

Five decades of the AICRP on Palms – Tasks accomplished

The All India Coordinated Research Project on Palms of Indian Council of Agricultural Research (ICAR) under the National Agricultural Research System (NARS) became operational in 1972. It is a unique institutional mechanism for evaluating site-specific and need-based innovations pertaining to palms under different agro-climatic conditions across the country. This paper articulates the outstanding achievements and future directions of coordinated research to meet the projected demand and diverse stakeholder interests.

PLANTATION crops form an important constituent of horticulture in the Indian agricultural scenario. Palms such as coconut (*Cocos nucifera* L.), oil palm (*Elaeis guineensis* Jacq.), arecanut (*Areca catechu* L.) and palmyrah (*Borassus flabellifer* L.) along with fruit crops such as cocoa (*Theobroma cacao* L.) have immense commerce potential. Plantation crops play a key role in socio-economic development as it helps in the transition from subsistence farming to market-oriented, commercial cultivation. The cultivation of plantation crops in India also has a rich diversity and varied history, with each crop having its own historical and economic development context.

Overview

In India, plantation crops are grown in three agro-climatic conditions, namely the North Eastern Plains Zone (NEPZ), the Central Zone (CZ) and the Peninsular Zone (PZ). As of 2021-22, there are 28 AICRP centres with its headquarters at ICAR-CPCRI, Kasaragod. Currently, 15 centres are working on coconut, six on oil palm, four each on arecanut and palmyrah, and seven on cocoa. These centres are located in different agro-climatic zones supporting improvement, production, protection and post-harvest processing in coconut, arecanut, oil palm, cocoa and palmyrah (Table 1). The coordinating centres are

located in 14 states and one union territory covering 13 SAU's/SHU's, one Central Agricultural University and four ICAR Institutes. The establishment of coordinated research at multi-locations based on a multi-disciplinary approach has enabled rapid strides in crop production in India.

Mandate crops

Coconut: Coconut (*Cocos nucifera* L.) is a perennial plantation crop with a very long productive period requiring the identification of a suitable variety/ hybrid to a particular agro-climatic region for achieving higher and sustained productivity. The two major morphoforms of coconut are Tall (T) and Dwarf (D). The Tall type is primarily out-crossing, while the Dwarf type is mainly self-pollinating (with a few exceptions). Tall cultivars are mainly grown for copra and oil purposes, while dwarfs are preferred for tender nuts. The four southern states, viz. Kerala, Karnataka, Tamil Nadu and Andhra Pradesh, are the main coconut-growing areas in the country which account for 90% of the area and contribute 93% to production.

Arecanut: Arecanut (*Areca catechu* L.) is an important commercial plantation crop in India. Many farming households depend on the sector for their livelihood.

Table 1. Zones, regions covered and research centres of AICRP on Palms

Zone	States covered	Centres	Numbers
North Eastern plains Zone	Bihar, Odisha, West Bengal, Assam and Plains of NE states	BAU, Sabour; BCKVV, Mondouri; AAU, Kahikuchi; CAU, Pasighat and OUAT, Bhubaneswar	4
Central Zone	Chhattisgarh and Gujarat	IGKVV, Jagdalpur and NAU, Navsari	2
Peninsular Zone	Maharashtra, Karnataka, Andhra Pradesh, Goa, Telangana, Tamil Nadu and Kerala	Dr BSKKV (Ratnagiri, Mulde and Wakawali); Dr YSRHU (Ambajipeta, Pandirimamidi and Vijayarai), TNAU (Aliyarnagar, Veppankulam, Killikulam and Pattukkottai); ICAR-CCARI, Goa; KAU (Pilicode and Thrissur); ICAR-CPCRI, Kasaragod; ICAR-IIOPR, Pedavegi; ICAR-CIARI-Port Blair; UAHS (Shivamogga and Bavikere); UHS (Arsikere and Sirsi) and SKLTSH, Kondamallepally	21

India ranks first in the world for arecanut cultivation in the area (49%) and production (50%). Commercial production is concentrated in the South-west and North-east regions of the country. The Indian states of Karnataka, Kerala, Assam, West Bengal and Meghalaya are the main producers; however, the products made from arecanut are widely available throughout the country.

Oil palm: Oil palm (*Elaeis guineensis* Jacq.) is currently India's most important oil crop with high productivity (4-6 t oil/ha) and an economic life cycle of 25-30 years divided into three phases: immature (1-3 years), stabilizing (4-8 years) and stabilized (>8 years) phase. Palm oil is extracted from the fruit's fleshy orange-yellow mesocarp, while palm kernel oil (PKO) is extracted from the stony kernel. Generally, oil palm is referred to as an irrigated smallholder crop grown under India's diverse agro-climatic conditions. Andhra Pradesh, Karnataka, Kerala, Odisha, Tamil Nadu and the north-eastern states of Arunachal Pradesh, Assam and Mizoram are the main oil palm-producing states of India. So far, an area of 3.45 lakh ha has been covered with oil palm cultivation. Palm oil production in India remains meagre compared to the ever-increasing demand for vegetable oils.

Palmyrah: Palmyrah palm (*Borassus flabellifer* L.), native to tropical regions, is an important multipurpose tree. It grows extensively in the southern states of India. This palm adorns the arid landscape of the semi-arid tropics in Tamil Nadu, Andhra Pradesh, Odisha, West Bengal, Karnataka and Maharashtra. There are almost 120 million palm trees in these regions. Akin to the coconut, every single part of the palm, from the fruit to the root, has an immense economic value; hence, the palmyrah tree was considered the *Kalpa Vriksha* in mythology. Although cultivation of this palm offers immense potential, no determined efforts have been made to bring the palm into cultivation.

Cocoa: Cocoa (*Theobroma cacao* L.), a beverage crop

with high commercial potential, is mainly grown in India as a mixed crop within areca and coconut plantations and, more recently, on oil palm plantations. It is mainly grown in the four major southern states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. The country's cocoa industry has grown substantially in recent years, with a significant contribution to the nation's GDP.

Thrust areas of the AICRP on Palms

- Varietal/hybrid evaluation through multi-location testing for different agro-ecological zones and specific target regions/areas. Germplasm enhancement and evaluation.
- Multi-location agronomic studies on integrated nutrient management and integrated farming system for optimization of input use.
- Multi-location screening of genotypes for disease and pest resistance, development and testing of different components of IDM and IPM and their integrated application.
- Coordinating and monitoring the quality planting material production.
- Dissemination of different technologies to the farmers through FLDs.

Crop improvement

India's diverse agro-climatic zones and abundant location-specific germplasm were utilized in developing trait-specific and general-purpose varieties and hybrids for different regions. Indigenous and exotic germplasms were evaluated for different traits, and the better performing types were released for different crop growing zones. The research conducted over five decades has resulted in the release of different varieties and hybrids. Varieties/hybrids of coconut, oil palm and arecanut due to collaborative research among the AICRP (Palm) project, SAUs and ICAR Institutes are listed in Table 2.

Table 2. Improved varieties of plantation crops developed through selection and hybridization under the aegis of AICRP on palms

Variety	Important traits	Nut yield (per ha/year)	Copra yield (t/ha/year)	Recommended states	Agency responsible for the release
COCONUT					
Pratap	High yield	20826	3.60	Maharashtra	Dr BSKKV, Maharashtra
Kamrupa	High yield	17877	2.90	Assam	AAU, Assam
ALR (CN)-1	High yield	22302	3.50	Tamil Nadu	TNAU, Tamil Nadu
Gautami Ganga	Dwarf, green fruits	13260	3.60	Andhra Pradesh	ANGRAU, Andhra Pradesh
Kera Bastar	High yield	19740	3.18	Chhattisgarh, Maharashtra, Tamil Nadu, Andhra Pradesh	AICRPP, IGAU, Chhattisgarh
Kalyani Coconut-1	High yield	14240	3.9	West Bengal	BCKV, West Bengal
Kera Keralam	High yield	26019	3.53	Tamil Nadu, West Bengal, Kerala	AICRPP
Kalpa Dhenu	High nut and oil yield, drought tolerant	14160	3.4	Kerala, Tamil Nadu, Andaman & Nicobar Islands	ICAR-CPCRI, Kasaragod
Kalpa Pratibha	High nut and oil yield, tender nut	16107	4.12	Kerala, Andhra Pradesh, Tamil Nadu	ICAR-CPCRI, Kasaragod

Variety	Important traits	Nut yield (per ha/year)	Copra yield (t/ha/year)	Recommended states	Agency responsible for the release
Kalpa Mitra	High nut and oil yield, drought tolerant	15222	3.68	Kerala and West Bengal	ICAR-CPCRI, Kasaragod
Kalpatharu	Drought tolerant, ball copra and high yield	20709	3.64	Kerala, Karnataka, Tamil Nadu	AICRPP, UHS, Bagalkot
Kalpa Jyothi	Dwarf, Yellow colour fruit, tender nut purpose	19935	--	Kerala, Karnataka, Assam	ICAR-CPCRI, Kasaragod
Kalpa Surya	Dwarf, orange colour fruit, tender nut purpose	21593	--	Kerala, Karnataka, Assam	ICAR-CPCRI, Kasaragod
Kalpa Shatabdi	High copra out turn and tender nut quality	18375	5.01	Kerala, Karnataka, Tamil Nadu	ICAR-CPCRI, Kasaragod
Kalpa Ratna	Suitable for tender nut, for tapping inflorescence sap. It is also tolerant for drought conditions	17482	2.61	Kerala, Karnataka, Tamil Nadu	ICAR-CPCRI, Kasaragod
COCONUT HYBRIDS					
Godavari Ganga (ECT × GBGD)	High yield	18585	2.79	Andhra Pradesh	ANGRAU, Andhra Pradesh
Konkan Bhatya Coconut Hybrids (GBGD × ECT)	High yield	20532	3.47	Maharashtra	Dr BSKKV Maharashtra
Vasista Ganga (GBGD × PHOT)	High yield	22125	3.88	Andhra Pradesh and Karnataka	Dr YSRHU, Andhra Pradesh
Kalpa Ganga (GBGD × FJT)	High yield, suitable for ball copra production	21417	3.38	Karnataka	USH, Bagalkot
Abhaya Ganga (GBGD × LCT)	High yield	22400	3.79	Andhra Pradesh	Dr YSRHU, Andhra Pradesh
VHC 4 (LCT × CCNT)	High yield	28497	4.27	Tamil Nadu	TNAU, Tamil Nadu
Kalpa Samrudhi (MYD × WCT)	Dual purpose variety, drought tolerant, higher nutrient use efficiency	20744	4.35	Kerala and Assam	ICAR-CPCRI, Kasaragod
OIL PALM					
Hybrid	Important traits	FFB yield (t/ha)	Oil to bunch (%)	Recommended states	Agency responsible for the release
Godavari Swarna	High yield	30.11	21.25	West Godavari (Andhra Pradesh) and Tungabhadra command area (Karnataka)	ICAR-IIOPR, Pedavegi
Godavari Ratna	High yield	22.69	26.5	Konkan region of Maharashtra	ICAR-IIOPR, Pedavegi
Godavari Gold	High yield	28.37	21.28	Cauvery delta zone of Tamil Nadu	ICAR-IIOPR, Pedavegi
ARECANUT					
Variety	Important traits	Mean dry kernel yield (per ha/year)	Potential dry kernel yield (per ha/year)	Recommended states	Agency responsible for the release
Sumangala	High kernel yield and high recovery of chali	3900-4350	7400-7700	Karnataka and Kerala	ICAR-CPCRI, Kasaragod
Sreemangala	High dry kernel and bold nuts	4240-4500	7100-7300	Karnataka and Kerala	ICAR-CPCRI, Kasaragod
Mohitnagar	High dry kernel yield	5030	7540	Karnataka, Kerala, North Bengal (West Bengal)	ICAR-CPCRI, Kasaragod
Samrudhi	High dry kernel yield with bold nuts	5987	--	Areca growing areas of Andaman and Nicobar Islands	ICAR-CPCRI, Kasaragod
SAS-1	High dry kernel yield and better storage of dried nuts	7193	--	Sirsi region (Hill zone) of Karnataka	UHS, Bagalkot



Nucleus seed gardens of released varieties established in AICRPP centres

Nucleus seed gardens for released varieties of coconut

The successful establishment of coconut plantations begins with producing good-quality planting material. Hence, selecting appropriate planting material before field planting ensures higher productivity in the long run. Direct field planting of coconut seed nuts is not recommended. Utmost care is recommended while selecting seedlings as quality planting materials is advantageous to enhance productivity and improve the coconut palm's economic life. Nucleus seed gardens were set up to produce high-quality planting material for released coconut varieties at AICRP on Palms centres. This mechanism has provided 9.67 lakh coconut seedlings of released variety/hybrids to coconut farmers, contributing significantly to acreage expansion.

Palmyrah: Pandirimamidi (Andhra Pradesh) and Killikulam (Tamil Nadu) are Research Centres under AICRP on Palms focussed on collecting, conserving and evaluating existing germplasm in Palmyra and hybridization to develop dwarf species. To date, 265 (Killikulam) and 272 (Pandirimamidi) germplasm accessions have been maintained and evaluated for yield and quality attributes.

Cocoa: Cocoa genotypes are evaluated in seven AICRP (Palms) centres covering the west coast, east coast and NE regions and different cropping systems, including arecanut, coconut and oil palm gardens. A 12 year trial at Kasaragod (Kerala), Ambajipeta (Andhra Pradesh)

and Veppankulam (Tamil Nadu) identified cocoa hybrids VTLC-2 and VTLC-1 as best performers, respectively, in the regions as an understorey crop. Among 8-year-old trees of Aliyarnagar (Tamil Nadu), Ratnagiri (Maharashtra) and Kahikuchi (Assam), VTLC-16, VTLC-17 and VTLC-20 were identified as the best performing, whereas VTLC-57 was high yielding at Vijayarai (Andhra Pradesh) under oil palm.

Crop production

Increasing input use efficiency through Drip fertigation

- **Fertigation in coconut:** Applying 50% of the recommended dose of NPK through fertigation in 10 monthly splits was found to be adequate for coconut in Kerala, Tamil Nadu and West Bengal. Similarly, 75% of the dose of NPK through fertigation in 10 monthly splits was found to be sufficient in Andhra Pradesh and Karnataka.
- Fertigation in oil palm with 1200:600:1200 g N, P_2O_5 , K_2O /palm/year in six equal splits at bi-monthly intervals in Gangavathi (Karnataka) and Vijayarai (Andhra Pradesh) centres and 1200:600:1800 g N, P_2O_5 , K_2O /palm/year in six equal splits at bi-monthly intervals in Mulde Centre (Maharashtra) recorded higher fresh fruit bunches (FFB) yield and consequently higher monetary returns.

Palm based-cropping systems

- **HDMSCS:** Coconut-Based High-Density Multi Species Cropping System (HDMSCS) involving crops like black pepper, cocoa, banana, drumstick (*Moringa*), nutmeg, cinnamon, pineapple, turmeric, elephant foot yam, tapioca, bhendi and coriander were recommended for different regions. HDMSCS has huge potential to enhance the net income to the tune of ₹1.75 lakhs to ₹3.25 lakhs/ha compared to coconut monocrop (₹70,000 to ₹90,000/ha).
- **Intercropping with medicinal and aromatic crops:** Crops such as galangal, lemon grass, patchouli, pipali, citronella, Aloe vera, tulsi, palmarosa, sarpagandha, ashwagandha, arrowroot, amahaldi, shatavari, garden rue, mango ginger, makoi and kalmegh were recommended for cultivation in coconut garden in different regions, resulting in an additional net income of ₹1.20 lakhs to ₹1.75 lakhs/ha.
- **Intercropping of flower crops in coconut garden:** Suitable flower crops were identified for growing



Nucleus seed garden at Aliyarnagar (Tamil Nadu)



Coconut based cropping systems



Intercropping of flower crops in coconut garden

under coconut. Cultivation of Marigold, Gomphrena, Celosia, Zinnia and Chrysanthemum at Aliyarnagar (Tamil Nadu); Chrysanthemum, Crossandra, China aster and Marigold at Arsikere (Karnataka); Gerbera, Tuberose, Gladiolus and Marigold at Kahikuchi (Assam); Gladiolus, Tuberose and Gerbera at Mondouri (West Bengal) and Lily, Heliconia and Jasmine at Ratnagiri (Maharashtra) has enhanced the net income to the tune of ₹2 lakhs to ₹4 lakhs/ha.

- **Integrated nutrient management under coconut-based cropping system:** Application of 50% of RDF (NPK) + 50% N through organic recycling with vermicompost + vermiwash + biofertilizer and *in situ* green manuring recorded higher system productivity followed by 75% of recommended NPK + 25% through organic recycling with vermicompost or fully organic - recommended from Aliyarnagar, Ambajipeta, Arsikere, Bhubaneswar, Jagdalpur, Kahikuchi, Mondouri, Navsari, Ratnagiri, Sabour and Veppankulam centres for adoption by farmers.
- **Intercropping in juvenile phase oil palm garden:** The vegetable okra intercropped with oil palm recorded higher fruit yield and net returns, followed by tomato and brinjal in the juvenile oil palm garden under the Tungabhadra command area of Karnataka.

Crop protection

Disease management

Bud rot: Talc-based formulation of *Trichoderma reesei* @ 5 g coconut/seedlings at spindle region is recommended for application during the pre-monsoon period in Andhra Pradesh.

Basal stem rot: Soil application of talc-based formulation @ 125 g each of *Trichoderma reesei* and *Pseudomonas fluorescens* + 5 kg of neem cake per palm at yearly intervals are recommended for the management of basal stem rot disease in coconut.

Stem bleeding: Smearing of talc powder paste of *T. viride*/ *T. harzianum* on the bleeding patches on the stem (paste can be prepared by adding 5 mL of water to 10 g

of talc powder). Soil application of 50 g of a talc powder formulation of *T. viride*/*T. harzianum* in combination with 5 kg neem cake/palm/year is recommended.

Insect-pest management

Management of rhinoceros beetle: Application of ICAR-CPCRI botanical cake @ 15 g/palm + paste @ 15 g/palm is recommended to manage rhinoceros beetle infestation in juvenile palms to reduce the spindle and leaf damages in coconut.

Management of Eriophyid mite: Effective INM and IPM packages involving (i) application of a recommended dose of fertilizers with 20 kg vermicompost and 5 kg neem cake/palm; (ii) growing of green manure crops, viz. cowpea/sunn hemp in the inter rows and ploughing *in situ* at flowering stage; (iii) application of Kera Probio (100 g/palm); (iv) root feeding with fenpyroximate 5% EC@ 10 ml (in March) and (v) spraying of palm oil-sulphur emulsion (during December) is an effective package for reducing infestation of eriophyid mite in coconut.

Management of Rugose Spiraling Whitefly: Installation of yellow sticky traps in coconut gardens is





Release of parasitoid by a farmer

recommended to attract RSW in coconut to mitigate their incidence effectively.

Black headed caterpillar: Management of Black headed caterpillar in coconut was conducted by producing and releasing parasitoids like *Goniozus nephantidis* and *Bracon* sp. in farmers' fields of different regions (Table 3).

Table 3. Supply of parasitoids to farmers (in lakhs) for the management of Black headed caterpillar

Centre	<i>Bracon hebetor/ B. brevicornis</i>	<i>Goniozus nephantidis</i>
Ambajipeta (Andhra Pradesh)	43.22	18.69
Aliyarnagar (Tamil Nadu)	7.33	0.61
Arsikere (Karnataka)	21.41	38.07
Ratnagiri (Maharashtra)	0.86	0.90
Total	72.82	58.27

- **Integrated management of Slug Caterpillar:** The IPM packages comprising mechanical removal and destruction of larval and pupal stages, installation of light traps @ 5/ha, application of a recommended dose of fertilizers, spraying of insecticide chlorantraniliprole 18.5% SC @ 0.3 ml/litre and release of potential parasitoid *Pediobius imbreus* @ 60/palm is recommended for effectively managing the incidence of slug caterpillar in coconut.

Post-harvest value addition in Palmyrah

- *Neera*, a delicious drink extracted from the unopened inflorescence, is fast becoming popular in rural and urban areas of India. It is one of the most economic produce and is a good source of calcium, phosphorus and iron, vitamin A, citric acid, niacin, thiamin and riboflavin. It has laxative and diuretic properties. When collected fresh under protected conditions, it can become a healthy and energetic drink.
- The jelly-like endosperm of the young fruit of 60–70 days old is called *nungu*, which is a summer delicacy and is very nutritious. Tender fruit, which contains the endosperm (2–3), is cut off, and the kernel, which is soft as jelly, translucent like ice, and accompanied by a watery sweetish liquid, can be eaten. The dehydrated

samples treated with sugar syrup concentration of 50 and 60°Brix is found to be acceptable in sensory qualities except for a slight colour change on storage. *Nungu* blanched and packed in 100 gauge polythene film with sugar syrup of 30°Brix and stored at 5°C gives good results.

- Jaggery powder prepared from fresh neera (collected as per CPCRI method) gives good colour and shelf life of up to one year. In contrast, jaggery from the traditional method turns into dark colour and spoils within three months at room temperature with normal packing. Dehydrated tuber and tuber flour was commercialized, one consignment was sent to the UK through an NGO (ASHA Chinturu, AP), and income was generated for tribal people.

Transfer of technology

Demonstrations: Field demonstrations (49) were conducted for effective transfer of technologies on various aspects such as Integrated Nutrient Management, development of Coconut Based Farming System, coconut production technologies, integrated management of pests and diseases, preparation of vermicompost and mass production of bioagents. ToT demonstrations have benefitted 5675 farmers.

Front line demonstrations: AICRP on Palms has conducted FLDs on production technologies and pest and disease management in coconut in collaboration with KVKs. Technologies recommended by the AICRP for palm have been effectively transferred to university KVKs in various states to benefit farming communities.

Future direction

- The productivity of plantation crops needs to be increased coherently, considering the increasing demand for crops due to multiple challenges such as growing population, changing dietary preferences, climate change and vulnerability, degradation of arable land, and changing demand for various end products.
- The small farmer perspective in research needs to be emphasized in plantation crops, considering the farm structure in this sector.
- Technologies suitable for small farms are required to be developed to ensure faster and wider adoption of technologies.
- Scope for crop improvement, particularly to develop genotypes resistant to biotic and abiotic stresses and also responsive to low-input management through conventional breeding and biotechnological approaches.
- Validation of intercropping in the oil palm garden needs to be strengthened to enhance income.
- Evaluation of promising cocoa hybrids as intercrop in palms under different regions is to be intensified.
- Validation of more palm based farming system models in non-traditional and north-eastern regions needs to get priority.
- The value-added products in Palmyrah are not commercialized as the products are not standardized.

In this context, developing value-added products and popularizing the same is essential.

CONCLUSION

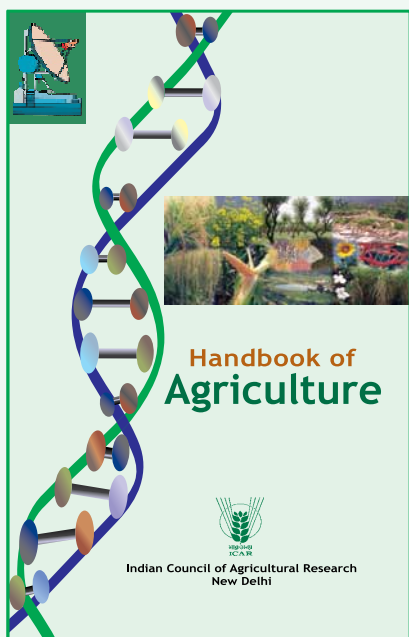
The AICRPP project aims to conduct location-specific research in different palm-growing areas of the country. The area of a particular crop, problems encountered by the farmers in the region and facilities available for conducting R&D activities determines the location selection. The project aims to assess the suitability and adaptability of the technology in different agro-ecological regions of the country. Thus, a multi-

disciplinary approach is pursued in the development of demand-oriented technologies. Research conducted by AICRP on Palms over five decades since its inception has achieved significant achievements for the benefit of the farming community.

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Handbook of Agriculture



The Handbook of Agriculture is one of the most popular publication of the ICAR with a wider readership. The present edition presents science-led developments in Indian agriculture, the ongoing research efforts at the national level and with some ideas on the shape of future agriculture. While information in some chapters such as Soil and water, Land utilization, field and forage crops has been updated with latest developments, many new topics such as the Environment, agrobiodiversity, Resource conservation technologies, IPM, Pesticides residues, Seed production technologies, Energy in agriculture, informatics, Biotechnology, Intellectual Property Rights, Agricultural marketing and trading and Indigenous Technical Knowledge have been included in the present edition. For those who take intelligent interest in agriculture – and their number is increasing fast – the present edition would serve as a useful book.

TECHNICAL SPECIFICATIONS

Size	:	Royal Octavo (16 cm x 24 cm)
No. of pages	:	i-xii + 1618
Price	:	₹ 1500
Postage	:	₹ 100
ISBN No.	:	978-81-7164-096-6

For obtaining copies:

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