row to row, 3-5 cm plant to plant</td>
<td>Manual irrigation at 10 days interval. Two manual weeding at 7 days interval.</td>
<td>Harvesting should be done at 6-7&quot; height and whole plant should be uprooted.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Crop protection

Insect pests management

- Shoot and fruit borer, Jassids, white fly, aphids and Blister beetle are some important pests of okra.

- Install pheromone traps @ 16-20 traps/ha for trapping of *Earias vittella* moths. Replace the lures at 20-25 days interval.

- Give two to three sprays of petroleum-oil based agro spray @ 10 ml/l or neem oil (1500 ppm) @ 3 ml/l for management of leaf hopper, white fly, aphids *etc.* in okra and aphids in pea.

- Blister beetle can be managed by manual collection and destruction and spraying of neem-based formulation @ 3 ml/l or *Beauveria bassiana* @ 5 g/l at the time of flowering.

- Wood ash can also be used to repel the insect.

- Cutworms, Red ant and aphids cause economic damage in potato.

- Crop should be rotated with suitable non-host crop *viz.*, rice and apply well-decomposed FYM for cut worm.

- Light traps should be laid in the fields to capture adults.

- Drenching of the base of the crop with neem oil (1500 ppm) @ 5 ml/l for cut worm and red ant.

- Two sprays of petroleum-oil based agro spray @ 10 ml/l or neem oil 0.15 EC (1500 ppm) @ 3 ml/l at 20 days interval is found effective against aphids in potato and pea.

Disease management

Okra

Yellow Vein Mosaic (*Yellow vein mosaic virus*)

- Grow tolerant varieties like Pusa A-4, Arka Abhay, Arka Anamika, Hisar Naveen.
● Grow tolerant varieties like Varsha Uphaar, Hisar Unnat, HBH-142 (F1 hybrid), and Azad Bhindi.

● The early sown crop is less affected as compared to July sown.

● Remove and destroy infected plants.

● Use neem oil @ 3 per cent or NSKE @ 5 per cent or petroleum oil-based agro spray @ 7 ml per l of water to control the vector.

**Powdery mildew (Erysiphe polygoni)**

● Late planting should be avoided.

● Remove and destroy plants after harvest.

● The disease can be controlled by two to three sprays of wettable sulphur compounds like Sulfex @ 3 kg per ha in 1000 liters of water. The first spray is done after the appearance of the disease in the crop. The second spray should be done 14 days after the first spray and the third spray only if there is a need for it.

● Application of finely ground sulphur @ 30 kg/ha is also found effective.

**Potato**

**Late blight (Phytophthora infestans)**

● It can be managed by adopting preventive measures viz., sprays of Blitox @ 5.0 g/l or Phytolan @ 2.5 g/l at 15 days interval.

● Use potato tubers for seed from disease-free areas to ensure that the pathogen is not carried through seed tuber.

● Remove and destroy infected plant material in the field.

Early blight (*Alternaria solani*)

- Crop rotation should be followed for 2-3 years with non-solanaceous crops to avoid the disease incidence since the pathogen is soil-borne.
- Diseased plants should be uprooted and burnt just after detection in the field.
- Dead haulms should also be raked and burnt after harvest.
- Moderately resistant varieties are Kufri Naveen, K. Sindhuri and K. Jeevan. Hybrid 66-528/8 (*Solanum tuberosum* x *S. andigena*) is a source of high resistance to early blight.
- Spray copper oxychloride @ 0.25 per cent and Bordeaux mixture @ 1.0 per cent at 15 days interval control the disease.

Brown rot (*Ralstonia solanacearum*)

- Use disease-free seeds.
- Field sanitation.
- In case cut potato tubers are being used, they should be kept at 12°C for four days so that the cut surface hardens.
- Sow in disease-free field.
- Crop rotation with non-solanaceaous crop.
- Regular cleaning and disinfection all machinery, equipments and containers.
- Soil application of bleaching powder @ 12 kg per ha at the time of planting.

Coriander

**Powdery mildew (Erysiphe polygoni)**

- Use sulphur dust @ 20-25 kg per ha.
- Spray wettable sulphur @ 0.25 per cent.
- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg and foliar spray of *Pseudomonas fluorescens* @ 2 g/lit.
- Spray neem seed kernel extract @ 5 per cent.
Organic fruit production techniques

Sikkim is endowed with varied agro-climatic conditions suitable for the cultivation of large number of sub-tropical and temperate fruits. Horticultural crops occupy substantial portion of area and contribute more than 25-30% of the gross value of agricultural output of the country. Fruits are important sources of minerals and vitamins and provide part of the calorie requirement in the daily diet of the people. They also provide most of the food roughage, which contributes to the prevention of disorders of the digestive system. The nutritional status of diet is on a declining trend due to low intake of fruits. The increased production and intake of fruits by the people will help compensate for debilitating nutritional deficiencies. Fruit crop diversification is an important step for sustainable economic growth. As the economy grows, there is a gradual movement from subsistence food-crop production to a diversified market-oriented production system. Therefore, integrated development of organic horticulture is essential to improve the overall growth of the region. Emphasis should be laid on economically desirable crop intensification and increasing the production of fruits. The new concept of high density planting is highly suitable to Sikkim where land is a limitation and even small and marginal farmers can allocate certain portion of their land for cultivation of fruit crops especially mandarin, guava, papaya, pomegranate, pear, walnut etc. In Sikkim, many fruit crops can be grown at various altitudes, the altitudinal suitability for subtropical and temperate fruits in Sikkim are given in Table 1.

<table>
<thead>
<tr>
<th>Altitude</th>
<th>Suitable fruit crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower hills (300-900 m)(with chilling</td>
<td>Sikkim mandarin, guava, papaya, banana,</td>
</tr>
<tr>
<td>temperatures up to 500 hrs)</td>
<td>pomegranate, etc.</td>
</tr>
<tr>
<td>Mid hills (900-1800 m)(fruits with moderate chilling requirements i.e., 500 - 1000 hrs)</td>
<td>Sikkim mandarin up to 1600 m, Pear (Asian and Japanese pears), litchi, kiwifruit and walnut</td>
</tr>
<tr>
<td>High hills (1800-2500 m)(fruits with sufficient chilling requirements i.e., &gt; 1000 hrs)</td>
<td>Pears (European type), kiwifruit</td>
</tr>
</tbody>
</table>

The brief crop-wise details of fruit crops’ cultivation is given in the following pages.

**Sikkim mandarin (Citrus reticulata Blanco.)**

1. **Land preparation**

   - The land for planting mandarin should be well ploughed and all weeds should be removed.
The rows should be oriented in north-south direction to maximize the use of sunlight.

- Pits of 3’ x 3’ x 3’ (length, width and depth, respectively) are dug and refilled with the top 1½’ soil, mixed with 20-25 kg of well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. **Time of planting**

- In Sikkim, planting is done after the first monsoon rains during June-July.

3. **Method of planting**

- Sikkim mandarin is recommended to be planted at a distance of 5 m x 5 m on terraces in contour system of plantation. Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. **Cultivars/varieties:** Sikkim mandarin

5. **Organic nutrient management**

- Bearing mandarin plants should be manured twice in a year *i.e.*, June-July and after harvesting in December-January.

- During 1-7 years age, FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied.

- After seven years, 25-50 kg FYM/tree and/or 15-30 kg vermicompost/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.

- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.

- Micronutrients are essential for proper growth and fruiting in mandarin and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.

- Soil amendment such as dolomite @ 100-200 g/plant may be applied every second year based on soil test values to maintain the soil pH.

- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.
6. **Intercropping**

- Commercial fruit bearing in Sikkim mandarin orchard generally starts after 5 to 6 years; until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, beans, French bean, gram, and leafy vegetables, root vegetables *etc.*, or any other traditional crop in rotation.

- Exhaustive crops *viz.*, maize, ginger *etc.* which drain the essential nutrients and moisture quickly from the field should be avoided as intercrops.

- Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. **Water management**

- Mandarin requires protective irrigation in the first year during winter and summer. Irrigation improves the plant growth, flowering and fruiting in mandarin.

- Irrigation of orchards at every 10 to 15 days interval from November to February promotes heavy flush in March-April followed by good flowering and fruit-set.

- The young and bearing plants should be irrigated by basin or ring system. Drip system of irrigation can also be used for the conservation of water especially during winter.

8. **Weed management**

- Frequent hoeing, hand-weeding and light tillage are essential in reducing the weed growth and maintain porosity and tilth especially during summer season.

- Hand-weeding should be done carefully to avoid injury to the roots.

- Ploughing, spading of basins, weed control, *etc.* are important inter-cultural operations for soil aeration and tree health.

9. **Training and pruning**

- Trees are trained to single stem with 4-6 well-spaced branches for making the basic framework. Further, the lowest branches should not be below 50 cm.

- The best time of pruning of bearing trees is when these trees are dormant *i.e.*, should be performed after harvest during late winter or early spring.
• The centre of the plant should remain open. Branches should be well-distributed on all sides. Cross-twigs and water suckers are to be removed early. All diseased, injured and drooping branches and deadwood are to be removed periodically.

10. Mulching

• Mulching is essential to avoid weed problem in the field during rainy season and also for moisture conservation during winter season.

• Mostly, leaf mulch is recommended for mandarin plantations. The best mulching material in Sikkim is *Schima wallichii* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*), which minimize some disease problems also.

11. Crop protection

Insect pests management

• Clean trunk and apply Bordeaux paste in April from the base of the trunk up to 1 m height.

• Frequent monitoring of the orchard.

• Two sprays of petroleum-oil based agro spray @ 10 ml/l during April-May for control of aphids and leaf miner and one spray of *Bacillus thuringiensis* @ 2 g/l when infestation of lemon butterfly is observed is recommended.

• Cleaning of infested plants and insertion of iron wire to kill the larvae and insertion of cotton soaked in petrol or kerosene in to the holes followed by plastering with soil and cow dung mixture is recommended for management of trunk borer and bark eating caterpillar.

• September onwards install methyl eugenol-based para pheromone traps to manage fruit fly.

• The dropped infested fruits should be collected on community basis and must be either buried under the soil or destroyed by keeping in hot water to reduce the infestation of fruit fly.

• During August-September spray of petroleum-based oil agro spray @ 10 ml/l should also be done in case of occurrence of aphids and leaf miner and one spray of *Bacillus thuringiensis* @ 2 g/l when the infestation of lemon butterfly is observed.

• Yellow colour trap can be installed in the field throughout the year to trap the population of aphids, leaf miner and psylla.
Disease management

Gummosis or Foot rot (*Phytophthora* spp.)

- Follow ring system of irrigation by heaping the earth around the tree trunk.
- Provide an inner ring of about 45 cm around the tree trunk to prevent water logging. (double ring method of irrigation).
- Select disease-free saplings.
- Bud union should be kept 15-20 cm above the ground level.
- Good drainage should be provided.
- Injury to the root should be avoided.
- Apply recommended dose of FYM and other organic manures.
- Treat soil with *Trichoderma harzianum* @ 2 per cent.
- Diseased and dead bark of the tree trunk should be scraped with sharp knife and Bordeaux paste or ZnSO$_4$ : CuSO$_4$ : lime (5:1:4) should be applied on tree trunk up to 45-60 cm.
- Drenching with Bordeaux mixture @ 1 per cent or COC @ 0.25 per cent.
- Drench soil with 0.5 per cent *Trichoderma viride*. Commercial formulation is also effective.
- Sprout removal and pruning are best done only in dry weather.

Powdery mildew (*Acrosporium tingitanium*)

- Apply wettable sulphur @ 0.2 per cent.
- Remove water shoots.
- Remove affected plant parts.

Scab (*Elsinoe fawcetti*)

- Remove and destroy infected parts.
Apply Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.3 per cent at 15 days interval.

**Greasy spot** or **Black melanose** (*Mycospherella citri*)

- Spray copper oxychloride @ 0.3 per cent during new flush formation and the spray should be carried out under the leaf surface.
- Remove severely infected twigs.

**Twig blight or Die back** (*Diplodia natalensis* and *Colletotrichum gloeosporioides*)

- Spray copper oxychloride @ 0.25 per cent during new flush formation and the spray should be carried out under the leaf surface.
- Remove severely infected twigs.
- Twig blight or wither tip or dry-up twigs can be effectively managed by pruning during January/February followed by two sprays with @ 0.25 per cent at 30 days interval.

**Citrus greening** (*Candidatus liberibacter* var. *asiaticus*)

- Remove, uproot infected plants and burn.
- Control insect vector (psyllid) using petroleum oil-based agro spray @ 0.7 per cent or NSKE @ 5 per cent or neem oil @ 0.3 per cent.

**Quick decline/Citrus Tristeza** (*Citrus tristeza virus*)

- Select seedlings from disease-free field.
- Infected trees should be removed.
- Use tolerant rootstocks for grafting like Rangpur lime, Jattikhatti, Cleopatra mandarin and Citranges.
- CTV is not seed-borne, so nucellar seedlings are free from the disease.
- Control insect vectors using petroleum oil-based agro spray @ 0.7 per cent or NSKE @ 5 per cent or neem oil @ 0.3 per cent.
- Cross protection with mild strains.
12. Harvesting

- All citrus ripen gradually over weeks or months and are slow to abscise from the tree. External color changes during ripening but is a function of climate more than ripeness; and a poor indicator of maturity.

- The main harvesting season of Sikkim mandarin is October to January. Plucking the fruits directly from the tree should be avoided, as it usually removes portion of the skin which later causes problem in storage. Removing the fruits with a portion of peduncle from the trees is an ideal method of harvesting.

**Guava (Psidium guajava L.)**

1. Land preparation

- Soil should be well ploughed and all weeds should be removed.

- Pits of 3' x 3' x 3' (length, width and depth, respectively) are dug and refilled with the top 1½' soil mixed with 20-25 kg of well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. Time of planting

- In Sikkim, planting is done during the monsoon rain in June-July.

3. Method of planting

- High density guava is planted at distance of 2 m x 1.5 m on terraces in contour system of plantation. However, generally planting of guava is done at distance 4 m x 4 m. High-density planting gives higher yield/unit area in early years of fruiting.

- The rows should be oriented in north-south direction to maximize the use of sunlight.

- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

- **Allahabad Safeda, Lucknow-49 (Sardar), Chittidar, Apple Colour**, Arka Mridula, Allahabad Surkha, Hissar Safeda, Pear Shaped, CISH G-1, CISH G-2 etc.

- **Lines**: RCGH-1, RCGH-4, RCGH-7, RCGH-11
5. **Organic nutrient management**

- Guava plants should be manured twice in a year *i.e.*, June-July and December-January.
- FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.
- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.
- Micronutrients are essential for proper growth and fruiting in guava and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.
- Application of soil amendment such as dolomite every second year @ 100-200 g/plant is essential to maintain the soil pH.
- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

6. **Intercropping**

- Commercial fruit bearing generally starts after 3 to 5 years until then the interspaces between the young trees should be intercropped with leguminous crops like pea, beans, French bean, gram, and leafy vegetables, root vegetables *etc.*
- Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. **Water management**

- Guava is generally grown as rainfed crop and irrigation is rarely practiced. Just after planting, watering is given in the absence of rains.
- Irrigation improves the plant growth, flowering and fruiting in guava.
- Irrigation during winter months has been found to reduce fruit drop and improve fruit size of winter crop.
- Irrigation is given to make the soil root zone moist; thus, heavy irrigation is unnecessary. The fruit quality of guava is adversely affected by high moisture content during harvest. Therefore, drip system of irrigation shall be best for harvesting quality fruits and conservation of water during winter months.
8. **Weed management**

- Manual weeding with the help of *khurpi* or hand hoe is the best pre-monsoon method to control the weed population.

- Hand-weeding should be done carefully to avoid injury to the roots.

- Ploughing, spading of basins, *etc.* are important inter-cultural operations for soil aeration and tree health.

9. **Training and pruning**

- Training of guava plants in young stage to build strong framework and to avoid weak crotches is necessary; whereas, fruiting trees should be pruned to check over-crowding in the orchard.

- The plants should be trained as low headed trees to facilitate multiple hand pickings.

- The open centre or delayed open centre system may be adopted. The scaffold branches in young plants are to be tipped back to encourage secondary branching.

- The root suckers, water sprouts and criss-cross branches are to be removed.

- Pruning is also undertaken during harvest as the fruit is plucked along with the shoot on which it is borne. Pruning is usually recommended after harvest or in spring.

10. **Mulching**

- Mulching is essential to avoid weed problem in the field during rainy season and for moisture conservation during winter season.

- Mostly, leaf mulch is recommended for guava plantations. The best mulching material in Sikkim is *Schima wallichi* (*chilaune*) followed by *Artemisia vulgaris* (*titepati*), which minimize some disease problems also.

- Weed growth can also be checked by mulching with black plastic mulch.

11. **Crop protection**

**Insect pests management**

- Fruit fly, bark eating caterpillar, tea mosquito bug and spiraling whitefly are some important pests of guava.
Collect and destroy fallen and infested fruits, summer ploughing to expose pupae, use methyl eugenol lure traps @ 25/ha to monitor and kill adults of fruit flies; and harvesting of the fruits should be done early for management of fruit fly.

In order to manage bark eating caterpillar, hook out the grub from the bore hole. Clean infested portion followed by insertion of cotton soaked in kerosene oil in to the holes and closing of the holes by plastering with mud.

Swab coal tar + kerosene @ 1:2 of water on the basal portion of the trunk up to 3 feet height.

Collect and destroy the damaged plant parts for management of tea mosquito bug. Apply neem oil (1500 ppm) @ 3 ml/l at 15 days interval at the time of flowering and fruiting.

Spiraling whiteflies can be managed through field sanitation, installation of yellow sticky traps and application of petroleum oil-based agro spray @ 10 ml/l at 15 days interval.

Disease management

**Wilt (Fusarium oxysporum f. sp. psidii)**

- Planting should be done in well-drained soil.
- Remove and destroy infected tree along with root.
- Soil treatment with lime (1.82 kg lime/tree) to prevent further spread of the disease.
- Apply 6 kg neem cake + 200 g dolomite per plant.
- Intercrop with turmeric or marigold to check the wilting of guava.
- Apply green manure or any other organic sources of nitrogen.

**12. Harvesting**

- Seedling guava tree requires 4-5 years to bear, while grafted, budded or layered plants start bearing at age of 2-3 years.
- Fruits are recommended for harvest between 106 to 121 days after fruit set to ensure higher amount of total sugars and appreciable amount of minerals.
- Guava fruit develop best flavor and aroma only when they ripen on tree. The fruits are harvested selectively by hand along with the stalk and leaves.
Ripening of guava starts on the tree and continues even after harvest. It is accelerated in rainy season due to high temperature and slows down in winter season due to low temperature.

Papaya (*Carica papaya* L.)

1. **Land preparation and sowing**
   - Papaya does not withstand waterlogging, hence, upland should be selected for its cultivation. Plants are also sensitive to strong wind, so suitable windbreaks are essential to protect them.
   - Soil should be well ploughed and all weeds should be removed.
   - Pits of 2' x 2' x 2' (length, width and depth, respectively) are dug and refilled with the top 1' soil mixed with 20-25 kg of well-decomposed farmyard manure or compost at least 15-20 days before actual planting.
   - About 250-300 gm seeds are sufficient for one hectare. Seedlings can be raised in nursery beds of 3 m length, 1 m width and 10 cm height as well as in pots or polythene bags. In Sikkim conditions, time of sowing is February to April.

2. **Time of planting**
   - Papaya is planted during monsoon (June-July) and autumn (October-November) in Sikkim conditions.
   - Monsoon planting is done in frost prone areas and autumn planting is preferred in high rainfall areas.

3. **Method of planting**
   - Planting distance is determined by the integration of light interception, cultivar and economic consideration. Spacing of 1.8 m x 1.8 m is normally followed for most of the cultivars. Spacing of 1.4 m x 1.4 m or 1.4 x 1.6 m is best suited for Pusa Delicious. Closer spacing of 1.3 m x 1.3 m is optimum for Coorg Honey Dew, and 1.2 m x 1.2 m for Pusa Nanha.
   - Planting of papaya saplings should be done in the evening. The seedlings from nursery-beds are lifted with a ball of earth and planted in the field. Plants raised in polythene bags are planted after removal of polythene. It is important to keep some extra saplings for gap-filling.
Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. **Cultivars/varieties**

- Pusa Dwarf, Pusa Nanha, Coorg Honey Dew, Solo Sunrise, Sinta, Taiwan, Pusa Majesty, Washington, Pusa Delicious, Pusa Giant *etc.*

5. **Organic nutrient management**

- Papaya is heavy feeder and requires heavy doses of manures. Basal dose of 20 kg FYM/pit should be applied and properly incorporated with the soil. FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied annually in two equal splits as either sole or in combination for sustained optimum yield.

- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.

- Application of soil amendment such as dolomite @ 100-200 g/plant every second year is essential to maintain the soil pH.

- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

6. **Intercropping**

- Any seasonal vegetable crop can be grown as intercrop in the interspaces available between rows. Suggested vegetables are cabbage, cauliflower, onion, radish *etc.* Planting of intercrops should be done just after establishment of papaya sapling.

- It is advised not to grow chillies, tomato, brinjal and Lady’s finger as intercrops to avoid virus diseases since they serve as hosts.

- No intercropping should be undertaken when flowering and fruiting starts. Suitable crop rotation should be followed to maintain soil fertility and avoid replanting problem. Intercropping leguminous crops after non-leguminous ones, shallow-rooted crops after deep-rooted once are beneficial.

7. **Water management**

- Watering should be done soon after planting the sapling. Optimum soil moisture is essential for growth, yield and quality of fruits.

- Under low moisture conditions, floral sex shifts towards female sterility, resulting in poor yield. At the same time, over-irrigation may cause root rot diseases. Hence, efficient water management is essential.
Generally, basin irrigation is used but care is to be taken to avoid water stagnation around the plant. In low rainfall areas where the water is scarce, sprinkler or drip irrigation system may be adopted to maximize water use efficiency.

Papaya plant is highly susceptible to waterlogging. Even 24 hours water-logging may kill well established plant. Therefore, upland should be selected for papaya cultivation.

8. Weed management

Weeds grow luxuriantly in papaya field and uptake most of the applied nutrients. Manual weeding with the help of khurpi or hand hoe is the best pre-monsoon way to control the weed population.

Deep hoeing is recommended during first year to check weed growth. Hoeing should not be done in rainy season or after fruiting as the plants are shallow rooted. Over growth of weeds also causes waterlogging conditions and makes the plants vulnerable to root rot in rainy season. Therefore, the papaya field should be kept free from weed.

9. Mulching

Mulching is essential to avoid weed problem in the field during rainy season and for moisture conservation during winter season.

Mostly leaf mulch is recommended for mulching of papaya plantations. The best mulching material in Sikkim is Schima wallichi (chilaune) followed by Artemisia vulgaris (titepati) which minimize some disease problems also.

Weed growth can also be checked by mulching with black plastic mulch.

10. Crop protection

Insect pests management

Red spider mite, fruit files, aphids and white flies are some important pests of papaya.

Spray wettable sulphur @ 0.25% and repeat at intervals of 12-15 days for management of mites.

Collect all fallen infested fruits and destroy for management of fruit fly. Install methyl eugenol based para-pheromone traps for monitoring and trapping of adult fruit flies.

Apply petroleum oil-based agro spray @ 10 ml/l at 15 days interval for aphids and white flies.
Disease management

Powdery mildew (*Odium indicum, Odium caricae*)
- Spray wettable sulphur @ 0.25 per cent.
- Remove and destroy severely infected foliage.

Foot rot of papaya (*Pythium aphanidermatum*)
- *Trichoderma viride* @ 15 g/plant mixed in well-decomposed FYM should be applied around the root zone of the plants at the time of planting.
- The crop should be irrigated by adopting the ring method of irrigation so that the water does not come in direct contact with the stem.
- The soil should be drenched with 2-3 litres of @ 0.25 per cent or Bordeaux mixture. The application should be carried out regularly at 15 days interval from the time of planting.
- During fruit formation, the plant should be sprayed with the same solution at the same time interval. The rotted portion of the plant should be scraped and copper oxychloride or Bordeaux paste should be applied.
- The base of the plant should be drenched with three litres of copper oxychloride @ 0.25 per cent.
- The plant should be drenched during fruit formation with copper oxychloride @ 0.25 per cent twice at 15 days interval.

Papaya mosaic
- Removal and destruction of affected plant reduces the spread of the disease.
- Use tolerant variety, Pusa Majesty.
- Apply neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

Leaf curl of papaya
- Remove and destroy the affected plants.
- Use tolerant variety, Pusa Majesty.
- Apply neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

**Papaya Ring Spot Virus**

- Remove and destroy the affected plants.
- Use tolerant variety, Pusa Majesty.
- Apply neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

**11. Harvesting**

- Papaya is quick growing fruit plant. It starts flowering and fruiting in 5 months after planting and ripe fruits become ready for harvest in about 9-10 months after planting.
- The fruits should be left on tree until they fully mature as the fruits are non-climacteric in nature.
- In hills, from February to May because it requires warm climate during ripening. It was also observed that high relative humidity and comparatively high temperature during ripening period may not be conducive for development of attractive color of fruits which may retain pale green even when ripe.

**Banana (Musa spp.)**

1. **Land preparation**
   - Soil should be well ploughed and all weeds should be removed.
   - Pits of 2' x 2' x 2' (length, width and depth, respectively) are dug and refilled with the top 1' soil mixed with 20-25 kg of well-decomposed farmyard manure (FYM) or compost at least 15-20 days before actual planting.

2. **Time of planting**
   - Normally banana plantation is done in June-July. Banana can also be planted in August-November or March-April.

3. **Method of planting**
   - Pits of 60 cm x 60 cm x 60 cm size are dug, filled with mixture of soil and FYM (farmyard manure) in a 1:1 ratio. Suckers are planted in the centre of the pit and soil around is compacted. This is mostly followed in biennial plantations for Dwarf Cavendish, Rasthali, Robusta, Poovan and Karpuravalli banana.
Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. **Spacing**

The spacing of banana crop is given below:

**Spacing for dwarf varieties**
- 1.2 m x 1.2 m (row-row x plant-plant)
- 1.8 m x 1.8 m (row-row x plant-plant)
- 2.0 m x 2.0 m (row-row x plant-plant)

**Spacing for tall and semi-tall varieties**
- 2.4 m x 1.8 m (row-row x plant-plant)
- 2.4 m x 2.4 m (row-row x plant-plant)
- 2.7 m x 3.0 m (row-row x plant-plant)
- 2.5 m x 2.5 m (row-row x plant-plant)

5. **Aftercare**

- **De-suckering**
  - Usually two suckers are retained per plant and the additional suckers are removed just below the ground level.

- **Propping**
  - Support is given to the bearing plant with the help of bamboo to protect them from bending down due to heavy bunch load and from any wind damage. Both tall as well as dwarf varieties require propping.

- **Wrapping**
  - Covering of bunches with polythene or gunny cloth that protects the fruits from intense heat causing sun-scald, hot wind *etc.*, and improves the colour of the fruits.

- **Earthing up**
  - Earthing up is important particularly during rainy season; this prevents plants from waterlogging and also it will provide support to the base of the plant.
6. **Cultivars/varieties**

- Grand Naine (G-9), Dwarf Cavendish, Rasthali and Robusta

7. **Organic nutrient management**

- Banana responds well to both manure and fertilizers. The dosages of nutrient to be applied depend on the variety, initial soil fertility, climate *etc*. Basal dose of 25 kg FYM/pit should be applied and incorporated with the soil properly. FYM @ 20-25 kg/plant and/or vermicompost @ 5-10 kg/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.

- Application of potash through biofertilizers (potash solubilizers) increases the number of hands/bunch and finger size, improves fruit quality, develops resistance to diseases and reduces water uptake in banana.

- Neem cake @ 2 t/ha should be applied during active growth stage in July-August.

- Application of soil amendment such as dolomite @ 100-200 g/plant every second year is essential to maintain the soil pH.

- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

8. **Water management**

- Banana requires adequate soil moisture throughout the year. Irrigation is done just after planting, if there is no rain. Drip irrigation can reduce the quantity of water and increases yield, and decreases number of days to harvest. Water use efficiency is greater with drip irrigation as compared to basin system of irrigation, and the system *i.e.*, drip irrigation saves up to 50% of water used.

- Water-logging should not be allowed.

9. **Weed management**

- Banana plantation offers shade, therefore, it does not suffer too much from weed infestation. However, the crop should be free from weed growth to optimize the nutrient use efficiency.

- Manual weeding is the best method to check weed population. Shallow cultivation at early stages of crop is essential to control the weeds and provide better conditions for plant growth.
10. Mulching

- Banana crop responds to mulching. It decreases the cost of cultivation by reducing the number of irrigations and suppressing the weed growth. Generally, weed biomass and banana trash are abundantly available which can be used effectively.

11. Crop protection

Insect pests management

- Aphids, corm weevil, pseudo-stem borer and burrowing nematode are major insects in banana.
- Adopt clean cultivation using healthy and pest free suckers, drench the petioles, furled leaves, whorls or young suckers with soapy water or insecticidal soap for management of aphids. Apply bio-control agent, *Beauveria bassiana* in the banana fields.
- In case of corm weevil, practice clean cultivation with the suckers, periodically prune, remove and destroy infested clumps, crop rotation with non-host crops like rice and sugarcane, use of pheromone traps @ 16 traps /ha, and applying bio-control agents, *Beauveria bassiana* and *Metarhizium anisopliae* causes mortality of the weevils.
- Remove the pseudostem from ground level and destroy them in order to avoid it serving as breeding site for the pest for stem weevil management after harvest of the bunch,
- Uproot and burn infested plants. Use longitudinal pseudostem traps @ 100/ha to trap weevils.

Disease management

Panama wilt of banana (*Fusarium oxysporum f. sp. cubensis*)

- Practice proper crop rotation with rice.
- Plant wilt resistant cultivars such as Poovan and Nendran in endemic areas.
- Remove and destroy affected plant reduces the spread of the disease.
- When only 1-3 plants are infected, kill and chop the diseased plants and strew all the material in water at a temperature of at least 70°C for 30 minutes.
- Fertilization, irrigation, weed control also helps to manage the disease.
Good drainage especially during rainy season should be provided.

Soil application of rice chaffy grain or dried banana leaf formulation or well decomposed compost the plants.

Provide mechanical barriers in and around the infected plants

Bactericide, *Pseudomonas fluorescens* @ 2.5 kg/ha can also be applied along with farmyard manure and neem cake.

About 60 mg of *Pseudomonas fluorescens* (in a capsule) can be applied in a 10 cm deep hole made in the corm.

Apply bio control agents like *Trichoderma viride* @ 25 g for 4 times once at planting in the pit and remaining doses at third, fifth and seventh month after planting.

Application of neem cake @ 250 kg/ha was most effective.

**Yellow sigatoka (Mycosphaerella musicola)**

- Remove and destroy affected leaves.
- Keep the banana field weed free and timely removal of the suckers.
- Planting in close spacing should be avoided.
- Water-logging in the fields should be avoided.
- Spray Bordeaux mixture 1 per cent + linseed oil @ 2 per cent or copper oxychloride @ 0.25 per cent 10-15 days interval, from initial appearance of leaf specks on lower side of the leaf.

**Bunchy Top (Banana bunchy top virus)**

- Use virus free planting materials
- Remove and destroy affected plants.
- Spray plants with neem oil @ 0.3 per cent or @ NSKE 5 per cent or petroleum oil-based agro spray @ 0.7 per cent.

**12. Harvesting**

- Banana is a climacteric fruit and does not ripe early and uniformly on the plant, and hence, they are harvested when they are green and fully mature. It responds well to external ethylene application.
The fruits are harvested when top leaves start drying and shed floral ends of the fruits with slightest touch of the end.

- The colour of the fruits changes from deep green to lighter green.
- The angles or ridges of the fruits become less prominent or they become round.
- Harvesting is performed by cutting the bunch while retaining 15-20 cm stalk; this helps in handling. Sometimes, partial harvesting is done when fruits are required for vegetable purposes.

**Litchi (Litchi chinensis Sonn.)**

1. **Land preparation**

- Litchi grows well on variety of soils including loam, sandy loam. The soil should be deep, well-drained and rich in organic matter. The soil should not have hard pan within 2.5 metres from the surface.
- Soil should be well ploughed and all weeds should be removed.
- Pits of 3’ x 3’ x 3’ (length, width and depth, respectively) are dug and refilled with the top 1½’ soil mixed with a basket full soil in a pit from a litchi orchard, containing mycorrhizal fungi and 20-25 kg of well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. **Time of planting**

- Planting is done during early monsoon season in April-May in Sikkim.

3. **Method of planting**

- Litchi trees are planted generally in a square system with 10 m x 10 m spacing. Planting distance can be reduced to 7.5 m x 7.5 m where litchi plants need protection against from either frost or desiccating winds.
- Healthy 6 to 9 months old, true to the type plants, with fine roots should be selected for quick establishment and less mortality. It is advisable that all plants should be inoculated with mycorrhizal fungi.
- The rows should be oriented in north-south direction to maximize the use of sunlight.
- After planting the land should not be allowed to dry completely.
4. **Cultivars/varieties**

- Early Seedless (Early Bedana), Rose Scented, Shahi, Dehradun, Gulabi, Calcutta, Bombay, Late Seedless (Late Bedana), and China are important.

5. **Organic nutrient management**

- Litchi needs high amount of organic matter. The doses of manure applied may be as follows: 1-3 years age: 10-20 kg FYM/year/tree; 4-6 years age: 25-40 kg FYM/year/tree; 7-10 years age: 40-50 kg FYM/year/tree and > 10 years age: 60 kg FYM/year/tree may be applied annually in two equal splits.

- Micronutrients are essential for proper growth and fruiting in litchi and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.

- Application of soil amendment such as dolomite @ 100-200 g/plant in every second year is essential to maintain the soil pH.

- Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pest and diseases.

6. **Intercropping**

- Litchi is slow growing and takes at least six years to start bearing, vacant interspaces can be utilized for intercropping in early years.

- During summer and kharif season, vegetables like pumpkin, cucumber, ridge gourd, bitter gourd and leguminous crops may be grown. During winter season, crops like peas, bean, and grams can be grown.

- Besides vegetables, quick growing fruit crops like papaya, pineapple and banana can also be planted to optimize the use of interspaces. The inter crops should be manured separately and protected from pest and diseases.

7. **Water management**

- Adequate soil moisture is essential for the cultivation of litchi. Where annual rainfall is well distributed, litchi can be grown without irrigation. January-end to the onset of monsoon is critical period for irrigation since vegetative growth and fruit development takes place.

- Litchi is deep-rooted, perennial fruit crop, however, absorbing roots mostly occur in the uppermost soil layer between 20-30 cm depth. Therefore, this zone should have 50% soil moisture during the critical period.
The fully grown trees are irrigated by flooding or by furrow irrigation, depending on the availability and source of irrigation. Depending on the availability of water, the orchard may be irrigated at fortnightly intervals in April and frequency may be increased further in May till the fruit is harvested.

Sprinkler or drip irrigation system may be adopted to maximize the water-use-efficiency.

8. Weed management

Manual weeding with the help of khurpi or hand hoe is the best pre-monsoon way to control the weed population.

Hand-weeding should be done carefully to avoid injury to the roots.

Ploughing, spading of basins, etc. are important inter-cultural operations for soil aeration and tree health.

9. Mulching

Mulching is essential to avoid weed problem in the field during rainy season and for moisture conservation during winter season.

Mostly, leaf mulch or weed biomass is recommended for mulching of litchi plantations. The best mulching material in Sikkim is Schima wallichi (chilaune) followed by Artemisia vulgaris (titepati) which minimize some disease problems also.

Weed growth can also be checked by mulching with black plastic mulch.

10. Crop protection

Insect pests management

Erinose mite, bark eating caterpillar, litchi fruit borer and litchi leaf roller are some important pests of litchi.

We should take preventive measures to avoid the infestation of mite. Layers should be prepared only from non-infested plants and the saplings should be sprayed with wettable sulphur before releasing from the nursery.

The leaves should be checked regularly for symptoms over summer and autumn and the branches infested with the mite should be cut off and burnt.

The damage caused by leaf rollers is tolerated as long as it is restricted to the foliage and unlikely to affect flower initiation. The rolled leaves that contain larvae may be removed manually during light infestation.
Moths can be excluded by enclosing the fruit panicles in nylon mesh bags for fruit borer, but is uneconomic in areas with high labour costs. Use of *Trichogramma chilonis* @ 50,000 eggs/ha and use of pheromone traps can effectively manage the fruit borer.

**Disease management**

**Brown blight (*Peronophythora litchi*)**
- Remove shaded, infected and dead branches after harvest.
- Spray copper oxychloride @ 0.25% during winter and spring.

**Anthracnose (*Botryodiplodia theobromae*)**
- Avoid overcrowding of trees and branches in the orchard.
- Prune and burn the affected plants.
- Spray copper oxychloride @ 0.25%.
- Spray 3:3:50 Bordeaux mixture in February, April and September-October.

**Tree decline and Root rot (*Phytophthora* spp., *Pythium* spp., *B. theobromae* and *Fusarum* spp.)**
- Select propagating material from disease-free mother plant.
- Provide proper drainage.
- Prune the tree to reduce evaporation and encourage root growth to help the tree to recover quickly.
- Apply well-decomposed FYM.

**Fruit rot**
- Low temperature storage (5°C) is the most successful means of slowing rot development.

**11. Harvesting**
- Harvesting of litchi is usually done in May and June. Generally, litchi fruits take 50-60 days after fruit set. Colour development varies according to variety from light green to deep red to pinkish.
● Epicarp or skin becomes soft and smooth and tubercles becomes somewhat flattened at the tip.

● The fruits for local market should be harvested at their fully ripe stage, while for distant markets, when they start turning reddish. The fruits should be harvested at proper stage to possess good quality.

● Litchi fruits, like other fruits, are not harvested individually to avoid rupturing of skin at the stem-end and quick rotting of fruits. They are harvested in bunches along with portion of the bunch and few leaves. It prolongs the shelf life of fruits.

**Kiwifruit (Actinidia deliciosa)**

1. **Land preparation**

   ● Establishment of kiwifruit orchard requires site free from spring and early autumn frost with well-drained soil and relatively high atmospheric humidity.

   ● Rows should be oriented in north-south direction to maximise the use of sunlight.

   ● Pits of approximately 0.6 m x 0.6 m x 0.6 m size are dug in the month of September-October. The pit should be well-filled by adding 20-30 kg well-decomposed farmyard manure.

2. **Time of planting**

   ● Planting is done in the month of January when plants are dormant.

3. **Method of planting**

   ● The spacing varies with the cultivars and training system. In general, plant to plant spacing should be maintained at 4 to 5 meters from each other.

   ● The kiwifruit is dioecious *i.e.*, male and female flowers are borne on different vines. Care must be taken to plant male and female in the ratio of 1:8 to ensure proper pollination and fruiting of the well-grown orchard.

   ● Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. **Cultivars/varieties**

   ● *Female*: Monty, Bruno, Allison and Hayward
5. **Organic nutrient management**

- Kiwifruit plants are heavy feeders of nitrogen which should be applied in abundance during the first half of the growing season through organic fertilizers.

- Apply well-decomposed and dried cattle manure or compost @ 10-40 t/ha from planting to peak fruit production age for sustained high yield and quality. This should be applied @ 25 to 100 kg/plant in two splits in Feb.-March and July-August.

- Neem cake @ 2 t/ha should be applied after vines have several inches of new growth during early spring. Gradually increase the amounts of manure applied each year until maturity.

- During active fruit growth stage, vermicompost @ 4 to 10 kg/plant should also be given for better growth, production and fruit quality.

6. **Intercropping**

- Commercial fruit bearing in kiwifruit orchard generally starts after 5 to 6 years until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, French bean and leafy vegetables, root vegetables *etc.*

- Exhaustive crops *viz.*, maize, ginger *etc.* which drain the essential nutrients and moisture quickly from the field should be avoided as intercrops.

- Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. **Water management**

- Water requirement of kiwifruit orchard particularly during the first 2-3 years is very high for successful establishment. Subsequently, the foliage covering the entire surface area of the soil acts as mulch and reduces the frequency of irrigation.

- Overhead sprinklers are often used in commercial kiwifruit vineyards for frost protection as well as irrigation (sprinkler heads should be about 3 feet above the training wire).

- Drip irrigation, however, promotes more efficient use of water.
Watering regularly in the heat of the summer is necessary at intervals of 10-15 days.

In summer, newly planted vines should be watered deeply about once a week. Never allow a plant to undergo drought stress.

8. **Weed management and mulching**

- Weeding is done just before manure application and mulching. Two-three weeding is required depending on the intensity of weed growth.

- Natural weed cover itself helps in the conservation of soil and organic matter. However, the basin of vine should be cleaned regularly and mulched to conserve soil moisture.

- The best mulching material in Sikkim is *Schima wallichi (chilaune)* followed by *Artemisia vulgaris (titepati)* which minimize disease incidence also.

9. **Training and pruning**

- In the first year, the vine is headed back at 30-40 cm distance from the ground and single apical bud is allowed to grow up to the wire. This will be the main trunk. No further branching on the main trunk is permitted.

- In the second year, two shoots are selected and tied down at both sides to the middle wire. These are the secondary arms.

- In the third year, the tertiary fruiting arms which bear fruits in the coming years are selected on these secondary arms.

- These tertiary arms should be tied down to the out trigger wire to hold them in position. The first crop forms on these laterals and develops on them or on replacement of fruiting arms. Fruiting arms should not be trained along the out trigger wires parallel to the permanent leaders because the shoots from these will compete with fruiting arms which originate directly from the leader causing dense growth, which adversely affects the management and vine growth.

- Kiwifruit flowers and bears fruit on wood that has grown from the previous season’s growth. Dormant pruning of female vines begins by heading back last years’ fruiting canes to 10-12 buds past the last fruit. Small, weak wood should be heavily pruned to force new vigorous canes. Avoid pruning in early spring after the plant growth has begun; excess bleeding can occur and may damage the plant.
10. Crop protection

Insect pests management

No major pest has so far been reported on kiwifruit plant. Leaf roller, Greedy scale and two spotted spider mite may damage the crop to limited extent. Two sprays of neem oil (1500 ppm) @ 3 ml/l at 15 days interval are found to be effective against leaf roller. Greedy scale and two-spotted spider mite can be managed by spraying petroleum-based agro spray @ 10 ml/l and wettable sulphur @ 0.25% at 15 days interval, respectively.

Disease management

1. Root rot, Collar rot, Crown rot (*Phytophthora coctorum*, *P. cinnamoni*, *P. citricola*, *P. lateralis*, *P. megasperma*)
   - Disinfect the planting material by root dip treatment with Bordeaux mixture (1.0 per cent) or copper oxychloride @ 0.25 per cent before planting.
   - Drench soil with Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.25 per cent.
   - Sites with good drainage should be selected to establish new orchards.

2. Bacterial leaf blight and Blossom blight (*Pseudomonas viridiflava*)
   - General field sanitation and pruning of diseased parts helps in checking the disease.
   - Drench soil with Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.25 per cent.

11. Harvesting

   - Kiwifruit is an exception in which no perceptible change either in skin or flesh colour occurs. Flavour and aroma do not develop because the fruit is harvested hard.
   - Maturity index of 6.2 per cent of total soluble solids or more has been established and found very satisfactory for fruit harvest.
   - Under Sikkim conditions, the fruit is harvested from first week of November. The kiwifruits are still hard when harvested by snapping their stalks easily at an abscission layer found at peduncle attachment.
   - After harvest, the fruits are rubbed with coarse cloth or shaken in gunny bag to remove the stiff hair present on the skin surface.
Pear (Pyrus spp.)

1. Land preparation

- Establishment of pear orchard requires site free from spring and early autumn frost with well-drained soil and relatively high atmospheric humidity.
- Soil should be well ploughed and all weeds should be removed.
- Pits of approximately 2.0' x 2.0' x 2.0' size are dug during October-November. The pit should be well-filled by adding 10-20 kg well-decomposed farmyard manure.

2. Time of planting

- In Sikkim, planting of dormant plant should be done in the last week of January to first week of February.

3. Method of planting

- The plant spacing varies with the cultivars and training system. In general, plant to plant spacing should be maintained at 4 m x 4 m on terraces or in contour system of plantation.
- Care must be taken to plant pollenizer cultivars in the orchard to ensure proper pollination and fruiting of the well-grown orchard.
- Rows should be oriented in north-south direction to maximize the use of sunlight.
- Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

- **Asian type for lower to mid hills**: Punjab Beauty, Punjab Nectar, Punjab Gold, China, Tumaria, LeConte, Kieffer etc.
- **Japanese type for mid hills**: Hosui, Kosui, Sojuru, Shinsui etc.
- **European type for high hills**: Bartlett, Red Bartlett, D Anjou, Doyenne du Comice, Victoria, Bagugosha etc.

5. Organic nutrient management

- Pear requires adequate nutrients for good vegetative growth and yield. Well-decomposed and dried cattle manure or compost @ 15-20 t/ha should be applied at the time of planting or during the dormant stage of plants.
● Neem cake @ 2 t/ha should be applied after pear has attained several inches of new growth during early spring.

● During active fruit growth stage, vermicompost @ 2 kg/plant should also be given for better fruit growth and production.

● Mulching with manure and/or straw is very beneficial. However, do not place the mulch directly in contact with the pear plant as crown rot may occur.

6. Intercropping

● Commercial fruit bearing in pear orchard generally starts after 4 to 5 years until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, French bean, and cole crops, leafy vegetables, root vegetables etc.

● Exhaustive crops viz., maize, ginger etc., which drain the essential nutrients and moisture quickly from the field should be avoided as intercrops.

● Intercrops with high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. Water management

● The requirement of water particularly during the first 2-3 years is very high for successful establishment of pear orchard. In summer, newly planted pears should be watered deeply about once a week. Never allow plants to undergo drought stress.

● In hills, pear cultivation is mostly done under rainfed conditions but at many places irrigation facility may be available which is an additional advantage. Besides rain fall, 75-100 cm irrigation may be applied annually in some regions.

● Both excessive and scanty moisture affects color, composition and keeping quality of fruits, therefore, drip irrigation is beneficial.

● After harvesting in July-August, the trees should be irrigated at 20 days interval or so up to the end of October. Thereafter, no irrigation is required up to January except when the manure and organic fertilizers are applied in December.

8. Weed management and mulching

● The basin of pear plant should be cleaned regularly and mulched to conserve the soil moisture. Weeding is done just before manure application and mulching. Two or three weeding is required depending on the intensity of weed growth.
The best mulching material in Sikkim is *Schima wallichi* (chilaune) followed by *Artemisia vulgaris* (titepati) which minimize disease incidence also.

9. **Training and pruning**

- The most common system of training pear is modified central leader, where one branch is allowed to grow vertically and form the main bole upon which scaffold limbs are spaced at selected intervals.
- Majority of pruning in pear is done during deep dormancy season and also at the planting time for newly planted trees.
- Young and juvenile trees should be pruned carefully for the purpose of training to bring in the desired shape.
- Pruning severity depends on the growth habit of the cultivar and the management practices recommended for the crop. Bearing and older trees are pruned with much care and in timely manner to balance vegetative growth and fruit production.

10. **Crop protection**

**Insect pests management**

- Aphids, Codling moth, Pear psylla and Oriental fruit fly are some important pests of pear.
- When numbers of aphids are low they can be squashed by hand.
- Collect and destroy infested fruits.
- Orchard sanitation is very important to prevent pest infestation.
- Two sprays of petroleum oil-based agro spray @ 10 ml/l or neem formulation (1500 ppm) @ 3 ml/l at 20 days interval are effective for management of aphids, psylla and Codling moth.
- Para pheromone trap can be used to catch the male adults of fruit fly.

**Disease management**

**Fire blight (*Erwinia amylovora*)**

- Field sanitation, collection and burning of diseased leaves, pruning of diseased shoots or branches help in managing the disease.
• Excise and destroy overwintering cankers or twig infections before the blossoms open.
• Spray copper oxychloride @ 0.25 per cent or Bordeaux mixture @ 1 per cent.

11. Harvesting

• European pears are harvested when ‘firm mature’ and stored immediately, and then allowed to ripen for several days prior to fresh consumption. When fully ripe, European pears have the typical ‘melting’ flesh texture, and full development of flavor.
• Asian pears, however, are harvested closer to physiological ripeness and placed in cold storage.
• Pears for marketing are picked by hand several times over a 10-20 day period.

**Walnut (Juglans regia L.)**

1. Land preparation

• Establishment of walnut orchard requires site free from frost in spring and extreme heat in summer with well-drained soil.
• Soil should be well ploughed and all weeds should be removed.
• Pits of approximately 3.0’ x 3.0’ x 3.0’ size are dug during November. The pit should be well-filled by adding 20-25 kg well-decomposed farmyard manure.

2. Time of planting

• In Sikkim, planting of dormant plant should be done in the last week of January-beginning of February.

3. Method of planting

• The plant spacing varies with the cultivars and training system. In general, plant to plant spacing should be maintained at 10 m x 10 m on terraces in contour system of plantation.
• Rows should be oriented in north-south direction to maximize the use of sunlight.
• Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars/varieties

• CITH-17, Kagzi, Lake English etc.
5. **Organic nutrient management**

- Walnut requires adequate nutrients for good vegetative growth and yield. Well-decomposed and dried cattle manure or compost @ 20-25 t/ha should be applied at time of planting or during the dormant stage of plants.

- Neem cake @ 2 t/ha should be applied after walnut has attained several inches of new growth during early spring.

- During active growth stage, vermicompost @ 2-4 kg/plant should also be given for better fruit growth and production.

- Mulching with manures and/or straws is very beneficial. However, do not put the mulch directly in contact with the plant as crown rot may occur.

6. **Intercropping**

- Commercial fruit bearing in walnut orchard generally starts after 6 to 8 years until then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, garlic, French bean, and cole crops, leafy vegetables, root vegetables *etc.*

- Exhaustive crops *viz.*, maize, ginger *etc.* which drain the essential nutrients and moisture quickly from the field should be avoided for intercropping.

7. **Water management**

- The requirement of water particularly during the first 2-3 years is very high for successful establishment of orchard.

- In hills, walnut cultivation is mostly done under rainfed conditions; however, drip irrigation is beneficial.

- After harvest in September-October, the trees should be irrigated once. Afterwards no irrigation is required up to January except when the manure and organic fertilizers are applied in December.

8. **Weed management and mulching**

- The basin of walnut plant should be cleaned regularly and mulched to conserve the soil moisture. Weeding is done just before manure application and mulching. Two or three weeding is required depending on the intensity of weed growth.
9. Training and pruning

- The most common system of training walnut is modified central leader.
- Young and juvenile trees should be pruned carefully for the purpose of training to produce the desired shape.
- Pruning severity depends on the bearing habit of the cultivar. In terminal bearing cultivars, pruning consists of heading back of selected framework of branches and thinning out competing limbs.
- The lateral bearing cultivars are both thinned and headed back heavily in order to encourage shoot growth which gets suppressed due to earlier fruit production.

10. Crop protection

Insect pests management

- Codling Moth, Walnut Husk Fly, Walnut Aphid, Two spotted Mite are major insects.
- When number of aphids are low, they can be squashed by hand.
- Orchard sanitation is very important to prevent pest infestation.
- Two sprays of petroleum oil-based agro spray @ 10 ml/l or neem formulation (1500 ppm) @ 3 ml/l at 20 days interval are effective for management of aphids psylla, two spotted mite Walnut husk fly and Codling moth.

Disease management

**Walnut blight (Xanthomonas campestris pv. juglandis)**

- Apply copper containing bactericides such as Bordeaux mixture @ 1 per cent.
- Bactericides should be applied weekly to protect new growth during periods of wet weather.

**Phytophthora root and crown rot (Phytophthora spp.)**

- Plant trees in well-drained soils.
Drainage can be improved by leveling soil or installing drainage systems.

Avoid wetting tree trunks when irrigating.

Graft union should be several centimeters above the soil line when planting trees.

Use resistant rootstocks.

Drench with Bordeaux mixture @ 1 per cent or copper oxychloride @ 0.25 per cent.

**Armillaria root rot (Oak root fungus) (Armillaria mellea)**

- Armillaria root rot cannot be effectively controlled once it is established in an orchard.
- Diseased or dead plants should be uprooted and removed.
- Planting resistant rootstocks is the most effective method to prevent the disease.
- Use tolerant rootstocks.
- Saving the infected trees: Remove soil from the base down to a depth of 9 to 12” in spring. Keep the crown and upper roots exposed to air and avoid wetting them for the duration of the growing season. Refill the soil before rains start.

**Black-line disease (Cherry leaf roll virus (CLRV-W))**

- Use virus-free graft and bud-wood.
- Remove and destroy trees identified as being infected.

**Crown gall (Agrobacterium tumefaciens)**

- Plant disease-free nursery stock.
- Plant trees in well-drained soils.
- Avoid wounding the plants as much as possible.
- Fresh wounds can be treated with bio-control agent (*Agrobacterium tumefaciens* K84), if available, to prevent the bacterium from colonizing.

11. Harvesting

Walnut is mostly harvested in month of September and October. Some nuts fall down naturally after hulling in a natural way, rest have to be harvested by manual picking or beating with long poles.
Pre-harvest treatment with ethylene @ 200-300 ppm at packing tissue brown (PTB) stage proved better to induce early and uniform hull dehiscence in walnut.

Pomegranate (Punica granatum L.)

1. Land preparation
   - Soil should be well ploughed and all weeds should be removed. In heavy soils, ridges should be prepared to have better aeration of the root system in order to obtain higher production.
   - Pits of 2' x 2' x 2' (length, width and depth, respectively) are dug and refilled with the top 1' soil mixed with 15-20 kg well-decomposed farmyard manure or compost at least 1-2 months before actual planting.

2. Time of planting
   - In Sikkim, January-February planting is suggested.

3. Method of planting
   - Pomegranate is planted at a distance of 4 m x 4 m on terraces in contour system of plantation.
   - The rows should be oriented in north-south direction to maximize the use of sunlight.
   - Irrigation is essential after planting if there is no possibility of immediate rainfall.

4. Cultivars
   - Bhagwa (Sinduri), Kandhari, Mridula, Ganesh, Bedana etc.

5. Organic nutrient management
   - Pomegranate plants should be manured twice a year i.e., June-July and December-January.
   - FYM @ 15-25 kg/tree and/or vermicompost @ 4.5-9 kg/tree may be applied annually in two equal splits either sole or in combination for sustained optimum yield.
   - Neem cake @ 2 t/ha should be applied during active growth stage in July-August.
   - Micronutrients are essential for proper growth and fruiting in pomegranate and these can be applied through foliar sprays of water soluble organic sources @ 0.2 per cent.
• Application of soil amendment such as dolomite @ 100-200 g/plant every second year is essential to maintain the soil pH.

• Manure and irrigation should be strictly applied in the basin of the plants to avoid insect pests and diseases.

6. Intercropping

• Commercial fruit bearing generally starts after 3 to 5 years; till then the unoccupied interspaces between the young trees should be intercropped with leguminous crops like pea, garlic, and leafy vegetables, root vegetables etc.

• Intercrops having high intercultural requirements should be avoided. The intercrop should be short duration and shallow-rooted.

7. Water management

• Pomegranate should be watered just after planting in the absence of rains.

• Irrigation during January-February helps in getting good vegetative flush.

• Irrigation improves plant growth, flowering and fruiting in pomegranate.

• Irrigation is given to make the soil root zone moist; thus, heavy irrigation is unnecessary. However, drip system of irrigation shall be best for harvesting quality fruits and conservation of water during winter months.

8. Weed management

• Manual weeding with the help of khurpi or hand hoe is the best pre-monsoon method to control the weed population.

• Hand-weeding should be done carefully to avoid injury to the roots.

• Ploughing, spading of basins, etc. are important inter-cultural operations for soil aeration and tree health.

9. Training and pruning

• Generally, pomegranate tree will have few trunks 3-5 in modern orchards. The trees are trained to grow as an open vase. In such a way that light penetrates the trees from between the rows as well as from the inside of the trees.
If the main trunks are bent too much, binding them with strong material to the opposite side branches is undertaken.

Trees should be pruned to check overcrowding in the orchard.

In order to achieve the desired shape trees are pruned in winter, some care is also taken during summer. In winter, pruning the height of the trees is reversed to the desired height.

Broken, bent, and interfering branches are removed. In order to keep the interior of the tree open during growing season, and according to need, summer pruning is done.

10. Mulching

Mulching is essential to avoid weed problem in the field during rainy season and moisture conservation during winter season.

Mostly, leaf mulch is recommended for mulching of pomegranate plantations. The best mulching material in Sikkim is Schima wallichi (chilaune) followed by Artemisia vulgaris (titepati), which minimize some disease problems also.

Weed growth can also be checked by mulching with black plastic mulch.

11. Crop protection

Insect pests management

Fruit borer, thrips and bark eating caterpillar are some important pests of pomegranate.

Remove and destroy the affected fruits for management of fruit borer.

Bag the fruits with butter paper before maturity.

At flowering stage, spray neem oil (1500 ppm) @ 3 ml/l at 15 days interval.

Do not inter-cultivate crops like chilli and onion for thrips; remove and destroy affected plant parts.

Use blue sticky traps @ 1 trap/10 plants.

Maintain orchard sanitation by avoiding overcrowding of trees. Clean the cobwebs around the affected portion and inject kerosene oil into the holes and seal with mud.
Disease management

Wilt (*Ceratocystis fimbriata, Fusarium oxysporum*)
- Adequate drainage should be provided.

*Cercospora leaf and fruit spot (*Cercospora punicae]*)
- Prune and destroy affected branches.
- Diseased fruits should be collected and destroyed.
- Spray copper oxychloride @ 0.3 per cent.

*Bacterial blight (*Xanthomonas oxynopodis pv. punicae]*)
- Provide wide row spacing.
- Prune the affected branches and burn.
- Select disease-free plants.
- Spray copper oxychloride @ 0.25 per cent or calcium chloride @ 1.5 per cent.
- Variety Wonderful is resistant to bacterial blight.

*Alternaria fruit spot (*Alternaria alternata]*)
- All the affected fruits should be collected and destroyed.
- Protective spraying with copper oxychloride @ 0.25 per cent is recommended.

*Anthracnose (*Colletotrichum gloeosporioides*)
- Protective spraying with copper oxychloride @ 0.25 per cent or wettable sulphur 0.3 per cent is recommended.

12. Harvesting
- Pomegranate fruits are harvested when rind attains the desired colour.
- The fruits are clipped off from the stalk with a pair of sharp scissors. Harvesting is generally done at weekly interval.
Insect pests

*Brassica* spp.

- Mustard aphid
- Saw fly
- Painted bug

Maize (*Zea mays*):

- Army worm
- Cob borer

Finger millet (*Elusine coracana*):

- Pink stem borer

Soybean (*Glycine max*):

- Leaf roller
Rice (*Oryza sativa*)

- White ear due to stem borer
- Dead heart due to stem borer
- Leaf folder damage

- Gundhi bug
- Dragon fly
- Spider

Chilli peppers (*Capsicum spp.*)

- Fruit borer damage
- Chilli aphid
- Tea mosquito bug
Ginger (*Zingiber officinale*)

- Shoot borer
- Leaf roller
- White grub damage

Tomato (*Lycopersicon esculentum*)

- White fly
- Fruit borer
- Pheromone trap for trapping adult of fruit borers

Large cardamom (*Ammomum subulatum*)

- Leaf caterpillar

Okra (*Abelmoschus esculentus*)

- Blister beetle
Mandarin (*Citrus reticulata*)

- Trunk borer damage
- Bark eating caterpillar
- Shoot borer
- Aphid
- Leaf miner
- Mealy bug
- Huanglongbing
- Lemon butterfly
Cole crops (*Brassica* spp.)

- Cabbage butterfly
- Cabbage semi-looper
- Diamond black moth
- Cabbage aphid
Diseases of foodgrain crops

Diseases of Rice

- Blast
- Brown spot
- Sheath blight
- Bacterial leaf blight

Disease of Soybean

- Rust
- Powdery mildew
Diseases of Blackgram

- Anthracnose
- Yellow mosaic
- Leaf crinkle
- Rust
- Powdery mildew

Diseases of Mustard

- Anthracnose
- Yellow mosaic
- Leaf crinkle
Disease of Maize

- Turcicum leaf blight
- Maydis leaf blight

Disease of Fingermillet

- Blast
Diseases of horticulture crops

Disease of Cole crops

Club root

Damping off

Black rot
Disease of Tomato

- Early blight
- Late blight
- Bacterial wilt
- Damping off
- Mosaic
- Laef curl

Disease of Cucurbits

- Powdery mildew
- Downey mildew
Disease of Pea

- Powdery mildew
- Rust

Disease of Potato

- Late blight
- Early blight
Disease of Capsicum and Chilli

- Anthracnose
- Cercospora leaf spot
- Phytophthora root rot
- Leaf curl
- Mosaic

Disease of Ginger

- Soft rot
- Bacterial wilt
- Dry rot