4. Farmer's Field Study

To enhance the production of artemisinin in plant and commercialize the cultivation of *A.annua*, the following study was taken up in different parts of the country (fig 4.1)

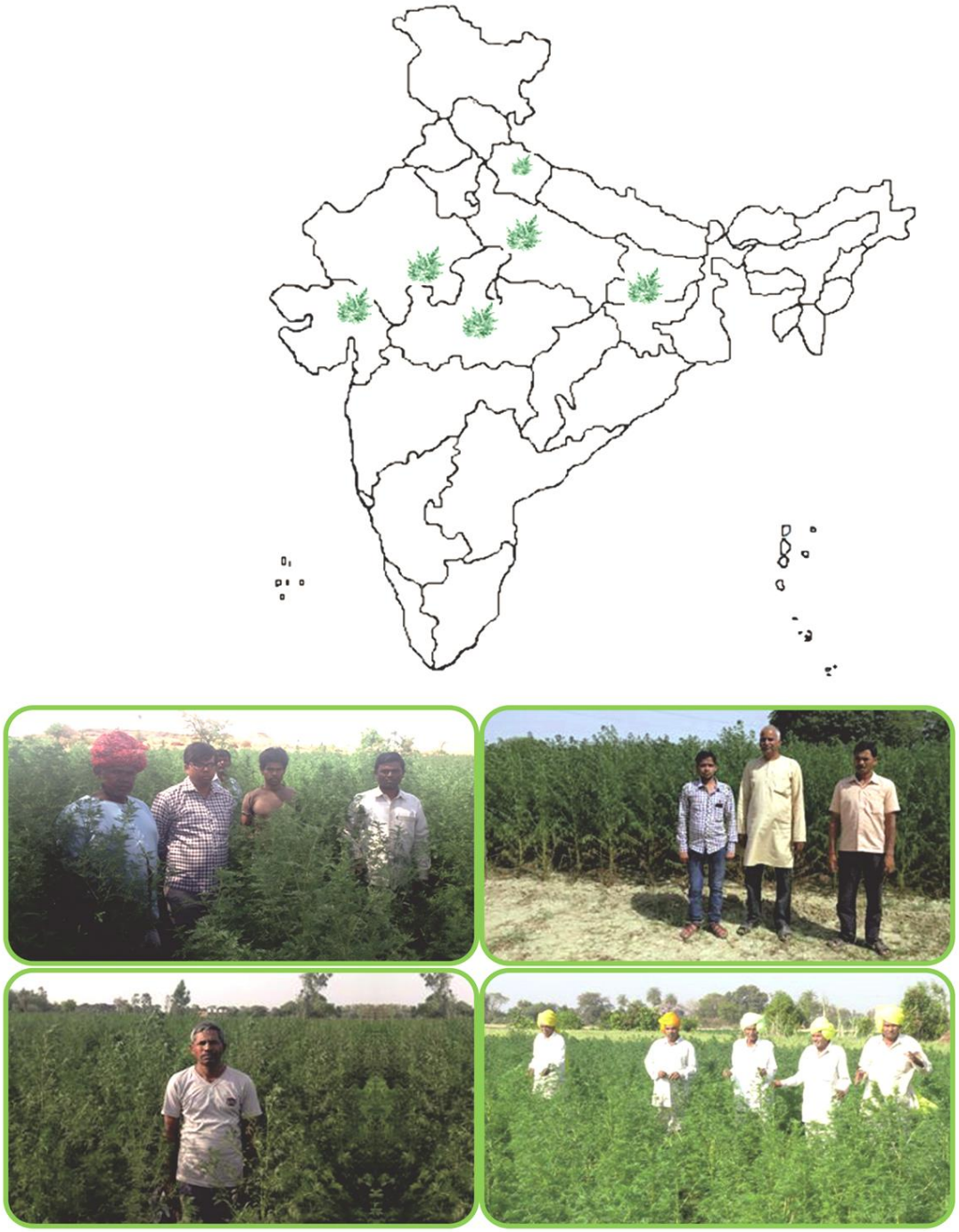

Figure 4.1: *A.annua* cultivation in different parts of the country

Anti-malarial drugs extracted from the Chinese plant *A.annua* have the potential to reduce greatly the incidence of malaria worldwide and, in combination with other approaches to pest management, to contribute ultimately to elimination of the disease. To reach this goal higher-yielding *Artemisia* varieties and cultivation methods are needed, together with more effective approaches to artemisinin extraction, manufacture and distribution of ACTs, and use of the drugs in a manner which delays appearance of resistant parasites and extends their useful life.

Over the last ten years as the worldwide demand for artemisinin has become apparent, Chinese, Vietnamese and Indian plant breeding institutes have followed Mediplant's example in developing high-yielding Artemisia hybrids. Factories have sprung up in all three countries to extract artemisinin and manufacture anti-malarial drugs. Between 5,000 and 15,000 ha of commercial Artemisia are now estimated to be planted annually worldwide, the exact area following fluctuations in the price of artemisinin and hence in the viability of the enterprise both for farmers and for pharmaceutical companies.

There is an increasing demand on medicinal plant resources due to the worldwide buoyancy in the herbal sector engaged in production of herbal health care formulations, herbal nutritional supplements. Forest resources are unable to meet the full requirement of medicinal and aromatic plants. Therefore, emphasis should be on encouraging cultivation of the potential medicinal and aromatic plants to meet out the sustainable supply of raw material for the use of industry. To meet out the raw material demand of the medicinal and aromatic plants, there is a lack of trained man power and knowledge among the farmer on production

and processing aspects. To boost the production of medicinal and aromatic plants in the country, there is an acute need for training of farmers for sustainable harvesting and cultivation of medicinal and aromatic plants. Thus, the knowledge of conservation, propagation, cultivation, maintenance and sustainable commercial use of these natural resources are essential. Cultivation of medicinal plants offers the opportunity to optimize a remunerative profit from production and these crops are also less affected from adverse weather condition, grazing animals and wild animals Also, ever increasing input costs have resulted in poor diminishing returns in conventional agriculture leading to farmer's inclination towards urbanization. Medicinal and aromatic Plants (MAPs) as natural source of raw material for industrial products, offer a great scope for the farmers to achieve net higher returns. Many medicinal and aromatic plants do not require intensive agri-inputs and grow well under natural stress conditions. Many of the farmers are now cultivating these crops in different part of the country and getting better return from other traditional crops. Some of the crops are also cultivated in under-utilized land i.e. in saline and rainfed lands or under shed conditions like in orchards or plantation crops etc. These crop can also be cultivated as inter crop in the existing crop like pulses, cereals etc.

There is unprecedented demand for natural medicines, green health products, pharmaceuticals, food supplements, cosmetics, and herbal pesticides to bring about this alarming loss of plant biodiversity. The sustainable production, conservation and use of medicinal plants are influenced by a number of factors, largely of socio-economic, technical, institutional and policy nature. Medicinal plants-based drug industries and enterprises which run into thousands presently source more than 85% of their raw materials from the wild as they are cheap and believed to be of higher potency. There is a great need to reduce pressure on the in-situ sources by diversifying the production sites of these important plants. Domestication is one of the alternatives being attempted but given the large population of

developing countries living below poverty line and growing need for economic and environmental security, it is unlikely that the current lands devoted to pure or mixed agriculture or forestry can be diverted to grow medicinal plants in a significant amount.

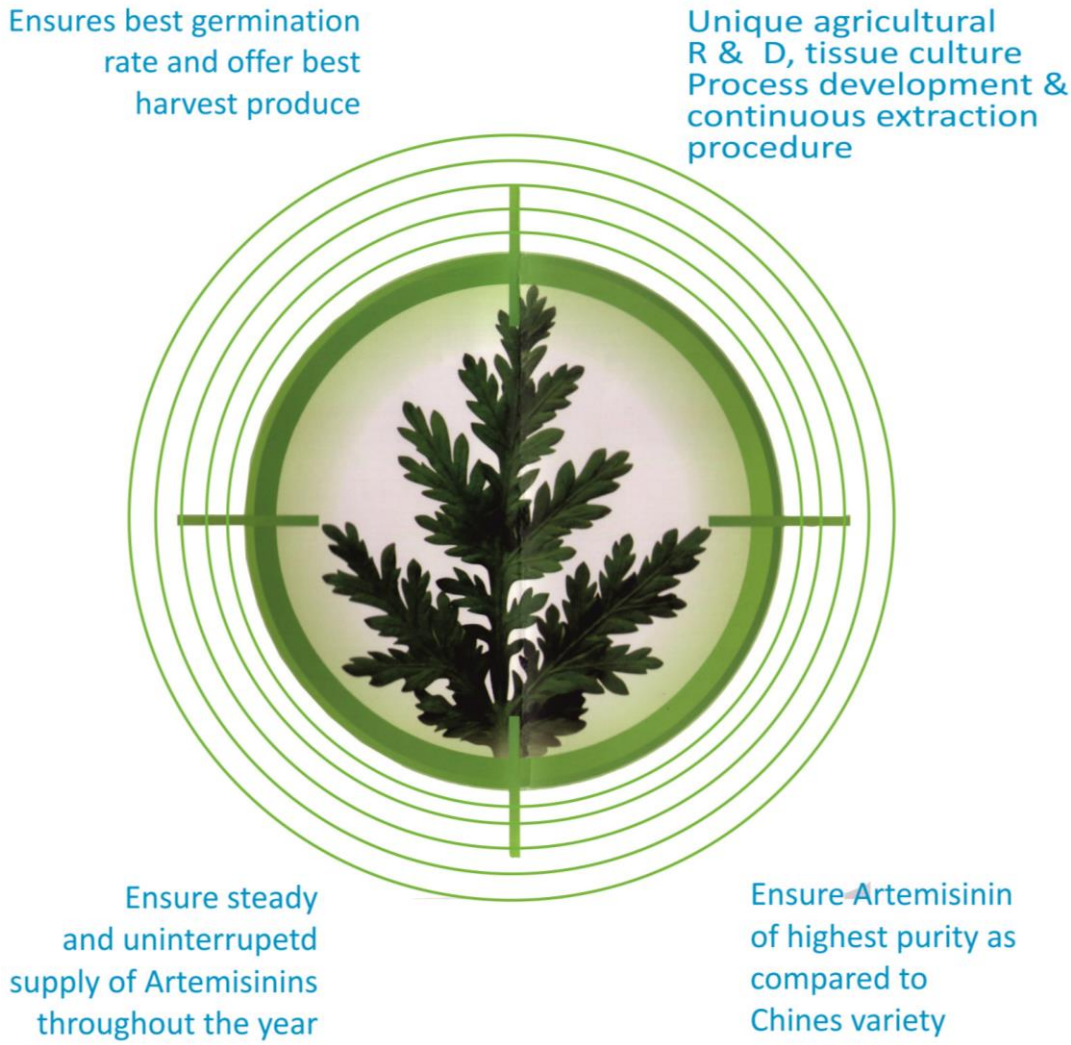

Fig 4.2: Integrated approach for artemisinin production

Material and methods

Once the experimental studies were over, the field experiments were done at farmer's field. The suitable soil type from sandy loam to loamy soil, free from water logging was used. A well drained light loam soil rich in organic matter is best for its cultivation. pH ranged from 4.5 to 8.5. Nursery beds of convenient size were prepared. 250-500 g seeds were mixed with

sand, spread uniformly over the nursery beds and covered with a thin layer of soil or sand. The beds are kept moist. Seeds germinate in about 5-8 days. Seedlings were ready for transplanting after 6-8 weeks. Planting time for Ratlam and Vadodara was November-December and for Dehradun, December- January. The seedlings which were 6-8 weeks old, healthy and uniform were transplanted at a spacing of 75x75 cm between the plants.

Nursery

Propagation.

The plants are raised through seeds, which are sown during September & October month. The seeds were germinated in nursery beds. They were transplanted to field when they attain a height of 7-12 cms. or bearing 8 to 10 whorls of leaves.

Nursery preparation

For raising the seedlings, seeds were sown in the raised nursery beds. The nursery beds were made as raised bed, so that they do not flooded any time. There was an assured irrigation facility.

The beds were 1.0 m – 1.25 m. wide to facilitate hand weeding and watering with rose cans. The bed was of any convenient length along the slope, but generally not more than 10 M. This size of bed was sufficient for one-hectare land. While preparing bed, well-decomposed farmyard manure was mixed with top layer of the soil. Seeds were sown on the surface of these beds. The beds were kept moisted until the seeds germinate. The seeds germinate in about 8-10 days. About 40 to 50 g. seeds were sufficient for raising the seedlings required, for planting in one hectare of land. The seedlings were ready for transplanting after 45 days.

Field Preparation

Land preparation

The land was ploughed and diced three times, to produce a fine tilth before the seedling are transplanted after applying the required dose of manure & fertilizers. For convenient management the field was laid out into ridge and furrow method, the ridge and furrows were made in 'V' shape above 60 cm apart and about 20-25 cm deep.

Transplantation

Plantation

The seedlings were transplanted in rows that are 60 cm apart; the plant-to-plant distance was 45-60 cm. Depending upon the soil and climate condition, seedlings were planted in Oct. to Nov. in plains where climate was subtropical for planting. Field was first irrigated, one day prior to planting and after the seedlings were transplanted the field was again irrigated

Field Management

Weed control:

The field was kept free of weeds by manual weeding or mechanical weeder.2-3 weeding was required at early stage of plant growth.

Application of fertilizer:

The crop was provided with proper nutrients in the form of inorganic fertilizers @ Nitrogen 80 Kg / Ha , 60 Kg each of phosphorous and potassium for proper growth and yield. The full dose of phosphorous, potassium and 20kg of nitrogen (45Kg urea) was incorporated into the soil at the time of land preparation. The remaining 60kg of nitrogen (135kg urea) was applied in three equal doses at interval of 30, 60 days and after first cutting of crop.

Irrigation:

The field was irrigated frequently for establishment of the corp. Irrigation was done after 15 days interval in winter and every week during summer. Water logging must be avoided.

Insecticides:

Sometimes while ants (Termite) and caterpillar causes sudden plant death. To fight the attack. 10 Kg. / Ha. Chloropyriphos or other insecticides may be applied periodically.

Drying & Storage of Herb

The harvested material of *Artemisia annua* was dried in shade and leaves were separated manually. The dried leaves must be stored in 'Jute' bags. The dry leaves having moisture of 8-10 % are stored dry place.

Yield

The dry leaves yield about 2 ton / Ha, in two cuttings. The artemisinin content generally varies from 0.5 – 1.0 %.

Results and discussion

In India, *A. annua* was introduced by CSIR-CIMAP in 1986, from the Royal Botanical Gardens, Kew, England. Agro-technologies for its cultivation developed and released by CSIR-CIMAP which were fine tuned and modified to suit the local need of farmer in the study area. Dried leaves of the plants are used for extraction of artemisinin. Leaves are the principal source for the synthesis and accumulation of artemisinin1. Jeevan Raksha variety of *.A. annua* was used in cultivation study of farmer fields. in different states like Uttar Pradesh (UP), Bihar, Madhya Pradesh (MP), Uttarakhand and Gujarat with contractual cultivation (on buy-back guarantee basis) by the industry (Table 1). This crop is now becoming popular among a large number of farmers. The plant is now economically grown for enhancement of rural livelihood and creating job opportunities. It also fits well in the existing cropping pattern adopted by the farmers2. The present correspondence is a case study on *A.annua* crop

in Gujarat, with regard to PPP for The study was conducted during 2012–13 in three districts of Gujarat, namely Vadodara, Anand, and Nadiad. This is because in these districts contractual cultivation of *A. annua* is done by the farmers with a buy-back agreement with M/s Ipca Laboratories, Ratlam. In the surveyed districts 80 farmers were identified based on the information available. Those selected were mostly small and medium farmers according to their land holdings. These farmers were trained for the cultivation of *A. annua* through organizing of awareness camps and demonstrations in their fields. During the implementation of study, farmers fields were regularly visited for solving problems in cultivation and also for educating farmers about primary processing of *A. annua*. Primary data were collected through personal interviews using a well-thought-out questionnaire.

The present study was conducted to look into the public-private-partnership towards rural development: a case study of *Artemisia annua* crop in Gujarat, MP, UP, Uttarakkhand and Bihar.

This study was conducted during 2011-2012 & 2012-13 in the study area because in this district contractual cultivation of *Artemisia annua* is done by Ipca Lab, Ratlam with the technical guidance of the CSIR-Central Institute of medicinal and Aromatic Plants, Lucknow. From the selected district 60 farmers were selected purposively based on the information available with the Institute and Industry. The primary data were collected through personal interview using a pre-tested questionnaire. To study the economics of anti-malarial drug plants Artemisia annua, simple cost accounting method was followed. The prices used in the analysis were offered to the farmers by industry under contractual cultivation the crop harvesting period 2012-13.

The Cob-Douglas production function was fitted well to evaluate the resource-use efficiency in the production of *Artemisia annua* crop cultivated by the selected farmers (Kumar S. *et al*., 2011 and Suresh R. *et al*., 2012).

Y=aX1b1. X2b2 . X3b3. X4b4. X5b5. X6b6 ---------- (1)

Where,

Y = Yield of *Artemisia annua* value (`/ha)

X1 = Human labour value (`/ha)

X2 = Machine & tractor hours value (`/ha)

X3 = Raising of nursery / seed value (`/ha)

X4 = Manure & fertilizer value (`/ha)

X5 = Irrigation value (`/ha)

X6 = Transport charges (`/ha)

The family size is one of the important factors influencing the cultivation adoption of this crop. The family size was found large in the selected farmers, average size of 7.50 in the (table 4.1). It was also observed that the majority of growers of *Artemisia annua* ware literates that mean education generates awareness and innovate the farmers for adoption the new crop technologies.

The average size of operational holding was found less than two hectares with the selected farmers. Farmers of the area has cultivation traditional crop i.e. paddy, wheat and sugarcane on 70 per cent of their total cultivation land and the anti-malarial crop *Artemisia annua* and other crops is being cultivation of the 30 per cent cultivable land.

The role of investment pattern being significant in the productivity of a crop enterprise, per farm investment on fixed assets like farm building, irrigation structures, tractor / equipment and distillation units was worked out and is given in Table.

States	2008-09		2009-10		20010-11		2011-12		2012-13	
	A	P	A	P	A	P	A	P	A	P
UK	-	-	20	5	60	28	100	60	80	50
U. P.	-	-	35	11	240	103	1200	769	1500	900
Guj	150	110	150	108	350	183	900	695	1000	850
M. P.	60	35	5	1	25	13	40	20	50	22
Others	15	5	15	5	25	23	40	28	40	28
Total	225	150	225	130	700	350	2280	157	2670	1850

Table 4.1: Estimated area and production of *Artemisia annua* cultivation in the country. A = Area (acre), P = Production (tons).

Many farmers were involved in the field experiments of growing *Artemisia* according to the studies done on application of fertilizer, space for population density, foliar sprays and time for harvesting. The most appropriate results were incorporated in the field experiments. 1410 farmers took part in cultivation of Artemisia. The dry leaves were collected from them and analysed for artemisinin content. The content of artemisinin ranged from 0.5%-1%. Highest artemisinin content was found with only 1% farmers while 12% farmers had 0.90-0.99% artemisinin. About 33% and 30% farmers had artemisinin ranging from 0.80%-0.89% and 0.70%-0.79% respectively. Others had comparatively low artemisinin content.

In all three regions Ratlam, Vadodara and Dehradun, the fertilizer dose NPKS 100:60:40:40 showed most suitable results. Plant height, artemisinin content, dry leaf to stem ratio, leaves harvest index and artemisinin yield kg/ha. Also the fresh herb yield, dry stem yield, dry leaves yield and percent artemisinin was found at its highest as compared to other doses of

fertilizer. Population density T2 (75x75) were found most appropriate for cultivation of *Artemisia.*

States	LOD%	Yield	Artemisinin %
Uttarakhand	10.53	4.53	0.90
UP	12.23	3.88	0.79
Guj	10.20	4.22	0.81
MP	8.01	3.51	0.80
Bihar	7.52	3.20	0.79

Table 4.2: LOD% (Loss on drying), Yield and artemisinin % in different states.

Cultivation done by the selected farmers across the different states can be seen in table 4.2. Loss on drying of leaves, yield and artemisinin % were recorded for the study. LOD ranged from 7.52 in Bihar to 12.23 in UP. Yield was seen to be ranging from 3.20 to 4.53 in Bihar and Uttarakhand respectively. Artemisinin content ranged from 0.79-0.90.

The expenditure of *A.annua* cultivation were calculated and presented in table 4.3.

S.No.	Particulars	Amount
1	Seed	----
2	Raising & maintenance of nursery	----
3	Land preparation including discing, tillage and preparation of beds	
4	Transplanting	1780.00
5	Manure, Inorganic fertilizer & their application	
6	Weeding (Two weeding)	1600.00
7	Irrigation (7-8 Irrigation)	4700.00
8	Cutting, Threshing, drying & filling in Begs	3200.00
9	Miscellaneous	1840.00
		1600.00
	Total	

Table 4.3: Economics of *A.annua* cultivation

Sr.no.	Particulars	
1	Average size of landholding (ha)	1.97
2	Averagae family size (no.)	7.89

3	Literacy level (%)	95.60
4	Occupation (%)	
5	Dairy, services and others (%)	27.20
6	Agriculture	72.80
7	Cropping pattern (%)	
8	Agriculture crops (paddy, wheat, tobacco, Chillies etc.)	55.32
9	Medicinal and aromatic crops (*A.annua*, menthol mint, satavar and tulsi)	44.68
10	Average farm assets of farm building and irrigation structures	226573
11	Average farm assets (Farm machinery/ equipment and distillation unit)	275982

Table 4.4: Socio-economic and resource structure of *A.annua* farmers in the study area

Sr.no.	**Particulars**	**Amount**
1	Yield of leaf main product (qts./ha)	24.61
2	Price (/ha)	3300
3	Return from main crop (/ha)	81213
4	Yield of by-product (wood) (qts/ha)	31.95
5	Price (/ha)	200
6	Return from by-product crop (/ha)	6390
7	Gross return (/ha)	90560
8	Total variable cost (/ha)	24900
9	Net return over variable cost (/ha)	65660
10	B-C ratio	4.00

Table 4.5: Economics of production of *A.annua*

The net return over variable cost was also 65,660 per hectare. However, the benefit cost ratio was 4. Therefore, it could be concluded that cultivation of this crops was highly profitable venture and farmers in these areas should be encouraged to diversify their existing cropping pattern towards these crop to enhance their farm income.

Figure 4.3: Different stages of cultivation in *Artemisia* crop from seed to plant. A: seed, B: nursery, C: transplanting D: field view E&F: harvesting

Figure 4.4: Cultivation done by farmers across the different states- field view

Figure4.5: Cultivation done by farmers across the different states- field view

Figure 4.6: Farmer's field of Artemisia in different states in India

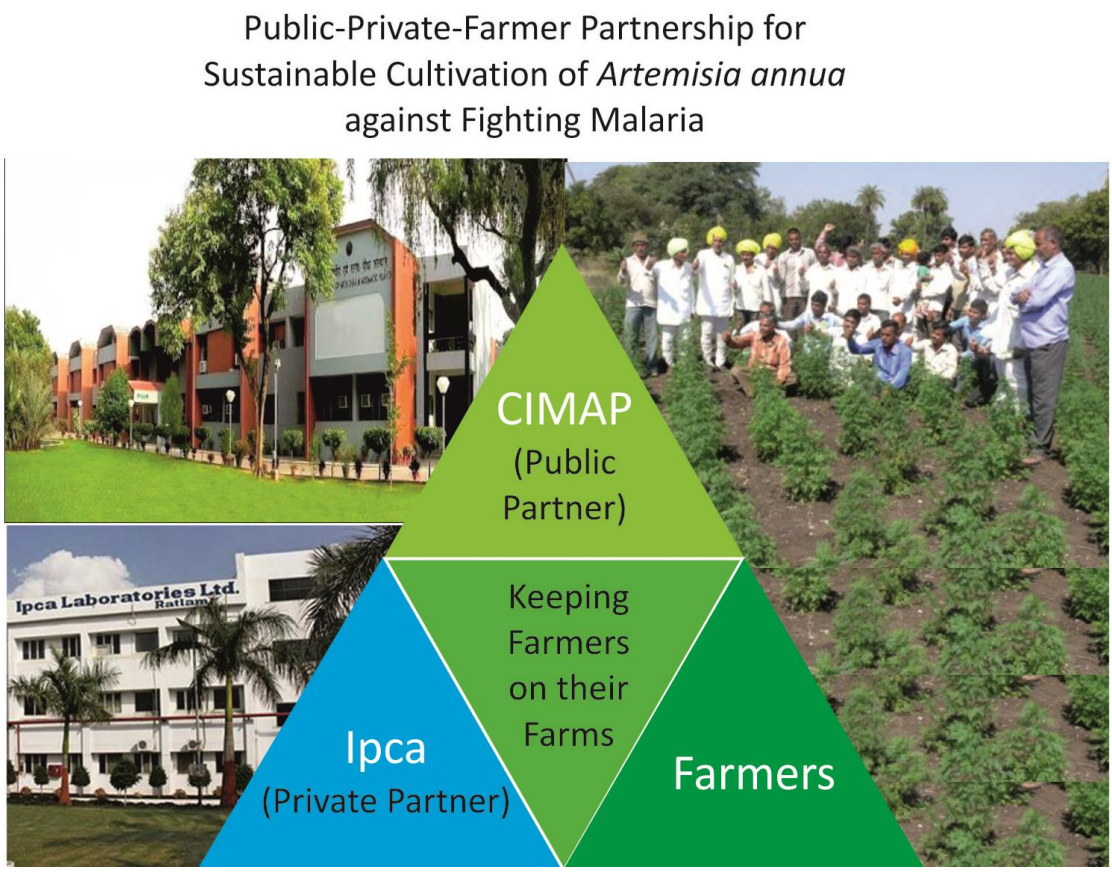

Figure 4.7: Public-private-farmer partnership for sustainable cultivation of *Artemisia annua* against fighting malaria.

The present study shows that cultivation of A. annua provides high returns to farmers in a short span of about four months. The contractual cultivation under PPP model strengthens the farmers to adopt new technologies and crops.

It is concluded from the study, that cultivation of industrial/medicinal crops under contractual cultivation will give a boost for expansion of new crops by providing assured returns to the farmers and avoiding the marketing problems and price lowering during peak harvest season.