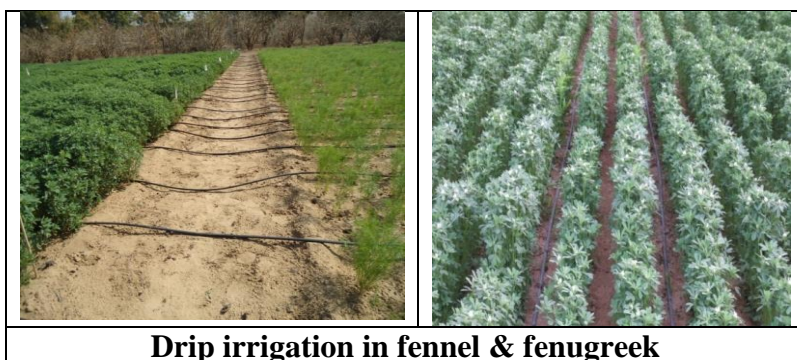


ICAR- AICRPS plays an important role in the development of varieties suitable to different agro climatic regions and addresses the problems faced by the farming community on crop diseases, crop management practices during adverse and aberrant weather conditions. ICAR- AICRPS has developed 176 crop wise technologies for varietal improvement, nutrient availability and plant health management in various spice crops. During 2010-19, about 48 technologies were developed (summarized below) for increasing the production, productivity and sustainability of spices and to solve the problems faced by the Indian Agriculture.

More crop per drop- for efficient utilization of water

- **Black pepper**-Drip irrigation in black pepper @ 8 litres of water daily and 50 RDF (half the Recommended Dose of Fertilizer as liquid fertilizer – 19:19:19 mixture) in 3 equal splits at weekly intervals during the months of June, September and February was beneficial than the conventional method of irrigation and basal fertilizer application with the highest benefit cost ratio (2.07).
- **Turmeric**- Application of water through drip system at 80% pan evaporation (once in a day for 45 minutes) increases 10-15 % yield in turmeric. Total water to be applied is 538.40 ha mm.
- **Coriander**- In water deficit situation only one irrigation with Raingum/Sprinkler at flower initiation or two irrigations, i.e., at flower initiation and grain filling stages is highly beneficial and increased the yield by 20.0% compared to rainfed.
- **Fennel**- Application of irrigation water by drip at 0.8% IW/ CPE ratio on alternate days with paired row planting resulted in increase in seed yield and along with 19% saving irrigation water in comparison to surface irrigation.
- **Fenugreek**- Application of irrigation water by drip at 0.6% IW/ CPE ratio on alternate days with paired row planting resulted in higher seed yield along with 35% saving irrigation water in comparison to surface irrigation



Drip irrigation in fennel & fenugreek

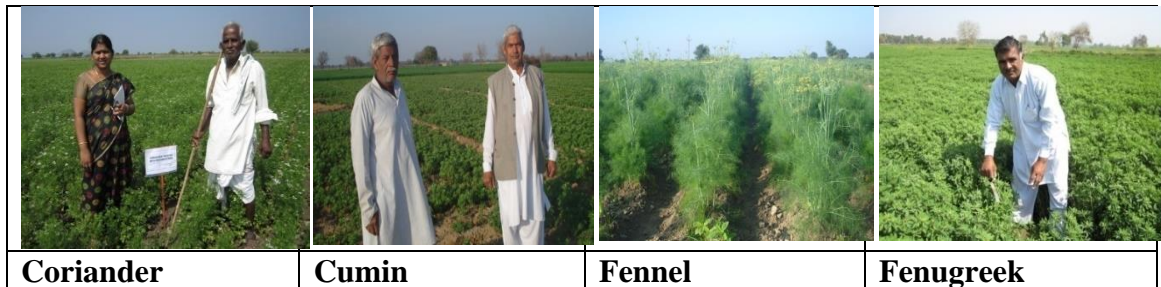
Fertigation – for precise nutrient use efficiency

- **Small cardamom**- Application of irrigation 9 litres per clump per day along with 100% recommended dose of fertilizers through drips gives the highest capsule yield (316.16 kg ha⁻¹) in cardamom with BC ratio of 3.37.

- **Turmeric-** Application of 100% RDF with urea and potash as straight fertilizers and P as water soluble fertilizer weekly once gives an yield of 49.11 t/ha and also saves labour and 40% water requirement with BC ratio of 2.94. Recommended for turmeric growing areas of Tamilnadu. Around 30% turmeric growing farmers adopt this technology in Tamil Nadu.
- **Coriander-** Fertigation with water equal to 80% of actual evaporation (0.8 IW/CPE ratio) at an interval of 2-3 days with recommended dose of fertilizers through soluble fertilizers at different growth stages (20, 40, 60 & 80 DAS) is recommended for improving the yield and WUE in coriander in light textured soils of India. By adoption of this method 18.7% water can be saved along with 45% increase in yield of coriander as compared to conventional practice with BC ratio of 3.62.
- **Cumin:** Fertigation with water equal to 60% of actual evaporation (0.6 IW/CPE ratio) at an interval of 4 days and 80% recommended dose of fertilizers through soluble fertilizers at different growth stages (10, 20, 40, 50, 70& 80 DAS) is recommended for improving the yield and WUE in cumin in light textured soils of India with 20% water saving and B:C ratio of 1.50.
- **Fennel-** Fertigation with water equal to 80% of actual evaporation (0.8 IW/CPE ratio) at an interval of 2-3 days with 75% recommended dose of fertilizers through soluble fertilizers at different growth stages (20, 40, 60, 80 & 100 DAS) is recommended for improving the yield and WUE in fennel in light textured soils of India. By adoption of this method 25% fertilizer and 18.9% water can be saved along with 51% increase in yield of fennel as compared to conventional practice with BC ratio of 3.73.

Organic nutrient management- for food safe spice production

- **Small cardamom** –Monthly application of Jeevamrutha (20 l plant⁻¹) along with 10 g each of biofertilizers (*Azospirillum* and PSB) and bio-control agent (*Trichoderma viride*) along with 30 tonnes of compost is recommended as an organic production practice for the Cardamom Hill Reserves, Kerala with BC ratio of 2.15.
- **Coriander-** Soil application of Phosphate Solubilizing Bacteria (PSB) @15 kg ha⁻¹ or *Azospirillum* @15 kg ha⁻¹ along with NPK@ 60:40:30 kg ha⁻¹ is recommended for improving the productivity of coriander with yield enhancement of 47.6% and BC ratio of 2.20 in Bihar.
- **Cumin-** Application of 100% in organic nitrogen + *Azospirillum* @ 1.5 kg/ha as seed treatment + 5 t FYM /ha resulted in highest seed yield (320 kg/ha) at Jobner.
- **PGPR technology in seed spices-** - An eco friendly, seed coating technology in coriander, cumin, fennel and fenugreek using PGPR (FK 14 & FL 18) isolates was developed for increased yield (10-30%), enhanced seed germination, reduced storage pest incidence and suitable for mechanical sowing. It is a low cost technology which enhances seed quality and viability during storage. The farmers who adopted this technique are very much satisfied.



Micro nutrient supplementation – for balanced nutrition

- **Black pepper-** Foliar application of Zn (0.25%) twice, once in June and again in August is recommended for increasing the yield. Basal soil application of 6 kg Zn and 1.0 kg Mo is beneficial for increasing yield and quality of black pepper under deficient conditions
- **Small cardamom-** Application of boron in the form of disodium tetraborate @ 20 kg/ha or molybdenum in the form of sodium molybdate @ 0.25 kg/ha mixed with appropriate quantity of FYM @ 2 kg/plant at the onset of monsoon (May 1st or June first week).
- **Ginger-** Soil application of borax @ 5 kg/ha recommended for increased yield in West Bengal.
- **Turmeric -** For iron deficient soils of Bihar (1.73ppm), foliar application of Ferrous sulphate @ 0.5% at 60 & 90 days after planting is beneficial for yield enhancement with Cost: Benefit ratio of 1:2.54.
- **Fennel-** Application of fertilizer to fennel with RDF of 90 + 30 kg NP per ha along with 200 kg FYM enriched with 3.0 kg Fe + 1.5 kg Zn per hectare as basal application in furrow for light textured soils deficient in iron and zinc produces maximum yield (14.27 q/ha) with a BC ratio of 2.11.
- **Crop specific micro nutrient mixtures for spices (black pepper, ginger, turmeric)-** Recommended @ 5g/L water and applied as foliar spray at 60 days after planting and 90 days after planting; spraying twice in a year at April - May and August - September for black pepper. Yield increase of 15 to 25% and improvement in quality recorded and realized by farmers in black pepper, ginger and turmeric.

Integrated nutrient management- for maintenance of soil and plant health

- **Black pepper-** Application of FYM 10 kg, *Azospirillum* 50 g, Phosphobacteria 50 g, *Trichoderma* 50 g, *Pseudomonas fluorescens* 50 g, NPK 50:50:200 g vine⁻¹ per year from 3rd year onwards increased the yield in Kerala.
- **Small cardamom-** In acidic loamy soils of Kerala, application of 2 kg dolomite for 3 years improves the yield (2763.30 g plant⁻¹) in cardamom with B: C ratio of 2.42.
- **Ginger-** For integrated nutrient management in ginger the fertilizer dosage of FYM @ 30 t ha⁻¹ + NPK 80:50:50 kg ha⁻¹ under Bihar conditions was recommended. Application of neem cake 2 t ha⁻¹ together with inorganic fertilizers increased the availability of nutrients in soil, increased yield and reduced incidence of rhizome rot.

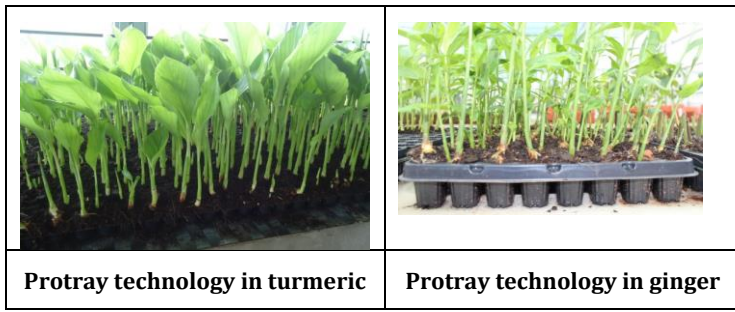
- **Turmeric-** Soil application of FYM @ 30 t ha⁻¹ + Vermicompost @ 20 q ha⁻¹ + Neem oil cake @ 8 q ha⁻¹ resulted in 68% increase in yield over control with C: B ratio of 1:3.64. Also, soil application of inorganic N @ 150 kg ha⁻¹ + *Azospirillum* @ 1.5 kg ha⁻¹ + FYM @ 5 t ha⁻¹ results in 35% increase in yield over control with C: B ratio of 1:5.27.
- **Nutmeg-** Application of 100 kg FYM, 400 g N, 300 P₂O₅ and 1200 g K₂O/tree/year and 50 g each of *Azospirillum* and phosphobacteria recorded highest yield.
- **Clove-** Application of 50g each of *Azospirillum* (10⁻⁶ CFU) and phosphobacteria (10⁻⁵ CFU) with 400 g N, 350g P₂O₅ and 1200 g K₂O/tree/year in two equal splits in May - June and October – November resulted in the highest green bud yield.
- **Coriander-** Soil application of inorganic N @ 33 kg ha⁻¹ + *Azospirillum* @ 1.5 kg ha⁻¹ + FYM @ 5 t ha⁻¹ resulted in yield of 1.98 t ha⁻¹ (56% increase in yield over control) and C: B ratio of 1:1.77.
- **Off season coriander-** Application of NPK @ 30:40:20 kg per ha along with spraying of GA @ 15 ppm at 20 DAS give maximum leaf yield of coriander (4824 kg ha⁻¹) with yield increase of 25% over control.
- **Multicut coriander-** Application of NPK as 60:30:00 kg ha⁻¹ as full dose of phosphorus and half dose of nitrogen as basal as well as remaining half dose of nitrogen after first cut i.e. 40-45 DAS for securing maximum yield (18 q ha⁻¹) and B:C ratio (2.5).
- **Cumin-** Application of 100% in organic nitrogen + *Azospirillum* @ 1.5 kg ha⁻¹ as seed treatment + 5 t FYM ha⁻¹ resulted in highest seed (320 kg ha⁻¹) at Jobner.

Clear cultivation technologies

- **Utilization of herbicides for the effective control of weeds in ginger for Andhra Pradesh-** Under severe shortage of labour for hand weeding, application of Oxyflurofen as Pre-emergent herbicide @ 500 ml per ha at second day after sowing followed by application of Quazilophop ethyl as Post-emergent herbicide @ 1 litre per ha at 30 days of crops stage followed by hand weeding at 90 days of crop stage reduces 3-4 manual hand weeding and gives a BC ratio of 2.96 with an yield of 22.79 t/ ha. Recommended for Chintapalle region.
- **Management of blight and powdery mildew in cumin -**Line sowing of cumin@ 30 x 10 cm and application of Potash @ 20 kg/ha along with recommended dose of fertilizers reduces the incidence of blight (PDI- 17.3) and powdery mildew (PDI- 5.7) with maximum yield (363 kg / ha) and BC ratio of 2.41 at Gujarat.

Rapid multiplication of planting materials- for minimal expenditure

- **Single bud protray method in ginger and turmeric-** Rhizome bits of 5-6 g with a bud planted in protray requires 1/4th of planting material requirement of conventional propagation. It saves 60% cost of seed rhizome and ensures 98- 100% field establishment with disease free planting materials suitable for early/ delayed planting.



Integrated pest and disease management- for sustainable spice production

- **Grafting of black pepper with *Phytophthora* resistant root stock-** A technique of grafting black pepper on *Phytophthora* resistant root stock, *Piper colubrinum* was developed which is an eco-friendly way to manage *Phytophthora* foot rot in water logged arecanut gardens reducing the excessive use of fungicides.
- **Integrated management for pseudostem rot in small cardamom-** Chemical control by drenching of Carbendazim @ 2 g l⁻¹ (5 l plant⁻¹) at monthly intervals from Feb-May or biological control by combined application of *Trichoderma harzianum* (50 g with 1 kg neemcake) + *Pseudomonas fluorescens* (2% spray) helps in checking disease
- **Eco-friendly technology for management of pests of cardamom in Kerala-** Spraying Ponem 2 ml l⁻¹ gives 50% reduction of shoot borer infestation and spraying Imidacloprid 200 SL (0.5 ml l⁻¹) gives 90% reduction of thrips infestation in cardamom.
- **Control of rhizome rot of ginger by biofumigation:** Crop residues of mustard and cabbage incorporated in soil (Biofumigation) and rhizome treatment with Metalaxyl + Mancozeb 1.25 g L⁻¹ of water for 15-20 minutes helps in controlling soil borne pathogens and is environmentally safe.
- **Management of *Phyllosticta* leaf spot in ginger using new molecules in different regions**
 - **Solan:** Spray with Hexaconazole two times at 20 DI (0.1%) gives 78.72% reduction of *Phyllosticta* leaf spot with B:C ratio of 1:09.
 - **Dholi:** Carbendazim (0.1%) + Mancozeb (0.1%) first at disease appearance and subsequently two sprays at 20 days interval after 1st spray or Foliar spray with Propiconazole (0.1%) first at disease appearance and then 2 times at 20 days interval or Foliar spray with Tricyclazole (0.1%) first at disease appearance and then 2 times at 20 days interval.
 - **Raigarh:** Foliar spray with Carbendazim: Mancozeb (1:1) (0.1%) first at a disease appearance with two times at 20 days of interval controls *Phyllosticta* leaf spot with the disease intensity of 14.52% and B:C ratio of 1:2.6
 - **Pundibari:** Spray with Hexaconazole (0.1%) or with Propiconazole (0.1%) first at disease appearance and then two times at 20 days interval manage *Phyllosticta* leaf spot of ginger upto 60% with B:C ratio of 1:2.07.
- **Bacterial wilt management in ginger-** For organic system of cultivation, adopting soil solarization along with the biocontrol agent, *Bacillus licheniformis* (GAP107 MTCC12725)




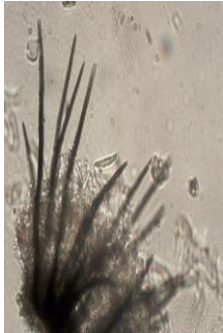




launched as *Bacillich* controls bacterial wilt in ginger with B:C ratio of 3.23. For inorganic system of cultivation, CaCl_2 along with soil solarization controls the disease with B:C ratio of 2.88 (both treatments to be imposed at the time of planting and at 30, 45, 60 and 90 days after planting).



View of bacterial wilt management trial of ginger at Kozhikode

- **Management of foliar disease of turmeric in Bihar**-Pre-planting treatment of rhizome and foliar spray of standing crop at 90, 105, 120 days after planting with Propiconazole (0.1%) controls *Colletotrichum* leaf spot and *Taphrina* leaf blotch with the per cent disease intensity of 18.34 and 21.67% respectively.
- **Management of *Colletotrichum* and *Taphrina* leaf blotch of turmeric at Chhattisgarh**-Rhizome treatment with Carbendazim + Mancozeb (1:1) (0.1%) + foliar spray of Carbendazim + Mancozeb (0.1%) on 45 and 90 days controls *Colletotrichum* leaf spot of turmeric with the disease intensity of 13.64 % and B:C ratio of 1:2.8. In the case of *Taphrina* leaf blotch of turmeric, seed rhizome treatment with Azystrobin (0.1 spray on 45, 75 and 105 DAP days gives low disease intensity of 15.48 % and B:C ratio of 1:2.8
- **Treatment for stem gall of coriander**- Seed treatment with IISR *Pseudomonas* talc formulation @ 0.40% followed by its foliar sprays @ 0.40% at 40, 60 & 75 days after sowing is found to be effective in control of stem gall of coriander in the susceptible variety Rajendra Swati.
- **A cost effective method for controlling powdery mildew of coriander**- An eco-friendly biocontrol method of spraying neem seed kernel extract (NSKE) @ 5% thrice, first spray immediately after the appearance of disease and the subsequent two sprays at 15 days interval controls the disease.
- **Management of powdery mildew in coriander using new generation fungicides**- Foliar spray of hexaconazole 5% SC (1.0 ml litre⁻¹ of water) at the time of initial appearance of disease and second spray after 15 days interval controls powdery mildew of coriander with B:C ratio of 4.75.

- **Integrated management for cumin wilt disease**- seed treatment with *T. harzianum* as well as soil application along with spraying of topsin (0.07%) or mancozeb (0.3%) and neem oil controls the disease.
- **Organic nutrient and disease management in cumin**- Soil application of vermicompost (2 t ha⁻¹) + seed treatment with *Trichoderma* (6g kg⁻¹) and spray of neem seed kernel extract 5% were recommended for organic production and management of diseases like blight and wilt of cumin with B:C ratio of 2.29.
- **Bio-efficacy of newer molecules of insecticides against cumin aphid** -For effective and economical management of cumin aphid, foliar spray of thiamethoxam 25WG (25g a.i. ha⁻¹ ; 2.5 g 10 L⁻¹ water) at 10% umbels infestation by aphids followed by spray of thiacloprid 21.7SC (25g a.i ha⁻¹ ; 2.88 g 10 L⁻¹ water) after 10 days is recommended for effective control of aphids in cumin growing regions of Gujarat with BC ratio of 21.64.
- **Chemical management schedule for cumin blight** -Spraying of kresoxym methyl 44.3 SC (1 ml L⁻¹), mancozeb 75% WP (3.7 g L⁻¹) and difenaconazole 25 EC (0.5 ml L⁻¹) at 40, 50 and 60 days after germination is recommended for effective management of blight in cumin growing regions of Gujarat with per cent disease intensity (PDI) of 21.32 and BC ratio of 21.64 *Taphrina* leaf blotch of turmeric

			
Phytophthora foot rot of black pepper	Shoot borer infestation in small cardamom	Colletotrichum leaf spot in turmeric	
			
Well maintained field of large cardamom	Stem gall infestation in coriander	Taphrina leaf blotch of turmeric	

Transfer of technology to reach farmers

As "Seeing is believing" to make the technologies visible to farming sector, scientists are actively involved in the demonstration of the technologies/varieties developed by the centre. ICAR-AICRPS is demonstrating around 19-20 technologies per year in the farmer's field.



Tribal welfare- Reaching the unreached

ICAR- AICRP on Spices under Tribal Sub Plan has 3 centres viz., Pottangi in Odisha, Chintapalle in Andhra Pradesh and Raigarh in Chhattisgarh. These centres work for the welfare of the tribal community. For the production of quality planting material of spices a polyhouse facility is also provided to these centres with the AICRPS funding of Rs. 10 lakh per centre. Quality planting materials of spices were distributed to the tribal farmers of Pottangi, Chintapalle and Raigarh area apart from conducting trainings.

Varietal spread- for uplifting the tribals

- **Black pepper**-about 80% of the Visakhapatnam district is occupied by Panniyur-1 variety of Black Pepper. Further, more Black Pepper varieties are under evaluation in CVT trials for their higher yield and *Phytophthora* disease

resistance.

- **Ginger**- Nadia and Suprabha were selected to be best yielders in ginger in the tribal belts
- **Turmeric**- IISR Prathibha and Roma with high yield and curcumin content were best suited for tribal regions and cover around 2000 ha in tribal region of Chintapalle, Andhra Pradesh. 1000 tonnes of organically grown Roma is produced in Odisha.

Supply of planting materials- for improving tribals

- About 25,000 cuttings of black pepper (Panniyur-1) are being supplied annually to the tribal farmers of Visakhapatnam agency area.
- Over 100 tonnes of turmeric nucleus seed (Roma rhizomes) supplied to tribal farmers for area expansion under turmeric in agency mandals.
- Over 25 tonnes of seed of Nadia and Suprabha was supplied for Ginger area expansion in the tribal agency mandals of Visakhapatnam district.
- Rendering help to Girijana Vikasa, an NGO from Andhra Pradesh for growing/production of ginger and turmeric in tribal areas.

Training programmes- *for empowering tribals*

- Farmers training programmes were conducted in 15 villages in Chintapalle of Andhra Pradesh, Pottangi of Odisha and Raigarh of Chhattisgarh to make awareness on high production technologies and quality up gradation in spices benefitting mostly women farmers.
- Demonstrations were conducted on single bud propagation of turmeric and ginger in Chhattisgarh and Odisha.



North East- *Exploring the unexplored*

ICAR-AICRP on Spices works for the development of North Eastern regions through its seven centers located in six states catering the research on crops like black pepper, ginger, turmeric and large cardamom. ICAR- AICRPS has 5 Co-opting centers catering to the states of Arunachal Pradesh, Mizoram, Meghalaya and Sikkim. Two new co-opting centers approved in 12th Plan and started functioning during 2015 cater the needs of Nagaland and Assam. Infrastructure for small micro irrigation and poly houses were being built for reduced water usage and production of quality planting materials in NE States.

ICAR-AICRPS centres functioning in North East

State	University	Centre	Crops
Arunachal Pradesh	CAU	Pasighat	Ginger, turmeric
Assam	AAU	Kahikuchi	Black pepper, turmeric
Meghalaya	ICAR RC NEHR	Barapani	Ginger, turmeric
Mizoram	ICAR RC NEHR	Mizoram	Ginger, turmeric
Nagaland	SARD, NU	Dimapur	Black pepper, ginger, turmeric
Sikkim	ICAR RC NEHR	Tadong, Gangtok	Large cardamom, ginger, turmeric
Sikkim	ICRI, Spices Board	Tadong, Gangtok	Large cardamom

Genetic resources- *hot spot of variability*

- ICRI Regional Station, Gangtok conducted survey at different districts of Sikkim, Darjeeling and Arunachal Pradesh which resulted in the collection of seventeen large cardamom accessions and their related species.
- Twenty four high yielding released varieties of turmeric introduced in to Meghalaya, Mizoram, Nagaland and Arunachal Pradesh. Six germplasm of ginger were collected and planted at Kahikuchi centre for evaluation and multiplication.
- Ten vegetable type bold gingers from Nepal collections were introduced in to Meghalaya, Mizoram, Nagaland and 15 from Arunachal Pradesh.

Improved varieties – for high yield and quality

- **Turmeric-** Introduced 12 high yielding varieties of turmeric viz., Rasmi, Prathibha, Alleppey Supreme, Duggirala Red, IISR Kedaram, Roma, Rajendra Sonia, Suranjana, Megha, NDH 1 and BSR 2 to NE States.

Megha Turmeric -1 was found to be the best for Meghalaya and NDH-98 gave maximum rhizome yield (22.64 t ha⁻¹) in Arunachal Pradesh

In Mizoram, turmeric varieties viz., Megha Turmeric -1, IISR Prathibha, NDH 1 and Duggirala red were the best for yield while Rajendra Sonia, NDH 1, BSR 2, Duggirala red and Megha were the best for curcumin.

- **Ginger-** Introduced seven high yielding varieties of ginger viz. Nadia, IISR Varada, IISR Rejatha, Surabhi, IISR Mahima, Himgiri, Suprabha to NE States to increase the farm yields. Ginger varieties Himgiri and Nadia were best in Mizoram, Suravi and Nadia in Pasighat while IISR Mahima, Maran and Nadia are best in Meghalaya whereas Gorubathan and Bhaise are the best ginger varieties in Arunachal Pradesh.
- **Black pepper-** Sixteen released varieties of black pepper were introduced to Assam and Nagaland for multiplication and distribution. Panniyur 1 and Panchami (Aimpiriyan) are performing well in Assam.
- **Large cardamom-** In Sikkim the large cardamom cultivar Verlange is the most consistent yielder in all elevations and is performing better than the older varieties like Golsay, and Ramsey. Sawney is the low altitude variety performing well.
- Large cardamom Guide and organic production packages of large cardamom for North East has been published in collaboration with Spices Board.

Training programmes – for knowledge dissemination

- Training programmes on improved spice production technologies and spice clinics were organised for educating the people in North East
- Two hundred and twenty FLDs were conducted on seed spices like coriander, fenugreek, ajwain and nigella at farmers' fields to disseminate technologies with respect to improved varieties
- To train the people working in black pepper plantation in the North East about the Nursery and high production technology in black pepper, a two days training program "Pepper Mitra" was conducted in collaboration with Assam Agriculture University and ICAR- IISR, Kozhikode at Kahikuchi, Assam.



Project Coordinator interacting with tribal cluster of Lungwah village of Nagaland



Survey in the large cardamom area of Anjaw district of Arunachal Pradesh



Black pepper field in Namsai, Arunachal Pradesh



Training programme at Kahikuchi, Assam