

Economic impact of ICAR-CPCRI technologies

Impact assessment is a critical component of agricultural research that helps to define the priorities of research and facilitate resource allocation among programs. It also guides the researchers and extension personnel to understand the way new technologies are assimilated and diffused among farming communities. Nevertheless, impact studies, in perennial crops, have encountered both conceptual and empirical challenges, due to the complexities of the relationships between the technology generated, the structural rigidity of the crops and the technology adoption process.

IT is pertinent to conduct a disintegrated level study, crop-wise and region-wise on the impact of various technologies generated, the adoption, and the pattern of diffusion and if possible, to quantify the economic impact of the technologies.

Methodological issues

Concerning the field study, for instance in coconut, analyzing the impact of improved coconut varieties/hybrids, it is advisable to employ a multistage random sampling technique covering major coconut-growing tracts of India. For illustration, we select four districts from Kerala, three districts each from Tamil Nadu and Karnataka and two districts from Andhra Pradesh, covering a total of 12 districts from four states. Also, within the districts, we may select the samples based on the agro-climatic classification of coconut growing tracts in each district. At least thirty respondents can be considered from each district and in case where the adopters are inadequate, the sample size can be increased.

Analyzing the economic impact of the improved varieties of the coconut, by combining the rate of adoption, the estimated area under improved varieties in the selected growing tract/district and the resultant incremental yield, the incremental production achieved through the adoption of improved varieties in the region can be computed. The economic impact is expressed as:

$$\text{Economic Impact (in rupees)} = (NR_V - NR_L) * (A * P / 100)$$

Where, NR_V = Net returns from improved varieties;

NR_L = Net returns from local varieties;

A = Area under improved varieties;

P = Percentage of adoption of released varieties.

Similarly, to study the impact of coconut-based cropping/farming systems, the additional benefit obtained over the coconut monocrop by adopting the cropping systems is considered. The percentage of adoption of different cropping systems may be estimated followed by estimation of approximate area under each cropping

system. Subsequently, the product of estimated area under each cropping system and additional returns from each system would provide the additional economic benefit realized over coconut monocropping.

A modified Cobb-Douglas production function using dummy variables Z_i , $i=1..4$ can be employed to delineate the variations due to the adoption of improved varieties in comparison with the local variety. By examining the elasticity coefficients, the response of different varieties to the input usage and increase in area under cultivation can be computed. Also, it permits the comparison between the performance of local and improved variety.

The model is given below.

$$Y = A_0 \prod_{i=1}^4 A_i^{Z_i} X_1^{a_0 + \sum_{i=1}^4 a_i Z_i} X_2^{b_0 + \sum_{i=1}^4 b_i Z_i} e^u$$

Where,

Y = Yield;

A_0 = Intercept of local variety;

A_i = Change in intercept for the i^{th} improved variety;

a_0, a_i, b_0 , and b_i are regression coefficients;

Z_i = dummy variables, ($i=1$ to 4);

$Z_1 = 1$ for improved variety 1 and "0" otherwise;

$Z_2 = 1$ for improved variety 2 and "0" otherwise;

$Z_3 = 1$ for improved variety 3 and "0" otherwise;

$Z_4 = 1$ for improved variety 4 and "0" otherwise;

X_1 = Area under cultivation; and

X_2 = Value of other inputs pooled together.

The multinomial logistic regression model will be used to investigate the factors that affect the adoption behaviour of coconut farmers with respect to ICAR-CPCRI recommended coconut production technologies. The model involves a dependent variable, the technology adoption decision variable (Y) and a set of explanatory/independent variables that might influence the final probability, P_i , of adoption of the technologies. These explanatory variables can be thought of as being in a

A case study: Impact of coconut planting materials supplied from ICAR-CPCRI, Kasaragod

Average sales proceeds of coconut planting materials from ICAR-CPCRI for the last 3 years are given below.

Particular	Sales (Numbers)	*Mature palms (Numbers)	Incremental benefit**	Economic impact (₹ Lakhs)
Coconut seed nuts	6000	2475	32	396
Seedlings (including WCT selection)	6400	4800	32	768
Coconut Hybrids	3000	2250	39	439
Dwarfs (Only COD)	1450	827	5	1.45

Note: *We assume that in the field, seed nuts to seedlings ratio is 55% and the seedlings to mature palms ratio is 75%;

** In the case of seed nuts, seedlings and hybrids it is incremental yield at field level (nuts/palm) in comparison with the average yield of local varieties. In the case of dwarfs, it is the price difference obtained at the farm gate in comparison with the local varieties of tender coconuts.

The economic life spans of seedlings and hybrids are assumed to be 50 years wherein that of dwarfs is assumed to be 35 years.

We assume a 30% yield reduction in the field conditions (due to various factors). The expected yield of hybrid palms and improved varieties are 120 nuts per palm and 110 nuts per palm, respectively, however, in the field conditions the yield would be 84 nuts/palm and 77 nuts/palm, respectively.

In seed nuts, we assume that about 40% of the seed nuts will become mature palms and will give average productivity of 77 nuts in field conditions for about 50 years of economic life span. The average yield of local coconut cultivars in the state is 45 nuts/palm/year. Therefore, the yield difference of 32 nuts/palm is realized, because of the adoption of seed nuts of improved cultivars supplied by CPCRI. In such a scenario, for the entire lifespan of the cultivated palms with the prevailing farm gate prices of ₹10/nut we might realize a sum of ₹396 Lakhs. Similarly, for the coconut seedlings (about 6400 seedlings/year), the economic impact would be ₹768 Lakhs. In hybrids (on an average supply of 3000 hybrids/year) the economic realization would be ₹439 Lakhs. The supply of dwarf seedlings is 1450 numbers/year, of which we assume 75% would become mature dwarf palms in the field (847 dwarfs) and will have an economic life of 35 years. At present, the farm gate price of a single COD nut is ₹18 which is five rupees more than that of the price fetched by the local tender coconut variety. Taking this into account, there would be an economic realization of ₹1.45 Lakhs. In nutshell, there would be an economic impact to the tune of ₹1604 Lakhs.

vector, X_i and the model then takes the form:

$$P_i = E [(Y_i/n_i) \setminus X_i]$$

Technological impact on production and resource conservation

The remarkable contributions made by the ICAR-CPCRI to the research and development of coconut, arecanut and cocoa sectors of the country are well reflected in the growth rates of production and productivity of the sectors. Coconut plays a very significant role in the economy of India. India is the leading coconut producer in the world (31%) with a production of 20308 million nuts from an area of 2173 thousand hectares. The productivity of India is the highest (9345 nuts/ha) among major coconut-producing countries in the world. The present production of arecanut in India is about 1.2 million tonnes from an area of 0.73 million ha. India ranks first in both area and production of the crop. The overall average yield per hectare has improved from 843 kg/ha in 1971 to 1654 kg/ha by the year 2021.

The breeder seeds and released varieties of mandate crops are used for the establishment of several mother gardens of improved varieties and in breeding programmes by ICAR and State Agricultural Universities (SAUs). The Institute serves as a repository of gene resources for the benefit of researchers and

farmers. Every year, about 1.5 Lakhs seed/seedlings of coconut, five lakhs seed/seedlings of arecanut and about one lakh seed pods of cocoa are being produced for distribution which is augmenting the area expansion under improved varieties in the country. Improved varieties contribute an additional yield of 5700 nuts/ha in the case of coconut, 750 kg/ha *chali* and 200 kg/ha dry cocoa bean with a possible additional annual gross value of ₹40,000 million.

Over the past 50 years, coconut production increased 3.25 folds with a contribution of 37% due to area increase and 31% due to yield increase. In the recent decade, the increase in production could be attributed to the yield effect (57%) than the increase in area (36%). A similar trend was observed in arecanut and cocoa with an increased effect of yield in increasing the production. In arecanut, during the last decade, the yield effect was higher (47%) than the area effect (42%) revealing the importance of research in productivity improvement, considering the limited scope of area expansion. Cocoa, a relatively new crop, has witnessed 5 folds increase in area and yield has increased to 1.5 times during the last two decades.

The average yield of newly released coconut varieties is around 120 nuts/ palm/ year. This is two folds higher than the national average of 60 nuts/ palm/ year. Adoption of

new varieties enhances the existing crop productivity levels to the tune of 100% in terms of nut/copra yield and will have a likely impact on product diversification and sustainability. In arecanut, the average yield of the improved varieties developed in the country is around 3.0 kg dry nut (*chali*)/palm/ year (3900 kg per hectare). In cocoa, the present national productivity is only about 450 kg dry beans/ha as against the average yield levels of 1500 kg dry beans/ha from the improved cocoa selections developed for cultivation in the different cocoa-producing zones.

The impact assessment of arecanut based cropping systems in Dakshina Kannada region revealed that the total economic impact, in monetary terms, due to the adoption of cropping systems in the region was ₹819 million per year.

The coconut-based high-density multi-species cropping system at ICAR-CPCRI, Kasaragod includes crops like black pepper, pineapple, banana, clove; annual crops such as turmeric, ginger; and vegetable crops (brinjal, pumpkin, and elephant foot yam), sweet corn and baby corn grown in the space available during different seasons. The economics of the system indicated an increase in net returns up to 2.5 fold over the monocrop per ha per year. When coconut cultivation is integrated with other enterprises like dairy, poultry, fishery, piggery and cultivation of grass, pepper, banana and other vegetables in the interspaces of coconut, the net income can be increased by more than 5 fold vis-a-vis the coconut monocrop.

Adoption of bio-engineering measures in coconut ecosystem has reduced the soil loss and nutrient loss by 98%. The beneficial effect also includes an increase of 25-30% yield of coconut. Adoption of drip fertigation technology produced a 25% increase in coconut yield and 50% reduction in chemical fertilizers and a 57% reduction in labour requirement for coconut cultivation. Drip fertigation in arecanut reduced the annual maintenance cost to the tune of ₹14,450/ha through saving in labour and fertilizer input over the conventional practice of basin application of fertilizers and irrigation during the pre-bearing stage.

The moisture conservation technology of husk burial in coastal sandy soil has helped in growing intercrops in a coconut garden and this cropping system has improved the yield of coconut from 35 to 150 nuts per palm per year, a four-fold increase, in the coconut yield. The average amount of rain/run-off water collected in coconut gardens where a combination of half-moon bund and trench were taken up in the coconut gardens was 51 m³ per year. Improvement in coconut yield because of these interventions was 58%.

On-farm trials have demonstrated the competence of vermiwash to increase biomass, yield and quality of the crops like bitter melon, amaranthus, green chillies and cowpea accompanied by enhanced soil microbial activities. The vegetables, particularly green leaves were observed to remain fresh for a longer period and fetched better market prices.

Rhinoceros beetle damage can cause yield loss of up to 10% in bearing palms. The effective biocontrol techniques for the management of rhinoceros beetle, using green

muscardine fungus (GMF), *Metarhizium anisopliae* along with the incorporation of common weed *Clerodendron infortunatum*, implemented in approximately 4000 ha in Alappuzha and Trivandrum districts of Kerala indicated 75% reduction in the fresh incidence of rhinoceros beetle, thus reducing yield loss to farmers.

Coconut palms with a severe infestation of leaf-eating caterpillar recorded a reduction in nut yield by 45.38%. IPM demonstration trials laid out by ICAR-CPCRI in Kerala and Karnataka, revealed that the release of stage-specific parasitoids, viz. *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoids per palm could reduce leaf damage to the tune of 63% and population of *O. arenosella* to the tune of 91.3% in a period of eight months and complete recovery of palms from *O. arenosella* incidence in a period of 2 years. In 12 months, the pest population declined to 94.7% (from 304 per 100 leaflets to 27 per 100 leaflets) and complete recovery of palms was recorded in 18 months.

Adoption of *Trichoderma* coir pith cake technology to manage stem canker caused 96% reduction in intensity of the disease over control. Further, buildup of *Trichoderma* population had an inhibitory effect on incidence of *Phytophthora* diseases.

The 'Kalparasa'® technology developed at the Institute for collection of unfermented fresh and hygienic inflorescence sap (*neera*) from coconut tree, without any additives, is swinging fortunes in favour of the beleaguered coconut farmers. A farmer could earn on an average ₹15,000/palm annually while a tapper can earn about ₹20000 per month in addition to the promotion of agri-preneurship. The technology has immense potential that tapping of 1% of the total palms, could generate revenue of ₹9563 crores.

Machinery developed at the Institute has significantly contributed in reducing labour requirements and the drudgery involved, thereby achieving gender mainstreaming. It has made the coconut processing industries especially, virgin coconut oil (VCO), coconut milk and coconut chips units, technically feasible and economically viable to the entrepreneur. The production cost of VCO and coconut chips could be considerably reduced and utilization of the by-products in producing different value-added products became effective.

Impact of technologies: A ready reckoner

Incremental annual returns from the adoption of improved varieties/hybrids of the Institute were found to be ₹45580 million. This comprises ₹31160 million from coconuts, ₹13480 million from arecanut and ₹940 million from cocoa. The incremental income (annual) over monocropping due to the adoption of cropping systems recommended by the Institute was observed to be ₹59100 million and ₹13500 million rupees in coconut and arecanut-based cropping systems, respectively. The impact of bio-suppression of pests and diseases resulted in the economic benefit of ₹21470 million/annum. The annual revenue generated from product diversification and value-addition is to the tune of ₹1000 million. The total monetary realization from the spread of other agro-techniques was estimated to be ₹45533 million.

Epilogue

The consistent research efforts of the Institute have greatly contributed towards the overall growth of area, production and productivity of the mandate crops. The technological advances made in coconut, arecanut and cocoa have contributed to the upliftment of the farmers, mainly in the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, Assam and Meghalaya, which are the major growing regions of the mandate crops. Directly and indirectly, the sectors together support about 20 million people who are dependent on these sectors for

their employment and livelihood. The efforts for rural employment and women empowerment and business incubation are reflected in the sectors in the form of Self Help Groups and small scale entrepreneurs.

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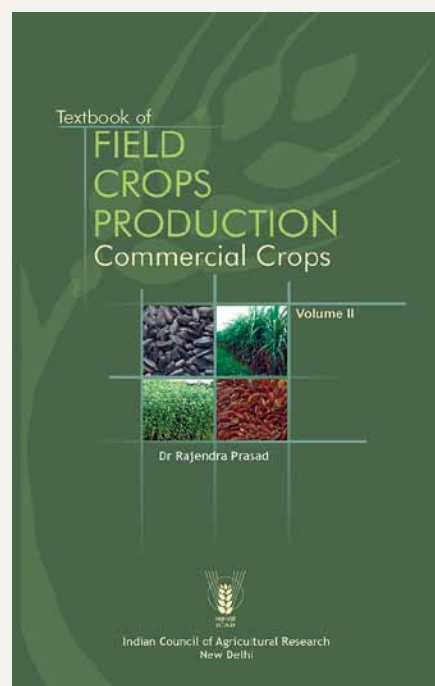
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Textbook of Field Crops Production – Commercial Crops

(Volume II)

Availability of high-yielding varieties/hybrids and increased irrigated facilities have resulted in the development of production-intensive cropping systems in several parts of India, and this has catalyzed further agronomic research based on the cropping-system approach. Many changes have also taken place in the crop-production technologies. And this necessitated the revision of the earlier publication brought out in 2002. The revised textbook is in two volumes: First is covering Foodgrains and second is on Commercial Crops.

The discipline of Agronomy has no longer remained mere field trials without application of discoveries emanating from the related disciplines of Genetics, Soil Science and Agricultural Chemistry, Plant Biochemistry, etc. The future Agronomy Landscape will face challenges of climate change, transboundary issues, TRIPS and other trade-related barriers, biotic and abiotic stresses, consequences of biotechnology and genetic engineering and increased market demands in terms of quality assurance, customized food crops, global competition, ecosystem services on land and social equities etc. The Agronomy must measure up to these futuristic challenges with well-defined metrics and methodologies for performance. The advent of hydroponics, precision farming, bio-sensors, fertigation, landscaping, application of ICT, GPS and GIS tools and micro-irrigation is in the horizon. This revised edition in two volumes covers fundamentals of the subject and at the same time will inspire and prepare teachers and students for the emerging frontiers.



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