Economic Impact of ICAR Research

Some Recent Evidence

ICAR-National Institute of Agricultural Economics and Policy Research
Indian Council of Agricultural Research

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Indian Council of Agricultural Research
New Delhi

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Printed at :
National Printers, B-56, Naraina Industrial Area, Phase II, New Delhi-110028; Phone No.: 011-42138030, 09811220790

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Foreword

The National Agricultural Research System of India is globally appreciated for its significant contributions to food security, sustainability and poverty alleviation. There are empirical evidences of agricultural growth induced by the improved technologies, which have benefitted the poor through reduction in food prices. The contributions are steered under the leadership and strategic support of ICAR. However, the impact of recent technological interventions is rather scanty. To bridge this gap, ICAR-National Institute of Agricultural Economics and Policy Research initiated an exercise to assess the economic impact of ICAR technologies introduced during the last two-decades. I am sure this publication would suffice the need of policymakers and other stakeholders for justifying higher public funding for agricultural research in the country.

Trilochan Mohapatra
Secretary, Department of Agricultural Research & Education and
Director General, Indian Council of Agricultural Research

March 2020
New Delhi

Acknowledgements

The exercise on economic impacts of major ICAR technologies was initiated at the behest of Indian Council of Agricultural Research. At the ICAR-National Institute of Agricultural Economics and Policy Research (NIAP) evidences were collated from SMDs and ICAR institutes on the technology which have made significant impact on farmers' fields. A core team of economists from different institutes was formed to undertake the impact assessment work in a collaborative mode. A number of consultative meetings were organized and the results were discussed in the national workshop. On behalf of the Institute and the core team, I sincerely thank Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for assigning this responsibility to NIAP. I also thank all DDGs and Directors for their cooperation. My special thanks are due to the core team members, Sant Kumar, Sreenivasa Murthy D., Pramod Kumar, Dwaipayan Bardhan, R.S. Singh, A. Suresh, Anil Kumar Dixit, P. Murali, Kiran Kumar and Ankita Kandpal for their excellent teamwork. I hope the evidence provided in this document will be useful to policymakers and other stakeholders.

Suresh Pal
Director
ICAR-National Institute of Agricultural
Economics and Policy Research

March 2020
New Delhi

The Indian Council of Agricultural Research (ICAR) is an autonomous organization under the Ministry of Agriculture and Farmers' Welfare (MoAFW), Government of India. It was established on 16 July 1929 and mandated for coordinating, guiding and managing agricultural research and education in the country. In 2019, it had 113 research institutes and it also coordinates with 75 state agricultural universities spread across the country. The ICAR has the highest number of approved scientific manpower (6500) in the country in 2019.

Both the central and state governments provide regular funding for agricultural research and education in the country, and ICAR is funded through block grants from the central government. The government funding to ICAR increased by 1.5 times, from Rs 2,000 crore in 1999-00 to Rs 4,909 crore in 2018-19 (at 2011-12 prices) registering a growth over 5% annually during this period (Figure 1). The funding in nominal terms was Rs 8,300 crore in 2019-20.

Despite having one of the largest research systems in the world, India under invests in agricultural research relative to other developing

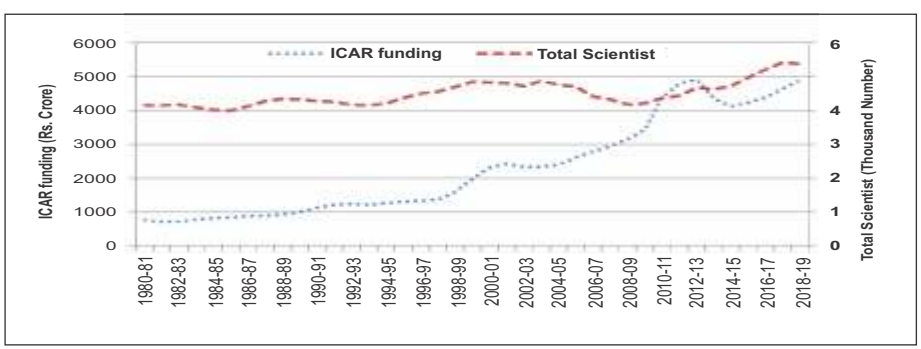


Figure 1. Trend in scientific manpower and expenditure (2011-12 prices) of ICAR

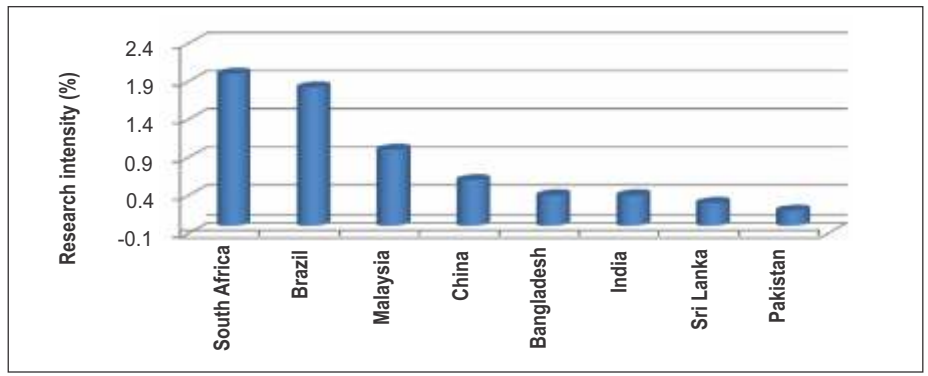


Figure 2. Agricultural research intensity in developing countries including India
Source: IFPRI (2019)

countries. Currently, India invests 0.40% of agricultural GDP in research, while China (0.62%), Brazil (1.82%) and South Africa (2.0%) spend much higher than India (Figure 2). The spending by the developed countries is more than 2% of AgGDP.

Returns to the investment

Many studies have examined the impact of agricultural research in India and estimated internal rate of returns (IRR) to the investment. Most of these studies have analysed the returns to the research for individual crops and some have analysed for the sector as a whole. These *ex-post* studies have used economic surplus model and some have used the econometric approach to decompose the growth in the total factor productivity. The average IRR was 72%, with a median value of 58% (Table 1). These facts make a case for higher investment in agricultural research in India.

Table 1. Internal rate of return to investment in agricultural research (%)

Measure	Agricultural research		
	Aggregate	Crop-specific	All
Mean	75.46	9.9	71.8
Medium	58.5	53.0	57.5
Minimum	46.0	6.0	6.0
Maximum	218.2	174.0	218.2
Number of studies	10	18	28

Source: Pal (2017)

Total factor productivity growth

Another way to examine the impact is to compute total factor productivity (TFP) which is commonly used as synonymous with technical change to signify the role of research. The estimates show that TFP growth was the highest in the southern region (0.59%), followed by the central (0.53%), and northern (0.45%) regions and it was the lowest in the eastern (0.30%) during the period of 1980-2008 (Table 2). A similar trend was noticed for the rate of returns and benefit-cost ratios.

Table 2. TFP growth and rate of returns from agricultural research in India, 1980-2008

Region	TFP growth (%)	Internal rate of return (%)	Benefit-cost ratio
Northern	0.446	80.509	16.603
Western	0.379	61.693	10.088
Central	0.531	-	-
Eastern	0.298	34.958	3.822
Southern	0.592	64.656	10.997

Source: Nicholas Rada and David Schimmelpfenning (2018) Evaluating research and education performance in Indian agricultural development, *Agricultural Economics*, 49: 395-406.

Economic Impact at a Glance

- The Indian agricultural research system is one of the most productive systems in the world. The median rate of return on the past investments was 58.5 percent. Recent studies show that the rate of return varied from 34.9 percent in the eastern region to 80.5 percent in the northern region during 1980-2008 (USDA). The rate of return was 38.8 percent from the technological interventions in the rice-wheat system during the last two decades (NIAP). Another study (IFPRI) estimated the rate of return 49.14 percent.

- Some of the technologies of ICAR have generated the annual gross economic benefits (surplus) as high as Rs. 14.7 thousand crore in 2017-18.The annual benefits were in the range of Rs. 9.6 to 14.7 thousand crore each for six technologies. Further, eleven technologies generated the annual benefits in the range of Rs. 1.2 to 4.7 thousand crore each. The environmental and social impacts are likely to be equally impressive.

- The recent technological interventions of ICAR were in the area of improved varieties of field and horticultural crops, animal health management, multiplication of planting material of fruits, and improved aquaculture practices. These interventions have made significant economic impact on the farmers' fields and also benefitted the consumers.

- Technologies for salt-affected soils, conservation agriculture, crop residue management, and soil testing kits are notable contributions to promote sustainability of Indian agriculture. The benefits of animal health management, machines for sowing and weeding in rice crop, and improvement in fish trawl net have contributed directly to the welfare of resource poor farmers and landless workers, including women.

Impact of Policy Research

The National Institute (earlier Centre) of Agricultural Economics and Policy Research (NIAP) was established in 1991 by the Indian Council of Agricultural Research (ICAR) with a mission to leverage the potential of agricultural research and policy to promote efficient, sustainable and inclusive growth of agriculture and rural economy. The Institute has contributed significantly in producing quality research outputs which have utilized by the various stakeholders. A few notable research contributions of the Institute are in the areas of R&D investment and policy, IPRs, food demand and consumption, commodity value chains, climate resilient agriculture, institutional innovations, farm income policy, agricultural diversification, and input markets.

Research uptake

NIAP's research is widely applauded and utilized by the various stakeholders including academicians, researchers, research administrators and policymakers. Till 2019, the Institute has published 34 Policy Papers, 45 Policy Briefs, 31 discussion and working papers, and 13 books, including workshop proceedings, its own or in collaboration with international and national institutes. In addition, over 500 research articles have been published in peer-reviewed national and international journals by its faculty. During 1996-2016, these publications received a total of 7,968 citations with an average of 11.5 per publication. According to CII study, the Institute occupies the highest rank within the ICAR system[1] in terms of number of citations per publication.

Influence on R&D and Agri-food Policies

Although it is difficult to quantify the impact of policy research undertaken by NIAP, but the implications emerging from its research have served as a credible source to help fill critical gaps in the policy process. The senior faculty of the Institute is engaged in policy consultation processes of the central and state governments. The key policy influences of NIAP's research are as follows:

- Its studies on research priorities and investment have helped the Council in mobilizing more resources for agricultural research, raising the intensity from 0.3% of agricultural gross domestic product in 1996 to 0.6% in 2016; bringing objectivity and transparency in allocation of research resources, aligning research agenda with emerging challenges and opportunities, designing competitive research funds, and measuring research impacts.
- Through its active participation in the World Bank funded projects of NATP and NAIP, the Institute sensitized national agricultural research system about the multi-disciplinary and eco-regional mode of research, and better monitoring and evaluation mechanisms.
- The studies on information asymmetry and structure of seed industry have contributed to development of IPR guidelines, framework for socio-economic assessment of GMOs, and reforms for promoting diversified seed systems.
- The Institute has been actively engaged in policy dialogues and processes. A notable contribution of the Institute has been the adoption of its proposed model to achieve agricultural growth target of 4% during the XIth Plan. The Institute takes pride that agriculture could hit the target growth.
- Another evidence of NIAP's research influence on the policy process is seen in terms of increased allocation of resources for diversification of agriculture towards horticulture and livestock during XIIth Plan that has considerable potential to push agricultural growth up and reduce poverty. Similarly, R&D investment for eastern India was enhanced.
- Institute's forecasts on demand and prices of agricultural commodities have also served as an important input in managing food economy and undertaking perspective research planning for meeting future demand. The estimate of feed use rates are utilized by the Central Statistical Organization.
- The evidence-based feedback on the efficiency of different marketing systems has been followed to bring transparency in price discovery, evolve efficient value chains and promote inclusive contract farming.
- The Institute is providing an analytical framework for estimation of farmers' income and actively engaged in evolving strategies to realize of doubling farmers' incomes by 2022. ■■

[1]Glimpses of Research Productivity of Indian Universities and Research Institutions, CII-ICI Report 2017, Confederation of Indian Industry, New Delhi.

Profile of Technology

Pusa Basmati 1121, a semi-dwarf variety was developed by ICAR-Indian Agricultural Research Institute, in 2003. It has an advantage over traditional basmati varieties which were tall, prone to lodging, photoperiod sensitive and low-yielding. This variety has extra-long slender grains (cooked length upto 22 mm), pleasant aroma and requires less cooking time. It gives an average yield of 4.0 t/ha over 2.5 t/ha of traditional basmati varieties, and requires 15-20 days less growing period facilitating early sowing of wheat.

Adoption Domain

PB 1121 is grown mostly in the Indo-Gangetic Plains region covering the states of Punjab, Haryana, Delhi, Himachal Pradesh, Uttarakhand, Jammu and Kathua districts of Jammu & Kashmir and 27 districts of Uttar Pradesh (west). This region got Geographical Indication (GI) tag for Basmati rice in 2016. Basmati from Indian sub-continent is highly valued and India is the largest producer and exporter in the world.

Presently, PB 1121 is grown in over 1.10 million hectares (Mha) in India. Within few years from its release, PB 1121 became the most widely grown variety. It covered two-third (70%) of total Basmati area in 2018, which was even three-fourths (74%) in 2014. The highest area (1.54 Mha under PB 1121) was noticed in 2014-15, and decline in area is attributed mainly to development of PB 1509, which resulted fall in price. The adoption of PB 1121 has likely reached to its ceiling (70%), may remain at this level by 2025 and decline to 50% by 2030.

Area and production of Basmati & PB 1121 in India

Estimated export earnings from PB-1121, APEDA

Target Beneficiaries and Key Benefits

PB 1121 is grown by millions of farmers having irrigation facilities irrespective of farm size and brought prosperity to the producers, and it is one of the leading agricultural export commodities from India. This variety generates two-fold employment over traditional Basmati varieties. The yield is higher at the almost same level of cultivation cost and thus, it gives higher returns to the producers. It has excellent global demand in Middle East, Iran, Australia, Africa, Canada, USA, etc. and fetches a higher price. It is recognized by its unique aroma & taste.

Economic Benefits

Basmati rice is a highly valued agricultural commodity in the international market for its cooking and eating quality. About 90% of Basmati rice trade in overseas market is shared by India. With the development of PB 1121, the export earnings from Basmati varieties increased nearly six-fold, from Rs. 5,573 crore in 2006-07 to Rs. 32,806 crore in 2018-19 (at 2018 prices). The annual export earnings from PB-1121 are estimated at Rs. 19,939 crore (i.e. US$ 2926.7 million) during triennium ending (TE) 2018-19. The annual economic surplus generated from PB-1121 is estimated at Rs, 14,707 crore during TE 2018-19, which is 2-fold more than total ICAR budget (Rs. 6, 440 crore) during TE 2018-19. The earnings from PB 1121 are about 96% of total expenditure of the NARS (Rs. 15,379 crore) during TE 2018-19. The ICAR allocates about 7% of its scientific manpower to rice research, while annual returns from PB 1121 is more than double of total ICAR expenditure during TE 2018-19.

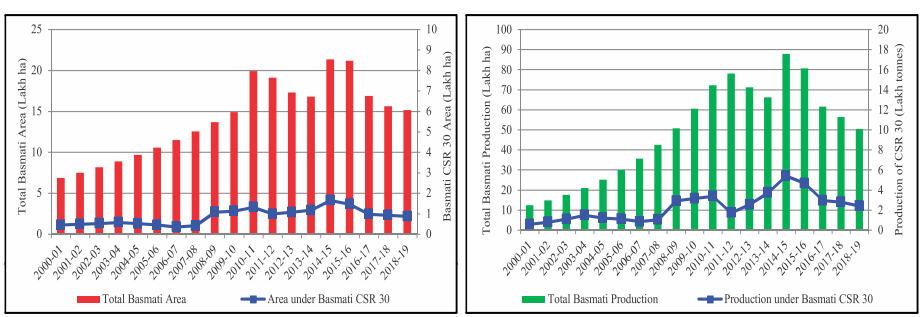
CSR 30: Salt Tolerant Basmati

Profile of Technology

ICAR - Central Soil Salinity Research Institute, Karnal, developed the first ever sodicity tolerant variety of Basmati rice, CSR 30. This is a very popular Basmati variety among the farmers of Haryana. It has been identified and notified by the Central Variety Release Committee (CVRC) in 2001 for growing in the salt affected areas in Haryana, Uttar Pradesh and Punjab and this variety was re-notified by CVRC as Basmati CSR 30 during 2012. The variety tolerates soil sodicity up to pH ~ 9.5 and salinity up to EC ~ 7.0 dSm-1. Basmati CSR 30 yields upto 28 q/ha in salt affected soils. The variety has long slender and highly aromatic grains with good head rice recovery and good elongation ratio of cooked rice.

Adoption Domain

The area under Basmati rice cultivation in India increased from 6.86 lakh ha during 2000-01 to 15.15 lakh ha during 2018-19, in which the Basmati CSR 30 is cultivated in 6% (87,300 ha) of the total area occupied by all Basmati varieties during 2018-19. In addition, as per latest estimates, about 60% area of Basmati rice cultivated in Haryana state is captured by CSR 30. The total Basmati rice produced in India during *Kharif* 2018-19 was 50.27 lakh tonnes, in which contribution of CSR 30 was 2.42 lakh tonnes (5%). CSR 30 covered about 16.45 lakh ha of salt affected area with a production of 43.80 lakh tonnes during 2000-01 to 2018-19. The maximum adoption of Basmati CSR 30 (8%) was noticed during the year 2008-09.



Area and production share of Basmati CSR 30 in of total Basmati in India

Target Beneficiaries and Key Benefits

The variety is preferred by Basmati growing farmers in the salt affected regions. CSR 30 Basmati gives upto 5 quintal/ha (20%) higher yield over Taraori Basmati (HBC 19) variety and 1.5 quintal/ha (6%) higher yield than Pusa Basmati 1121 in salt affected soils. This variety fetches higher premium price in the market (Rs. 3,800-4,000 per quintal) due to its higher aroma and other quality parameters compared to other Basmati rice varieties (Rs. 3,500-3,600).

Economic Benefits

The total economic surplus generated from CSR 30 is estimated to be Rs. 26,217.59 crore (at average export price of 2016-17 to 2018-19 prices) during the period 2000-01 to 2018-19. The share of producer and consumer surplus was 51% and 49%, respectively. The estimation based on export price revealed that the revenue generation from Basmati CSR 30 is Rs. 1,379.87 crore per annum during the same period.

CSR 36: Salt Tolerant Rice

Profile of Technology

The salt-tolerant rice variety CSR 36 was developed by ICAR-CSSRI, Karnal, and released in 2005 for field cultivation in the sodicity prone areas of Haryana, Uttar Pradesh and Puducherry. It tolerates sodicity upto pH ~9.9 and salinity upto EC 10 dSm-1. The variety gives yield upto 40 quintal/ha in salt affected soils and 60-65 quintals/ha in normal soils. CSR 36 has long slender grains (6.76 mm) with good cooking quality, and has other features like high head rice recovery (67.5%) and intermediate amylose content (25.0%) with better gel consistency.

Adoption Domain

CSR 36 variety is grown in salt affected areas of Haryana, Uttar Pradesh, West Bengal and Bihar. The variety has covered an average of 2.52 lakh ha area since its release, accounting to 11.45% of rice area under salt affected soils in these states. CSR 36 variety was cultivated in 1.75 lakh ha salt affected area in 2018-19 and maximum adoption of about 25% was noticed during 2010-11.

Target Beneficiaries and Key Benefits

The variety is cultivated by majority of the farmers of salt affected states in the country. CSR 36 has 8 quintal/ha (25%) higher yield advantage over Pusa 44 rice variety in salt affected soils. It has in-built moderate resistance to biotic stresses like blast, rice tungro disease, and green leaf hopper.

Economic Benefits

The proportionate input cost change per tonne of output due to CSR 36 is about 2.4%. The total economic surplus generated from CSR 36 is Rs. 8,374 crore (at 2018 prices) during the period 2006-07 to 2018-19. The share of producer and consumer surplus is in the ratio of 51% and 49%, respectively. The annual economic surplus from CSR 36 is estimated at Rs. 644 crore.

Salt Tolerant Rice Variety CSR 36

HD 2967 (Pusa Sindhu Ganga) Wheat

Profile of Technology

HD 2967 is a double dwarf wheat variety was developed by ICAR-Indian Agricultural Research Institute, New Delhi. It was first released for the North Western Plains Zone (NWPZ) in the year 2011, and later it was extended for cultivation in the North Eastern Plains Zone (NEPZ) in 2014-15. It has potential grain yield of 7.0 t/ha in NWPZ and 6.52 t/ha in NEPZ. This variety gives an average grain yield of 5.04 t/ha in NWPZ and 4.54 t/ha in NEPZ. It has profuse tillering. Ears are medium dense and tapering in shape with white glumes. Its grains are amber, medium bold and lustrous, ovate shaped grain with 40 gm. test weight and 12.7% protein content. The variety takes an average of 143 days and 129 days to mature in NWPZ and NEPZ, respectively, and has high degree of resistance to leaf rust as well as of 78S84 and 46S119 races of yellow rust. The variety also showed lower incidence of leaf blight, Karnal bunt and flag smut than the checks. The variety has high zinc, copper and manganese content, sedimentation value and suitable for bread and chapatti making.

Adoption Domain

It is well adapted in NWPZ comprising states of Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of J&K, Ponta valley and Una district of Himachal Pradesh and Tarai region of Utarakhand and NEPZ covering of Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Assam and plains of North Eastern states.

After its release, this variety spread very fast covering about 40% of wheat area of NWPZ and NEPZ during the year 2016-17 and would be a ruling variety by 2020-21. It replaced PBW 343 due to its vulnerability to stripe (yellow) and leaf (brown) rust that affected the yield. Also, some new wheat varieties have been released. For example, the variety HD 3226 has higher protein content (average 12.6%) and has potential yield of 7.96 t/ha. The variety Karan Vandana (DBW 187) is released for irrigated and timely sown conditions of North Eastern Plains zone. It possesses resistance to leaf rust and leaf blight and has potential yield of 6.47 t/ha. The stiff competition from the new released varieties will gradually bring down the area under HD 2967 to 20% of total wheat area in NWPZ and NEPZ by 2030.

Target Beneficiaries and Key Benefits

Fluctuations in temperature during flowering season have become regular now and the HD 2967 variety can tolerate in such fluctuations. In view of better grain yield, good straw and resistant to certain diseases (yellow and brown rusts), the variety is grown by all farmers in the Indo-Gangetic plains. The NEPZ has more small farmers and it is benefitting all of them.

Economic Benefits

The total economic surplus generated from HD 2967 is estimated at Rs. 62,405 crore (at 2018 prices) during the period of past 8 years (2011-2018), and was distributed between producers and consumers in ratio of 61:39. The total economic surplus generated from this variety was estimated at Rs. 12,889 crore for TE 2018-19 (at 2018 prices).

KRL 210: Salt Tolerant Wheat

Profile of Technology

Development of salt tolerant varieties is an effective way to overcome the limitations of crop production in salinized areas of the country. The crop grain yield is frequently used in crops like wheat as the main criteria including effective tiller, and plant height for the development of varieties. Wheat cultivar KRL 210, a salt-tolerant with medium grains, was developed by ICAR-CSSRI, Karnal. It was released in the year 2010 for the salt affected regions of Haryana, Punjab, Uttar Pradesh, Gujarat and Rajasthan. The variety has tolerance to high degree of sodicity upto pH ~9.3 and salinity upto 7.3 dSm-1. This variety attained grain yield upto 34 q/ha in salt affected soils and 55 q/ha in normal soils. Although grain yield in salt affected soils depend on salt stress severity.

Adoption Domain

The variety is most popular in salt affected areas of Haryana, Punjab and Uttar Pradesh. Hitherto, salt tolerant wheat variety KRL 210 has covered about 22,279 ha area annually since its release. The estimate accounts to 1.27% of salt affected area under this variety in these states during the period 2010-11 to 2018-19.

Target Beneficiaries and Key Benefits

The salt tolerant wheat variety KRL 210 is preferred in comparison to other ruling cultivars by the farmers in salt affected areas. Under farmer participatory approach, it has been observed that KRL 210 gives 5 quintal /ha (14%) higher yield over HD 2967 in salt affected soils (>pH 9.3 and RSC >5.0). This variety contains about 11% protein and is also known for better bread making quality, and consequently it is most popular among the farmers.

Salt Tolerant Wheat Variety KRL 210

Economic Benefits

The economic surplus from the wheat variety KRL 210 is estimated at Rs. 404 crore for the period 2010-11 to 2018-19, this amount was shared between the producer and consumers in the ratio of 61:39, respectively. The annual economic surplus was observed of Rs. 45 crore from the salt tolerant wheat variety KRL 210.

Pusa Mustard 25 (NPJ-112)

Profile of Technology

Pusa Mustard 25, developed by ICAR-Indian Agricultural Research Institute, New Delhi, was released for field cultivation in 2010. The variety was developed from cross Sej 8 x Pusa Jagaranth and followed by pedigree method of selection. It is suitable as early sown variety for multiple cropping systems between September (after harvest of *Kharif* crops) to mid-December (upto sowing of *Rabi* crops particularly wheat and vegetables) to have an additional crop. This variety matures in 107 days, which is 7-10 days early to Pusa Mahak. Due to its early maturity, it fits well in different cropping system. The leaves are simple, small, green in colour and pubescent. Average seed yield of Pusa Mustard 25 is 14.7 q/ha. Seed is small in size (4.5 g/1000) with average oil content of 39.60%. The plant of this variety is of bushy type having basal branching with medium height which attains an average height of 165 cm with 4-7 primary branches/plant having long main shoot with high siliquae density.

Target Domain

Pusa Mustard 25 is recommended for cultivation in Delhi, Haryana, Punjab, Jammu & Kashmir, Rajasthan and Uttar Pradesh (west). This short-duration variety is sown in September and matures by mid-December. By this time there is no disease or insect pest incidence mainly due to escape mechanism. It is a good substitute of *B. rapa* cv. Toria (in toria's traditional belt).

Target Beneficiaries and Key Benefits

It is suitable for early sown irrigated condition, and has tolerance to high temperature. The variety gradually gained popularity and covered area 20% of total mustard area from its modest start in the year 2010. It is

expected to show a modest pace of deceleration in area reaching a level of 10% of total mustard area by the year 2027-28. The yield gain is about 100% over check variety average yield of 8 q/ha. It is considered to be a good replacement for Toria. Its potential yield is 1,324 to 1,654 kg per ha and oil content is 36 to 41%.

Economic Benefits

The total economic surplus generated from Pusa Mustard 25 is estimated at Rs. 14,323 crore (at 2018 prices) during the period for past 9 years (2010-2018), and was distributed between producers and consumers in ratio of 51:49. The average surplus for TE 2018-19 was estimated at Rs. 2,919 crore and was allocated Rs. 1,499 crore to producers and Rs. 1,420 crore to consumers.

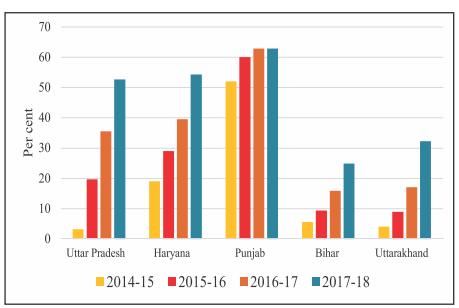
Co-0238 (Karan) : Sugarcane Variety

Profile of Technology

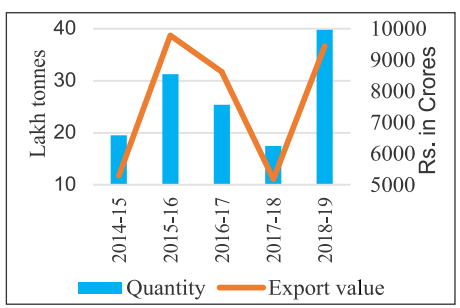
Sugarcane is an important cash crop of the country and cultivated over 5 million ha in both tropical and sub-tropical regions. Co-0238 (Karan 4) is a wonder variety of sugarcane developed by ICAR-Sugarcane Breeding Institute, and was notified for field cultivation in 2009. It is a high-yielding, high-sugar recovery variety over earlier varieties which were low-yielding with less sugar recovery and vigour due to biotic and abiotic stresses. This variety gives an average yield (>81 t/ha) with a sugar recovery of above 12%. The variety is tolerant to drought, water logging, salinity, and suitable for all planting seasons. It is a good ratoon yielder and tolerance to low temperature. The variety is suitable for wider row planting, which is a pre-requisite for mechanical harvesting.

Adoption Domain

Co-0238 spread at an exceptionally faster rate in Uttar Pradesh, Punjab, Haryana, Bihar, Uttarakhand, parts of Madhya Pradesh, Odisha and Gujarat. The area occupied by this variety increased to 23.04 lakh ha in 2018-19 from 2.70 lakh ha in 2014-15 in the sub-tropical region, which is the highest area (44.9%) ever occupied by a single variety in a very short-period of time. Before release of Co-0238, the share of sub-tropical region in area and production of sugarcane in the country was 55.8% and 49.4% in 2012-13, which increased to 59.6% and 57.9% in 2017-18, respectively.



Area and adoption of Co 0238 in the sub-tropical states



Estimated earnings through sugar export from Co 0238

Target Beneficiaries and Key Benefits

This variety is grown by millions of farmers with irrigation facilities irrespective of farm sizes and brought prosperity to farmers and sugar industries. During the period of 2014-15 to 2018-19, Co-0238 fetched an additional return of Rs. 14,381 crore to the farmers (from sugarcane and fodder). As a result, the profit of farmers increased by about Rs. 45,405/ha. Similarly, high-sugar recovery led to additional production of 67.4 lakh tonnes of sugar worth Rs. 25,007 crore without much increase in the cost to sugar mills.

Economic Benefits

Co-0238 yielded an additional return of Rs. 28,795 crore in four years (2014-15 to 2017-18) from sugar and by-products (58.5 lakh tonnes of fodder worth Rs. 305 crore, 135.0 lakh tonnes of bagasse worth Rs. 2,643 crore, 20.3 lakh tonnes of molasses worth Rs. 837 crore and 1.35 lakh tonnes of press mud worth Rs. 2.7 crore). Hence, the total additional benefit from sugar and by-products was estimated to be Rs. 7,199 crore every year. The annual total economic surplus generated from Co-0238 was Rs. 10,064.3 crore during the period of 2014-2018 and distributed among producers and consumers in the share of 60:40. The surplus production paved the way for exporting of sugar worth Rs. 6,400 crore during 2018-19.

Impact on Policy Implementation

The Government of India was keen on implementing the ethanal blending program (5%) in gasoline from 2003. However, it could not be implemented due to vicious cycle of sugarcane and sugar production. Co-0238 has broken the inverse relationship of yield and sugar recovery and has revolutionized sugarcane production in the country. So, the Government has allowed diversion of heavy molasses and juice to ethanol program to produce required quantity of fuel ethanol. Now, the country has achieved 5% blending target during 2018-19 and soon it would achieve 10% level, which was made possible due to cultivation Co-0238.

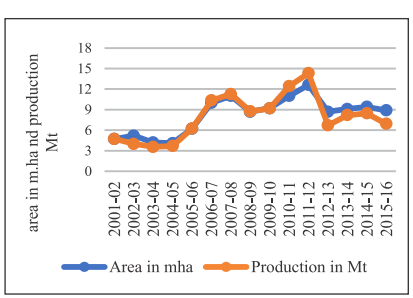
Co-86032 (Nayana) : Sugarcane Variety

Profile of Technology

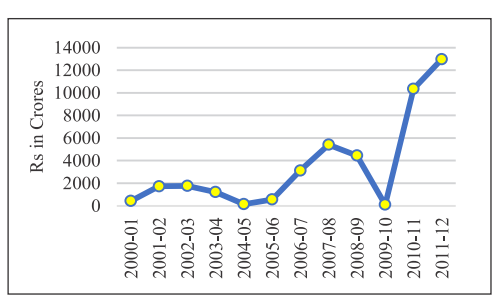
Co-86032 (Nayana), a high-yielding and high-recovery sugarcane variety was developed by ICAR-Sugarcane Breeding Institute, Coimbatore. It was notified and released for field cultivation in 2000. It is a wonder variety of the new millennium. Co-86032 is suitable for both October and January/February planting. It is well adapted and suited to wide row spacing of 120-150 cms without any reduction in cane yield. It is highly amenable for mechanical harvesting and mechanisation of sugarcane cultivation. It can retain the high juice quality beyond twelve months. The additional yield gain of 23t/ha was recorded in the AICRP trial over check variety. In the farmers field, average additional yield of 10-12 tonnes/ha was estimated and the sugar recovery improved by 0.24 to 1.2% in the tropical states of India. Ratoon crop gives excellent yield even up to three ratoons. This variety is well suited for jaggery and khandsari production in India.

Adoption Domain

Co-86032 has quickly replaced almost all the earlier varieties in peninsular zone comprising of Tamil Nadu, Karnataka, Maharashtra, Gujarat, Andhra Pradesh and Kerala. Tamil Nadu was the biggest beneficiary of this variety with over 80% area under Co-86032 for more than ten years. This is the ruling variety being cultivated in states of Karnataka, Maharashtra, Gujarat, and Kerala (at least 50% area under it) and in significant area in Andhra Pradesh and Odisha. This is the most popular variety in the tropical parts of the country and cultivated in more than 1.2 million hectares during 2011-12. It was cultivated in about 24.9% of total cane area and contributed to 30.7% of the total cane production (105 million tonnes) during 2011-12. The adoption of Co-86032 has reached to its ceiling in the tropical states and would decline to 40% level by 2020. Still it's being cultivated in about 8 lakh ha in the tropical region of India.



Area and increment production by Co 86032 tropical states



Estimated Forex earnings through white sugar export

Target Beneficiaries and Key Benefits

This variety is grown by lakhs of farmers with assured irrigation facilities irrespective of farm size and brought prosperity to them and sugar industries. It provides high yield at almost same level of cultivation cost and gives higher returns than other cane varieties. As a result, the profit of farmers increased by about Rs. 33,000/ha (at 2018 prices). It helped sugar mills to operate in their full capacity and provided regular employment to people engaged in cane production and processing.

Economic Benefits

The impact of Co-86032 on cane output and sugar industry has been tremendous over the past 15 years (2002-2016). The economic impact of this variety is in the range of over Rs. 20,354.6 crore by 2015-16 in terms of net additional value since large scale adoption of the variety in the tropical India. Similarly, higher sugar recovery of Co-86032 led to production of an additional 4.12 lakh tonnes sugar worth Rs. 694.4 crore by the sugar mills. This variety has additionally produced by-products of 53.4 lakh tonnes of molasses worth Rs. 2137.9 crore and 336 lakh tonnes of bagasse worth Rs. 4,453 crore. Totally, Rs. 27,639.9 crore of additional economic benefits were generated by Co-86032. The annual economic surplus generated from Co-86032 was Rs. 13,098 crore during the period of 2001-2016 and distributed among producers and consumers in the ratio of 67:33. The total export earnings from white sugar increased from Rs. 1,147 crore to Rs. 12,973.7 crore (at 2012 prices) during 2000-01 to 2011-12.

Kufri Phukraj: Potato Variety

Profile of Technology

Varieties with characteristics like early or medium maturity, fast bulking, insensitive to photoperiod, slow rate of degeneration, high productivity, good storability, and resistant to late blight, are desired for major potato producing regions of the country. ICAR-Central Potato Research Institute, Shimla, developed a variety called Kufri Phukraj in 1998, with early to medium maturity and a yield potential of 35-40 t/ha. The variety is having medium storability and resistant to early blight and moderately resistant to late blight. As regards, consumer preference and processing quality, this variety has a waxy texture, mild flavour, and free from after-cooking discoloration and coloration on exposure to light.

Adoption Domain

Kufri Pukhraj was targeted for the North Indian Plains and plateau regions wherein more than 80% of total potato area (21.42 lakh ha) is located in states of Uttar Pradesh, West Bengal, Bihar, Punjab, Haryana, Jharkhand, Chhattisgarh, Assam and Odisha. Adoption rate of Pukhraj variety across the targeted states has varied from 27.54% in Uttar Pradesh (1.67 lakh ha), 41.25% in Bihar (1.30 lakh ha), 18.93% in West Bengal (77,836 ha) and 85% in Gujarat (95,585 ha). Presently, Kufri Pukhraj covers about 33% of the total potato area in the country. The four states of Uttar Pradesh, West Bengal, Bihar and Assam together accounted for about 70% (each) of total potato area and production of India. This variety is reaching to its ceiling of adoption due to release of improved varieties like Kufri Chipsona, Kufri Khyathi and Kufri Sadabahar.

Target Beneficiaries

All categories of farmers under both rainfed and irrigated conditions of the northern plains and plateau regions grow this variety on their farms.

Key Benefits

Kufri Pukhraj had realized 15% higher yield over the check variety Kufri Jyoti and it also has less cultivation cost (15%) due to savings on disease management. The special attributes of Kufri Phukraj are early bulker and suitable for low input eco-system. Even today, it is most popular early to medium maturity variety in Uttar Pradesh and Bihar, though a few other varieties were released with better storability.

Economic Benefits

Kufri Phukraj is one of the most popular short-duration varieties in North Indian Plains region even today. The total economic surplus/benefit generated from Kufri Phukraj is estimated as Rs. 92,650 crore during 1998-99 to 2017-18 (at 2018 prices). The economic surplus during the year 2017-18 was Rs. 4,729.0 crore (at 2018 prices) and estimated area under this variety was 7.1 lakh ha mostly in the North Indian plain and plateau regions.

Pomegranate - Phule Bhagwa

Profile of Technology

Concerted research efforts under AICRP on Arid Zone Fruits resulted in release of pomegranate variety called Phule Bhagwa (popularly known as Bhagwa) by MPKV, Rahuri in 2003-04. This variety is soft seeded with bright red attractive rind and aril colour. The variety became highly popular over traditional cultivar Ganesh which is having pink coloured arils. "Bhagwa' variety is heavy yielder and possesses desirable fruit characters viz. bigger fruit size, sweet, bold and attractive arils, glossy, very attractive saffron coloured thick skin, suitable for distant markets, less susceptible to fruit spots and thrips.

Adoption Domain

This variety is suitable for both tropical and subtropical regions of the country covering the major growing states of Maharashtra, Karnataka, Gujarat, Andhra Pradesh and Madhya Pradesh. The state of Maharashtra accounted for nearly 63.2% of total pomegranate area (2.34 lakh ha), in India during 2017-18, while Karnataka (11.1%), Gujarat (13.04%), Andhra Pradesh (4.0%) and Madhya Pradesh (4.1%) are the other major states. Overall, Bhagwa variety is adopted in 86.10% of total area i.e., in 1.69 lakh ha during 2015-16. In Maharashtra the adoption rate is 90%, while it is over 75% in other states. The maximum adoption rate is likely to be 90%, which can be attained by 2025-26. Establishment of Pomegranate Cooperative Society and Agri-Export Zone in Maharashtra state helped farmers in export activities.

Target Beneficiaries

All categories of farmers viz., Small, medium and larger farmers mostly under irrigated production system are the targeted beneficiaries of this variety. Entrepreneurs, industries, exporters are also benefitted from this variety as India is the largest exporter of pomegranate in the World.

Key Benefits

In Bhagwa variety 100% yield increase was observed over national check i.e. cv. Ganesh. The keeping quality of fruits is about 15-25 days with no loss at ambient temperature. The fruits of Bhagwa variety received more than 200% premium price over other cultivars due to its superior quality in terms of arils, colour and size. The popularity of this variety can be adjudged through unprecedented increase in area (123%), production (280%), productivity (70%) and export (380%) in 2016-17 over 2007-08. Bhagwa cultivar has high acceptance in European and other international markets.

Economic Benefits

India is the largest producer of pomegranate in the world with nearly 86% of present area under Bhagwa variety (2.05 lakh ha). With an estimated 100% yield increase, the total economic surplus during past 15 years since its release in 2003-04 is Rs. 46,100 crore (at 2018 prices). The distribution of gains between consumers and producers was in the ratio of 73:27. The annual economic benefit for the year 2017-18 is Rs. 9,617 crore at 2018 prices. On export front, pomegranate export earnings increased from Rs. 21 crore from 10,315 MT in 2003-04 to Rs. 688.47 crore (98.98 million US$) from 6.78 lakh MT. Bhagwa variety holds a major share in the pomegranate exports from India.

Grapes – Dogridge Rootstock

Profile of Technology

Saline and alkaline conditions in Maharashtra and Karnataka during the 1990s necessitated to undertake research work on the rootstock that benefits the grape cultivation. ICAR-Indian Institute of Horticultural Research evaluated a series of rootstock during early 1990s and standardized the cultivation of grapes on dogridge rootstock in 1993-94. Growing grapes on 'dogridge rootstock" has resulted in improved quality, reduced production cost, increased yield of grapes and all these resulted into higher profit for farmers.

Adoption Domain

The field level adoption of dogridge rootstock technology was started from 1996-97 onward and since then it has spread widely to nearly 90% of grape area. Adoption of technology was quick and widespread in Maharashtra which accounts for about 70% of total grape area in Karnataka, Andhra Pradesh and Tamil Nadu, it gained momentum after 2002. The states of Maharashtra and Karnataka together account for 95.11% of total grape area and at present 1.25 lakh ha area of grapes is raised on dogridge rootstock. It is expected to expand to 95% of total area under cultivation by 2025 as grapes area is expanding in the North-Eastern areas like Mizoram and Nagaland under TSP programme.

Target Beneficiaries

Grape cultivation on dogridge rootstock was targeted for all the categories of farmers under irrigation production systems in plains area. Efforts are also being made to expand to hilly areas in NE region for its suitability under TSP programme.

Key Benefits

Application of dogridge rootstock has provided yield gain in the range of 5-10%, while reduction in the cultivation cost was noticed by 10-15% across major grape growing regions of Maharashtra and Karnataka. There were other intangible benefits such as improved quality of the berries and reduction in the total water requirement for the crop. The technology also expanded scope for the farmers to use new varieties of grapes for wine production as these could be grafted onto the well-established dogridge rootstock.

Economic Benefits

Grape is one of the important export-oriented fruit crops of India. The direct total economic surplus/ benefits since adoption of dogridge rootstock for raising grape crops was Rs. 15,212 crore during 1996-97 to 2017-18 (at 2018 prices). The economic surplus for the year 2017-18 was Rs. 1,721.6 crore.

Exports of fresh grapes earned a foreign exchange of US $ 334.91 million (Rs. 2,335 crore) while the value of export of raisins was US $ 26.217 million during 2018. Nearly 90% of these exports are based on the fruits obtained from grapes raised on dogridge rootstock.

Cashew - Softwood Grafting

Profile of Technology

Owing to cross pollinated nature of cashew crop, the seedling progenies raised even after identification of varieties, were highly heterogeneous and variable in their performance. With the emphasis of developing a reliable and commercially viable vegetative propagation technique in cashew, epicotyl grafting was first developed by the ICAR-Directorate of Cashew Research and subsequently refined soft wood grafting technique was released for propagation in 1990-91.

Adoption Domain

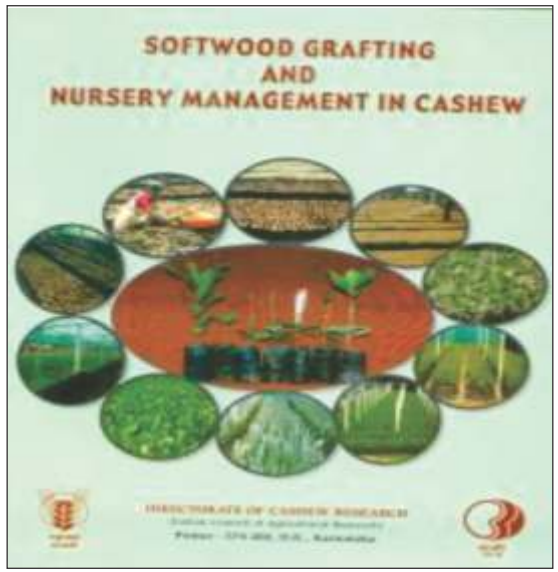
It is targeted to cover all cashew seedlings nurseries/progressive farmers in different agro-climatic regions of the country to bestow this superior vegetative propagated soft wood grafting technique. Over 100 Regional Nurseries supported by the Directorate of Cashew and Cocoa Development (Ministry of Agriculture and Farmers Welfare), Kochi, are adopting this technology for production of superior cashew seedlings. At present, 6.72 lakh ha out of 10.62 lakh ha of cashew area is under plantation raised on softwood grafting. Every year nearly 70 lakh seedlings were produced by these nurserymen/ growers by adopting only softwood grafting technique and expansion of new gardens is taking place with these seedlings only.

Target Beneficiaries

All categories of farmers under resource poor and rich conditions in all major cashew growing states of India viz., Kerala, Karnataka, Goa and Maharashtra along the west coast and Tamil Nadu, Andhra Pradesh, Odisha and West Bengal along the east coast.

Key Benefits

Uniformity of the planting material and reduction in the pre-bearing age from 5-6 years to 3 years are the key benefits from the planting of seedlings raised by using this propagation technique. Nearly 15% yield gain was observed in softwood grafted cashew plants over conventional seeds planted, though there is no difference in cost of cultivation. Entrepreneur - ship development at farm level was accomplished as growers were major suppliers of seedlings and nearly 80 lakh seedlings were produced every year with a minimum return of Rs 10/ seedling.



Economic Benefits

Since its adoption, the annual average benefits (economic surplus) is Rs. 9,965.69 crore and the economic surplus for the year 2017-18 was Rs. 937.14 crore. The distribution of gains between consumers and producers was in the ratio of 74:26.

Citrus - Shoot-Tip Grafting

Profile of Technology

Under conventional nursery practices, large scale multiplication of mother plants with promising traits is not possible due to infection of systemic pathogens like citrus greening and viruses. The only possibility is to obtain virus-free plants from virus infected mother trees is through Shoot-Tip Grafting. The ICAR-Central Citrus Research Institute (CCRI), developed a shoot tip grafting (STG) technique for elimination of virus and virus like diseases in 2003-04. The technology developed facilitated cleaning of local selections and production of true-to-type, healthy mother tree even from infected sources.

Adoption Domain

All citrus growing regions, particularly for Mandarin and sweet orange types, were targeted for adoption of STG technique in Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Punjab, Haryana and all the southern states. CCRI so far has released about 15 lakh certified healthy planting material to citrus growers/ nursery men covering nearly 5,500 ha in the central India. There is an annual demand of one crore planting stock all over India, while only 1% planting material need can be met from CCRI owing to limitations of manpower and infrastructure. With the participation of private nursery men it is anticipated that about 1805 ha area (5,00,000 grafts) shall be covered every year.

Target Beneficiaries

Progressive farmers, nurseries, universities, tissue culture companies, farm producers organisations who are interested in manifold increase of disease free planting stock in states of Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Punjab, Haryana and southern states.

Shoot tip graft ready for transfer

Successful double graft

Key Benefits

The major benefit is producing uniform, true-to-type and disease-free planting materials for realising higher yield. By growing with these grafts, there is timely flowering, which will result in improved quality and yield. An average yield increase of 10 t/ha to 20 t/ha was estimated in grafted plants over the conventional methods. Further, the size of fruits are relatively bigger (150 g) with higher TSS (110 B) and juice recovery (48%) in fruits of the grafted plants.

Economic Benefits

Total economic surplus/benefits from growing mandarin and sweet oranges on plants obtained from STG technique was Rs. 2,491.2 crore (15 years) at 2018 prices. The economic surplus for the year 2017-18 was Rs. 515 crore (at 2018 prices) and estimated area under gardens under this technology was 17,900 ha mostly under mandarin and sweet orange types. With target of 2000 ha every year till 2029-30, the likely benefits will be Rs. 12,799.68 crore from a total area of 41,900 ha under this technology. CCRI, Nagpur so far earned revenue of Rs. 1.19 crore by selling these elite planting materials. ■■

Arka Rakshak & Arka Samrat: Tomato Hybrids

Profile of Technology

Tomato leaf curl virus (ToLCV), bacterial wilt (BW) and early blight (EB) are among the most difficult tomato diseases to manage as no chemical treatments available to stop their spread leading to enormous yield losses. ICAR-Indian Institute of Horticultural Research (IIHR), developed triple resistant tomato hybrids Arka Rakshak (2010) and Arka Samrat (2016) which were found resistant against ToLCV, BW and EB with a yield potential upto 80 t/ha in 140 days. Fruits of these hybrids are large (90-110g), deep red and firm. The fruits of Arka Rakshak are square round and found suitable for both fresh market and processing, while fruits of Arka Samrat are oblate to high round suitable for fresh market only.

Adoption Domain

Triple resistant tomato hybrids were targeted mostly for areas infected with BW sick soils and for summer cultivation due to occurrence of ToLCV. These hybrids can also be grown during other seasons, viz. *kharif* and *summer* as high-yielding hybrids. Arka Samrat was recommended at National level to zone VIII (Karnataka, Tamil Nadu, Andhra Pradesh and Kerala) in May 2015 and notified for national release in September 2016. These hybrids spread to nearly 4,900 ha during 2018-19. For faster spread there is a need to produce seeds of these hybrids on a large scale by the seed agencies. ICAR-IIHR is also making efforts to license parents of these hybrids to private seed companies (so far sold to 12 companies)

Target Beneficiaries

All categories of farmers in the irrigated production systems in the plains of India can adopt these varieties. Efforts are also being made to spread in the NE region under TSP programme.

Key Benefits

Field studies indicated that these hybrids have given 35.32% higher yield with reduced cost of production per unit of area, though farmers incurred higher cultivation costs by 23%. The net returns realised were higher by 58.8%. Another key benefit is that the number of harvests is also more (18-21) and this spread of harvest period also helps to overcome the price fluctuations.

Economic Benefits

In vegetable seed industry, the private sector is a dominant player. ICAR-IIHR has developed first public triple disease resistant tomato F1 Hybrid in India and the total economic surplus/benefits accrued since its release (2010) is Rs. 237.82 crore (at 2018 prices). The present benefit during the year 2017-18 was Rs. 89.08 crore. The distribution of gains between consumers and producers was in the ratio of 68:32. To accelerate the adoption, ICAR-IIHR is making available parental lines to seed companies on non-exclusive basis and parents of both these hybrids were licensed to 12 seed companies, and the Institute is earning Rs. 34 lakh annually.

Live Attenuated PPR Vaccine

Profile of Technology

Peste-des-Petits Ruminants (PPR), an acute contagious disease in sheep and goats, is considered as one of the most important health constraints in rearing of small ruminants. ICAR-Indian Veterinary Research Institute (IVRI) has developed a live-attenuated vaccine (as per OIE standards) against the disease during the period 1997–2001. The production of live PPR vaccine involves culturing of Vero cells in glassware/ disposable plastic wares (both stationary and roller bottles) using a simple commercial media and serum and infection with the vaccine seed virus. The vaccine developed by ICAR-IVRI is cheaper than equivalent vaccine produced outside India.

Adoption Domain

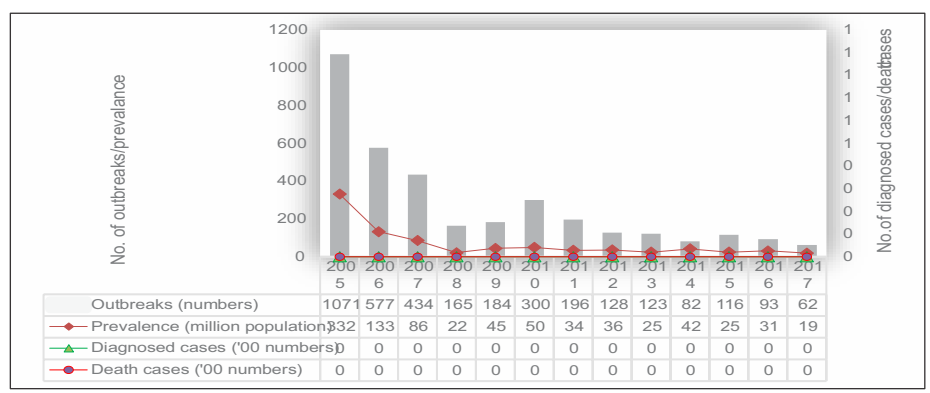
The vaccine is and will be in great demand as Government of India has launched PPR control programme. There is a movement of PPR control at the global level through Global PPR research alliance and other international agencies. Several other Governments in Asian and African Countries have initiated PPR Control by mass vaccination campaign, which encourages extensive use of this vaccine throughout the world. The technology has been transferred to several pharmaceutical and research organizations, like Indian Immunologicals, Intervet, Hester Biosciences, Biomed Private Ltd., IASVB, Kerela and ISVB, Karnataka. The Departments of Animal Husbandry in several states like Maharashtra, Haryana and West Bengal are also utilizing the technology. Indian Immunologicals is the major marketer of this vaccine as more than 90% of vaccine doses (about 5 crores) are marketed by it. The vaccine has been marketed by various agencies, both public and private since 2007–08 in many states of the country.

Key Benefits

PPR is the one of the priority animal diseases whose control is considered important for poverty alleviation in enzootic countries. As per the latest estimate, most likely expected economic losses due to PPR was about Rs. 4,600 crore in 2017. Since PPR is a transboundary disease, eradication of PPR will improve food and nutrition security, incomes and livelihood of millions of poor farmers around the world.

Economic Benefits

The change in total economic surplus from research and delivery cost were projected for the period from 1997 (year of the start of the research project) to 2030 (by which 100% of small ruminants to be vaccinated, as per OIE/FAO specifications). The change in total surplus as a result of vaccination of sheep and goats against PPR was Rs. 8,253 crore per annum. The study revealed that the vaccination programme is likely to result into significant economic surplus of Rs. 11,673 crore in 2018-19, and is expected to increase of Rs. 18, 310 crore in 2030. The IRR and BCR were 119% and 123:1, respectively.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Outbreaks (numbers)	1071	577	434	165	184	300	196	128	123	82	116	93	62
Prevalence (million population)	332	133	86	22	45	50	34	36	25	42	25	31	19
Diagnosed cases ('00 numbers)	0	0	0	0	0	0	0	0	0	0	0	0	0
Death cases ('00 numbers)	0	0	0	0	0	0	0	0	0	0	0	0	0

Trends in PPR incidence in India during 2005-16, since start of PPR vaccine in 2007-08

Source: Department of Animal Husbandry

ICAR-IVRI Cryptoscope

Profile of Technology

Failure to inseminate dairy animals in field conditions is often perceived as a common problem. However, any delay in timely breeding leads to delay in conception and missing of estrus cycle(s) in dairy animals causing significant losses to the dairy farmers. Efficient and accurate estrus detection is one of the most important factors limiting reproduction in most dairy animals/herds. ICAR-Indian Veterinary Research Institute, developed a simple and cost-effective tool called 'ICAR-IVRI Crystoscope', for ascertaining optimum time of breeding the animals for getting maximum conception rate. This instrument is used to visualize the typical fern pattern of cervical mucus which is observed in animals during fertile oestrus or ovulatory heat. About 62.5% success rate is expected when an animal is allowed to conceive while showing the typical fern pattern. Under on-going insemination practices, mean conception rate is only 35.29%.

Adoption Domain

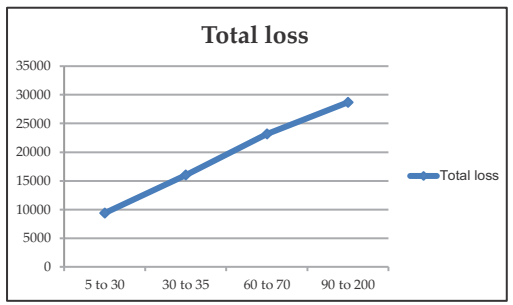
The technology has been commercialized to five companies. About 29,000 pieces of Crystoscope have sold in the market, generating revenue of Rs. 25 lakh to IVRI. The Crystoscope is targeted for entire milch animals in the country.

Target Beneficiaries and Key Benefits

The technology is of immense importance for both smallholder dairy farmers and the large scale dairy farmers. The accurate and timely detection of heat (estrus) in dairy cattle is an important and essential component of a good reproductive management program. Inadequate heat detection affects herd profitability viz. longer calving intervals, lower lifetime milk production and fewer calves. Breeding cows unsuitable for insemination leads to decrease conception rates and wasted semen and time. Combinations of unrecognized estrus and low conception rates may lead to culling of normal cows. Insemination of pregnant cows mistakenly identified in heat may cause abortion.

Crystoscope

Source: Department of Animal Husbandry



Association b/w days open & economic losses in milch animals

Economic Benefits

Average number of services required to inseminate per conception, which depends upon breed and age of dairy animals. It was lesser with 'ICAR-IVRI Crystoscope' intervention (2.5 to 3.4) than that in animals with no such intervention (3.6-5.2). As such, average days delayed in conception were also lesser in animals with Crystoscope' intervention (36-38 days) as compared to animals with no intervention (56-67 days).

The overall farm level potential loss (including milk yield loss and opportunity cost, light extra feed, labour, treatment and breeding cost) that can be avoided using Crystoscope to the tune of Rs. 27,102 crore annually in the country. The annual economic benefit per animal on account of loss avoided from early detection of heat cycle is estimated at Rs. 2,965.55. Thus, the use of 'Crystoscope' has significant impact on the reduction in losses due to delayed conception. The total economic surplus likely to be generated (*ex-ante* framework) for the period 2004-2025 would be Rs. 51,325 crore (at 2018 prices). The surplus estimated was Rs. 2,333 crore for the year TE 2018-19 (at 2018 prices).

Technology Profile

Rinderpest has been a persistent problem in India for centuries, infecting animals such as cattle, wild buffaloes, nilgai and even sheep, goats and swine. Concerted international control campaigns helped to eradicate the disease globally. These relentless efforts for generations were possible due to creation of several organizations with rinderpest eradication as their primary goal, such as World Organization for Animal Health (OIE), the Food and Agriculture Organization (FAO) and the Indian Veterinary Research Institute (IVRI). Rinderpest was the first animal infection to be eradicated globally and this has been done not only in the domestic animals but also in wild animals.

Impact of Rinderpest Eradication

The successful implementation of rinderpest eradication programme has yielded major economic benefits, particularly to small and marginal livestock owners and landless labourers. Three important interventions in eradication of rinderpest have been the launch of National Rinderpest Eradication Programme (NREP) in 1954; formation of Task Force on Rinderpest Eradication in 1983; and National Programme on Rinderpest Eradication (NPRE) in 1992.

By comparing the counterfactual with the actual scenario, it was observed that investment made in NREP launched in 1954 yielded net benefit ranging from Rs. 157.6 crore in 1956-57 to Rs 693.3 crore in 1994-95 (Figures 1 & 2), and the average net benefit during 1956-57 to 1994-95 was Rs. 379.3 crore (at 1995 prices). Investment in vaccination programme during this period to control rinderpest resulted in a B-C ratio of 43:1. The eradication of rinderpest (due to launch of NPRE in 1992) reduced India's import dependence of livestock products and in fact, the increased net exports of milk by Rs. 493.5 crore per annum during 1992-93 to 2018-19. In a study by Rich et al. (2014) reported BCR of 64 : 1 of investment made in NPRE when increased market access of livestock product to export market were factored in as one of the benefit to ascertain the economic feasibility of NPRE.

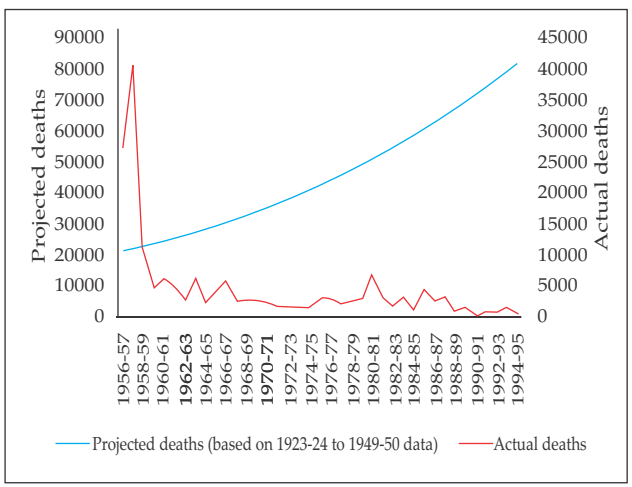


Fig 1. Projected deaths (based on 1923-24 to 1949-50 datasets)
Source: data from Department of Animal Husbandry

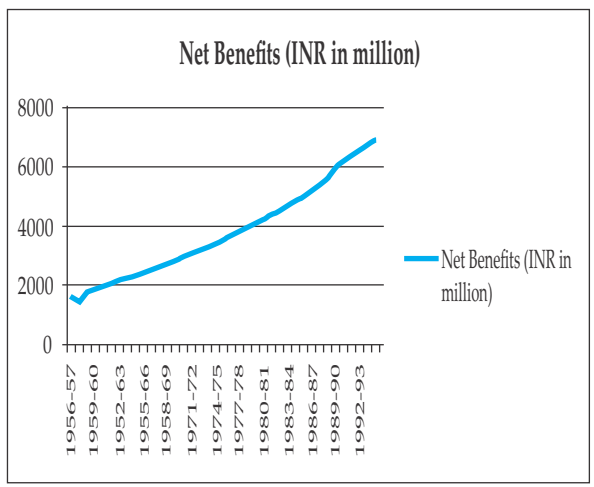


Fig 2. Net benefits after implementation of NREP in 1954 Vis-à-vis actual death (after launch of NREP in 1954)

Indirect Benefits of Rinderpest Eradication

Development of disease surveillance and diagnostic infrastructure, e.g. laboratories equipment and training of laboratory personnel can be used as a platform for galvanizing support in future disease control/eradication initiatives, viz. as a model to shorten the duration needed to eradicate other transboundary animal diseases such as PPR and FMD.

Rapid Detection of Adulterants in Milk

Technology Profile

The Food Safety and Standards Authority of India (FSSAI) in 2011 survey of milk quality indicated that most of the milk sold in India did not meet quality standards and was adulterated with various chemicals including detergents. Keeping this in view, ICAR-National Dairy Research Institute, Karnal, developed two technologies during 2012-14, viz. (i) Paper strips for rapid detection of seven adulterants in milk (neutralizers, urea, glucose, hydrogen peroxide, maltodextrin, sucrose & salt), and (ii) Rapid test for detection of detergent in milk. Paper-strip test is very easy to apply as it requires just dipping of the strip in milk and observing colour change within 30 second to 8.0 minute. Technologies of these tests have been transferred to nine commercial houses for use.

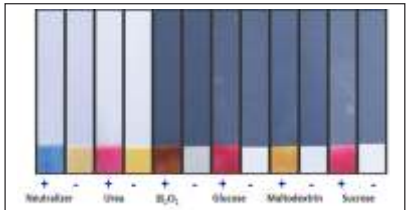
Adoption Domain

The major dairy industries such as Mother Dairy, Sanchi Milk Industry, Punjab State Cooperative Milk Producers' Federation Limited, Haryana Dairy Development Cooperative Federation Limited, Rajasthan Cooperative Dairy Federation Limited , etc., located in the major milk-producing states of Uttar Pradesh (16.5%), Rajasthan (12.7%), Madhya Pradesh (8.3%), Andhra Pradesh (7.8%), Punjab (6.7%), Maharashtra (6.3%), Haryana (5.6%), Bihar (5.2%) and Karnataka (4.1%) are using these tests for milk quality. These ten states together accounted for about 73.4% of total milk production in the country in 2018. In 2019, 10 lakh milk testing kits were marketed and nearly 33.53% of milk in the organized sector was tested for the adulterants.

Target Beneficiaries

Dairy cooperatives, private/ multinational dairy food industry, farmer' producer organisations (FPO), milk vendors/traders (*dudhiyas*), small and medium dairy units and consumers are the key beneficiaries of technologies.

Key Benefits



Colour change in paper strip based tests for detection of adulterants in milk

Change of pink colour to blue colour in lower layer indicate adulterated sample

Quality testing of milk has become very easy, as the results are reliable and available immediately. Test kits are 50% more sensitive and 60% economical over the existing methods. The consumers are benefited as they receive nutritional and quality milk. A significant reduction in the incidences of maltodextrin/ sucrose/glucose adulteration in milk from 39% to 3.7%, and detergent from 8% to 0.1% are evident from two rounds of FSSAI surveys conducted during 2011 and 2018, respectively. This success can be credited mainly to the adoption of the detection technology and administrative control measures.

Economic Benefits

The economic benefits to the society from the reduction in the adulterants (maltodextrin and detergents) accrued through the saving of the cost of milk testing and ensuring the quality of milk. The cost-saving to the dairy industry is estimated as Rs. 3.8 crore annually. The annual benefits from the technology are estimated at Rs. 174.44 crore in 2018-19. However, the benefits to society from ensuring milk quality could be even much higher than what is indicated here. Some major health benefits are reduction in incidences of diseases among the consumers such as hypertension, renal diseases, and skin, eye and heart problems, and cancer. It was also found that the consumers are willing to pay a higher price (15%) for the quality tested milk.

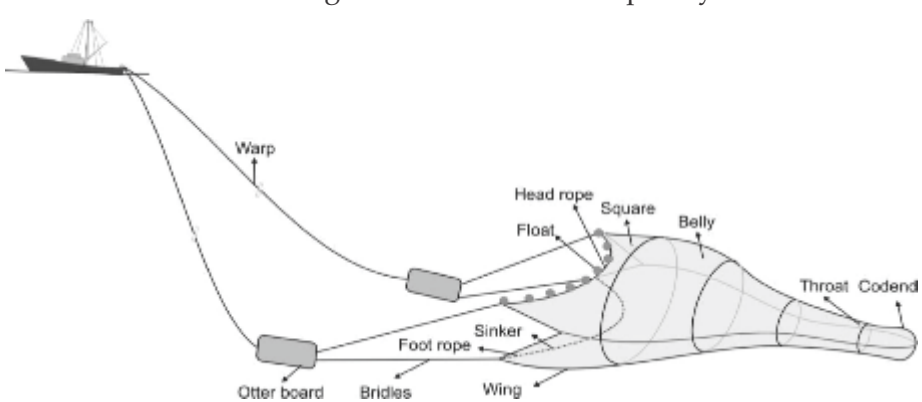
CIFT Trawl Nets

Profile of Technology

Trawling has become an established fishing method in India since its introduction. The mouth of a trawl net, which is basically a conical shaped gear towed through water, the mouth of which is kept open horizontally by means of otter boards and vertically by means of floats and sinkers. Trawl nets can be operated at the bottom or mid-water and can be towed by one or two boats. Since its introduction, the trawl net has been modified by ICAR-CIFT in its design, fabrication and operation depending to the type of fishes caught, local conditions, size and the engine power of the trawler employed for fishing. Initially, specific attention was given in designing shrimp trawls due to its economic importance and export value, gradually designs were developed to harvest both shrimp and fish by developing high opening trawls, semi-pelagic trawls, and other trawl designs for small, medium and large vessels. The effect of long wings and attachment of ticker chain on the foot rope were successful innovations to increase the shrimp catch in the trawl net. Further improvements were made on reducing drag on trawls and effective utilization of power.

Adoption Domain

Traditional hand braiding of trawl nets has completely ceased and has been replaced by ready-made netting. The net making industry is able to cater to the varied mesh size requirements of the fishermen. With the increasing number of trawlers in the country, there is a great demand for good designs of ready-made trawl nets. Many net makers have established themselves over the years and gained experience in the art of designing and fabricating trawl nets by keeping the wastage of netting materials to the minimum.



Target Beneficiaries and Key Benefits

The technology is intended to be used for harvesting shrimp and fishes from bottom- and mid-waters of the sea. The technology is suitable for small, medium and large vessels. The harvested fish and shrimps have high demand both in domestic and international markets. Newer designs of trawl gear have been developed by the institute with improved selectivity and reduced negative environmental impacts to protect the biodiversity and environment and ensure long-term sustainability of fishery resources.

Economic Impacts

The trawler has emerged as one of the most important intervention in Indian marine fishing sector. The major benefit is in the form of increasing the yield compared to close alternative method, like gillnetting. For marine shrimp and demersal fishes, trawling remains the most effective fishing method. In the year 2017-18, the technology has generated an economic surplus of Rs. 4,588.8 crore (at 2018 prices), in which the consumers and producers have benefited almost in equal proportion. The net present value of the economic surplus generated during the period of 2000-01 to 2017-18 amounted to Rs. 1,28,098 crore (at 2018 prices).

Profile of Technology

Significant reduction in operational cost can be achieved by optimizing fishing vessel and machinery design, which results in fuel savings. The operational cost is high due to lack of standardized design of a commercial fishing vessel and the construction of fishing vessels were mainly in the unorganized sector. Further, facility for Refrigerated Sea Water (RSW) storage for fish on-board increases the quality of fish and improves the income of fishermen. ICAR-CIFT in collaboration with Goa Shipyard Limited, Ministry of Defence, Government of India, designed and developed the multi-purpose fishing vessel called Sagar Harita.

The hydraulic deck winch installed in this vessel improved the efficiency of fishing gear operations from this vessel. The vessel also has an RSW. The design was approved by Indian Register of Shipping and Construction. Field trials for deep sea fishing carried out by ICAR-CIFT for multi-day fishing operations and the results showed a saving of 15-20% in different fishing conditions, over to similar fishing vessels used in the region.

Adoption Domain

In view of significant saving in fuel, Government Departments have entrusted the responsibility of preparing technical specifications (22-23 m long liner cum Gillnetter under "Blue Revolution scheme") to ICAR-CIFT for procuring. Following due procedures, Cochin Shipyard was given the responsibility for the construction of 16 vessels under this scheme. ICAR-CIFT signed the memorandum of understanding (MoU) with M/S Cochin Shipyard Limited for design of this vessel of size 22.50 m long liner cum Gillnetter for the fishermen of Tamil Nadu. The first eight vessels were completed and flagged off, which are successfully carrying out commercial fishing. The Government of Tamil Nadu has also short listed 7 commercial boat builders for construction of 60 gillnetter cum long liner vessels.

Target Beneficiaries and Key Benefits

F.V.Sagar Harita at deep sea

The commercial fishermen in all the maritime states of our country are the target beneficiaries. Trawler of Rameswaram, Tamil Nadu needs a conversion to Long liner-cum-gill netter to resolve the issues of border crossing by them to Sri Lanka. So they were given priority in the implementation of the Blue revolution scheme. The key benefits are: reduce trawling, settling issues with Sri Lanka, fuel savings, combination fishing which enables the commercial fishermen to improve their catch, improvement in the quality of fish caught, and avoid catching juvenile fish.

Economic Impacts

The economic benefits include reduction in the cost of fishing, value of the fossil fuel (diesel) saved, and the benefits to the environment in terms of the emission of GHG gases. The net present value of the economic surplus generated during the period of four years since commercialization in 2016-17 is estimated at Rs. 169 crore. The potential benefit that could accrue for the period of 25 years since the project inception in 2012-13 is around Rs. 4,854 crore (at 2018 prices) with an annual average of Rs. 194 crore. At 50% adoption level, an amount of 145 million liters of diesel would be saved, valued at market price of Rs. 1,019 crore per year. The amount of CO2 production averted is about 0.38 million tonnes, valued at about Rs. 3,193 crore. The technology contributes to reduced fishing cost, fossil fuel usage and reduced carbon emission.

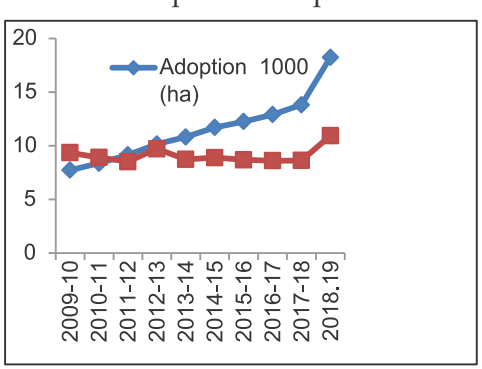
Jayanti Rohu Fish

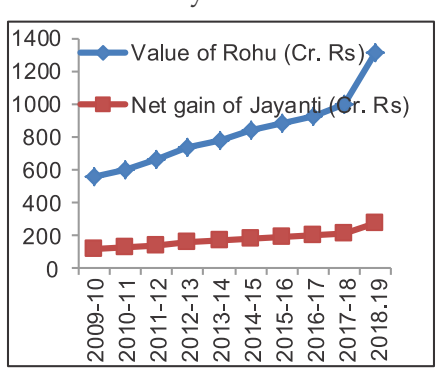
Profile of Technology

Jayanti Rohu is an improved stain of Rohu (*Lebeo spp.*), developed by ICAR-Central Institute of Freshwater Aquaculture, through selective breeding programme initiated in 1992. It was first released in 1997 and subsequently improved versions were released every year. It has advantage over local rohu in faster growth, lesser crop period, disease resistant to aeromonasis. Jayanti rohu has the advantage of better growth due to genetic gain as well as quality restoration of degraded stock. It reduces growing period by 53 days (18.0%), seed rearing period (17.4%), cost (20.1%) and increases the yield by 23.6% as compared with the locally produced strain of rohu.

Adoption Domain

Jayanti rohu is being adopted mainly in states of Odisha, Andhra Pradesh, West Bengal, and Assam, though this was demonstrated in all parts of India. Presently, there are 9 multiplier units distributed in the country. During 2010-2018, a total of 198.2 million spawn have been distributed by CIFA and it is estimated that 18.24 thousand hectare of aquaculture ponds brought under Jayanti rohu in 2018-19. Since 2016 National Freshwater Brood Bank of National Fisheries Development Board is a major disseminator of the technology to the hatchery. In 2019, 230 million spawn was produced and distributed by NFDB across the country. Presently, 1216 million of spawn was produced to fingerlings of 182.4 stocked in the ponds contributing around 1.1 lakh tonne of fish, which is 11% of total rohu production in the country.





Target Beneficiaries and Key Benefits

Since the start of induced breeding in seed production in early 1900's most of hatcheries did not replace their broodstock leading to lower growth of fishes. Efforts have made to replace with better performing broodstock at all levels in the country. Hence, there is a high demand for Jayanti seed across all parts of the country. The technology is scale neutral and both small as well as large farmers were benefitted equally. Also, the technology is well suited to polyculture conditions, commercial as well as backyard system and low saline areas. The reduction of the time period for harvest upto 56 days is a major benefits as farmers are able to avoid two most driest period of the year (May-June), reduce cost of production and are able to find time to prepare for pre-stocking operations before monsoon.

Economic Benefits

The economic benefits at the farmers level is mainly due to reduction in the cost of production upto Rs. 12 /kg and Rs. 72,000 /ha. It yields sizable benefits to commercial farmers and upto Rs. 30,000 /ha for average farmers. Most of the large commercial farmers are adopting these technologies to reach to the market in shorter time period, which saves cost and interest on capital. The annual market value of Jayanti Rohu is Rs. 1,313 crore, out of with net gain due to technology is about Rs. 275 crore. The net present value of economic surplus, with certain assumptions, for Jayanti Rohu for the period of 1992 to 2018 yielded a value of Rs. 2,547 crore, with Rs. 110 crore for the year 2018 (at 2018 prices). The economic surplus that could arise in future (2020-30) could be considerable Rs. 1,931 crore.

Open Sea Cage Farming

Profile of Technology

Cage farming is a low-volume and high-density fish farming system which has great potential for enhancing marine fish production. Development of indigenous cost-effective technology, seed production techniques for high-value fishes and farming demonstrations by ICAR-Central Marine Fisheries Research Institute, facilitated effective adoption and diffusion of the technology. Cage farming yields 40 times more yield than the conventional marine fish farming systems.

Adoption Domain

Cage fish farming could be undertaken in all maritime states & Union Territories in the sea and coastal water areas. Cage farm units in the country increased from 500 to 5000 numbers during the period 2014-2018. Annual production potential is one million tonnes of high-value fishes through cage farming in suitable sites. The adoption level is expected to reach 36% by 2030. Lack of suitable mariculture policy and insurance facilities constrain large scale adoption of the technology.

Target Beneficiaries & Key Benefits

Cage fish farming is being successfully adopted by fishermen, fish farmers, co-operatives, self-help groups and private entrepreneurs in maritime states and Union Territories. An estimated annual production of 3.6 lakh tonnes of high-value fishes (@ 3 tonnes/ 6 m dia. cage) could be achieved by 2030. Cage farming has huge potential for employment generation through direct and indirect activities in cage maintenance, fabrication and allied sectors. The estimated annual employment generation in 2030 is 7.86 million man-days.

Economic Benefits

The gross earnings generated through cage farming at current level of adoption is Rs. 600 crore and an estimated gross earnings of Rs. 14,400 crore could be achieved by 2030. The total economic surplus generated from the farming technology during 2005-2030 is estimated at Rs. 5,268 crore (at 2018 prices).

Low cost Galvanised Iron (GI) cage

Harvested fishes from cage farms (Sea bass & Cobia)

Conservation Agriculture

Profile of Technology

The development of conservation agriculture is associated with the wheat production constraints, particularly, decline in wheat productivity during 1980s due late planting, inefficient production practices and over-exploitation of resources in the rice-wheat cropping system of the Indo Gangetic Plains. Development of the zero tillage (ZT) machine enabled farmers to practice no-till farming on a commercial scale. The technology is being promoted on a large scale in India through CIMMY in collaboration with ACIAR, IRRI and National Agricultural Research Institutes.

Adoption Domain

Conservation agriculture practices are largely being adopted in the rice-wheat cropping system of IGP in India, consisting of Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. The spread of conservation agriculture in rice-wheat system is substantially higher in North Western IGP (Punjab, Haryana and western UP) as compared to the Eastern IGP (eastern UP, Bihar and West Bengal). The estimated area under conservation agriculture in wheat in Punjab and Haryana increased from 0.115 mha in 2000-01 to around 0.8 mha in 2018-19. The technology covers about 13.5% of wheat area in Haryana and Punjab at present and is expected to spread further in the coming years.

Target Beneficiaries and Key Benefits

Conservation agriculture is mainly targeted for the wheat crop in the rice-wheat system in the IGP. The technology has helped the farmers mainly in overcoming the constraint of late sowing of wheat after the harvesting of late maturing basmati rice in the IGP region and also in controlling the incidence of Phalaris minor. The technology is largely endorsed due to its cost and yield advantage over conventional tillage. ZT system also helps in increasing carbon sequestration (0.595 tonnes/ha/year) and decreasing the emission of GHGs. Another important benefit of the technology is increasing the irrigation water productivity (0.46 kg wheat per m3 water) by using less water in comparison to conventional tillage system.

Economic and Environmental Benefits

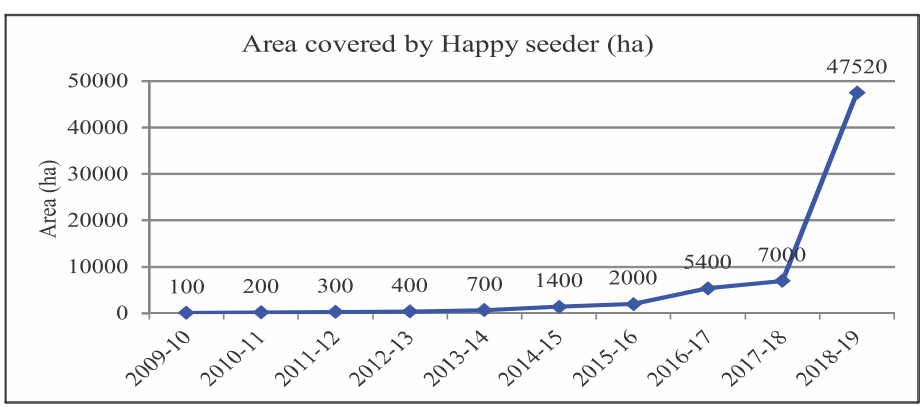
Based on the meta-analysis of published studies carried out in rice-wheat system of Haryana and Punjab, adoption of conservation agriculture provides yield gain of 4.6% and cost reduction of 10.66% in wheat over the conventional tillage system. The total economic surplus due to the adoption of conservation agriculture in wheat, is estimated to be Rs. 10,193 crore (2000-01 to 2018-19). The estimated monetary gains from increase in the water productivity and addition of carbon is about Rs. 882 crore and Rs. 9,759 crore, respectively, for the above noted period. The total economic gains from the adoption of conservation agriculture in wheat is Rs. 20,833 crore for the period 2000-01 to 2018-19 (i.e. Rs. 1,096 crore per annum). The estimated monetary gain from the adoption of conservation agriculture technology in wheat in the north western IGP of India is about Rs. 2,765.79 crore during TE 2018-19.

Happy Seeder: In-situ Crop Residue Management

Profile of Technology

The problem of on-farm burning of crop residues has intensified in recent years due to inaccessibility of suitable machinery, a major constraint to direct drilling into heavy rice stubbles. Now the machine called Happy Seeder (HS) or Turbo Happy Seeder (THS) is in place to solve the burning of crop residues of rice field. The ICAR-CSSRI used this machine at experimental sites for in-situ crop residue management during 2009-10. An estimated 23 million tonnes of crop residue are burnt each year in Punjab, Haryana and western Uttar Pradesh and the smoke is a significant source of air pollution across large swathes of northern India. The toxic haze leaves many people in the region with respiratory problems.

Happy Seeder is the ideal solution since it sows seed and removes the straw at the same time, scattering it evenly across the field, thus mulching the field and helping it retain its moisture, and encouraging seed germination. The straw naturally decomposes over time, enriching the soil. Studies have validated the benefits that the Happy Seeder has delivered through residue incorporation in the soil and savings on input costs. The Happy Seeder wasn't well-received in Punjab by farmers till 2016 when just around 620 machines were operating in the state covering just 64,000 hectares back then. Wheat is sown over 35 lakh hectares (86 lakh acres approx) across Punjab. Currently there are almost 12,000 HS machines operational in Punjab and that wheat yield has even touched 24 q/acre in some cases after using them. "Farmers who have used it are giving positive feedback. During 2018-19 season, almost 5 lakh hectares of wheat area (12.35 lakh acres) was sown using Happy Seeder in Punjab.



Adoption Domain

In-situ crop residue management with Happy Seeder was adopted in rice-wheat growing areas of Haryana. Area coverage has significantly increased from 100 ha in 2009-10 to about 47,250 ha in 2018-19 in Haryana.

Target Beneficiaries and Key Benefits

The direct sowing of wheat using Happy seeder technology has led to the wheat yield enhancement by 2-5 quintal/ha (5-10%) over conventional tillage machine. This also results into saving of cost of cultivation to the tune of Rs. 4,000-5,000/ha. The savings is mainly due to reduction in the cost of tillage (60-70%), cost of weed management (20-25%) and cost of irrigation management (15-20%). Wheat sowing with Happy seeder also resulted in saving of irrigation water upto 700 m3/ha (15-20%). The carbon sequestration accounts to1 t/ha/year.

Economic Benefits

The additional economic surplus due to Happy seeder in Haryana is estimated to be Rs. 59.2 crore during 2009-10 to 2018-19 (at 2018 prices). The share of economic benefits accounts to additional yield (51%) and savings in cost of cultivation (49%). The manufacturers/companies were generated revenue of about Rs. 48.8 crore during 2009-10 to 2018-19. Happy seeder has generated employment of about 40,000 man days during the period. As compared to 2018, the burning incidents reduced from 8750 to 6296 (29%) in Haryana during 2019.

ICAR-Flexi Rubber Check Dam

Profile of Technology

ICAR-flexi check dam commonly known as rubber dam is an inflatable structure build across a stream used for soil and water conservation in watersheds. During long dry spells/ lean seasons, the head wall can be easily inflated to store additional water due to its flexibility. During extreme events of cyclone, high intensity rainfall and flood situation, the structure can be easily deflated, so there is no damage to the structure and there is no breaching of stream bank/ levees and no scouring or erosion of stream bed.

Adoption Domain

ICAR-flexi rubber check dam technology was launched in the year 2010 in Khurda district of Odisha. At present the rubber dams were installed in about 33 locations covering 8 States of India viz., Odisha (13), Maharashtra (6), Gujarat (4), Uttarakhand (4), Himachal Pradesh (2), West Bengal (2), Meghalaya (1), and Tamil Nadu (1) and the installation process is continuing in several other locations.

Target Beneficiaries and Key Benefits

The flexi rubber check dams are useful for the farmers of rainfed ecosystem of India and provide huge scope for efficient soil and water conservation in watersheds. This technology has potential to create an additional water storage capacity of 9000m^3 for a 5 m width of rubber dam with height of 1.5 m and channel slope of 0.1% at any point of time. About 52,000m^3 to 80,000m^3 of storage volume could be created during whole crop season. Overall, the installed rubber dams in different agro-ecological regions of India resulted in enhancement of irrigation command area by 400 ha during *kharif*, 130 ha during *rabi* and 60 ha during summer season. Further, this technology has a potential to contribute to groundwater recharge immensely.

Inflated rubber dam at Chandeswar, Odisha

Economic Benefits

The adoption of ICAR-flexi rubber check dams significantly increased productivity of *Kharif* season crops viz. Rice (12-62%), pulses (24-46%) and vegetables (17-36%) and thereby contributing an additional net returns of Rs. 13,500 to Rs. 32,000 per ha under rubber dam command area. The benefit-cost ratio of the system was worked out to be 2.3:1. The additional economic benefits were estimated to Rs. 1.34 crore annually from rubber dam command area. The migration rate of the farmers (to urban areas) was reduced by 28.5% during post-installation phase in Chandeswar (Odisha) rubber dam command area.

Mridaparikshak

Profile of Technology

ICAR-Indian Institute of Soil Science, Bhopal, in collaboration with M/s Nagarjuna Agrochemicals Pvt. Ltd., Hyderabad developed and launched the 'Mridaparikshak' a soil test kit to meet the need for having a quick, portable, scientific, and economical system of determining soil health. It is a digital mobile quantitative MINILAB/ soil test kit to provide soil testing service at farmers' doorsteps. This soil test kit determines all the key soil parameters i.e. soil pH, EC, organic carbon, available nitrogen, phosphorus, potassium, sulphur and micronutrients like zinc, boron and iron. Using this soil test kit, soil health cards are being generated. The first version of Mridaparikshak was launched in 2015. Subsequently, the technology has been upgraded to include all the essential parameters required for making the soil health card as per the Soil Health Card Scheme (SHC) being sponsored by the Government of India.

Adoption Domain

About 11,200 Mridaparikshak and 43,000 refills were sold in Indian markets as on March 31, 2019. A total of 5.4 million soil samples have analysed using this technique. The total number of soil health cards prepared using Mridaparikshak is estimated to be 20% (i.e. 27 million numbers) of total soil health cards distributed under SHC scheme. This MINILAB technology has been procured by all the Krishi Vigyan Kendra, agricultural laboratories (State departments), NGOs, Public Sector Organizations and other agencies.

Target Beneficiaries and Key Benefits

The technology is helpful for farmers, scientists and technicians working in Governments and private soil testing laboratories. Mridaparikshak provides one-stop, easy and affordable solution to the soil health problem. The equipment is light weight and easy to handle. It reduces cost on power requirement to analyse required parameters and quick dissemination of soil test results.

Mridaparikshak MINILAB technology

Economic Benefit

Mridaparikshak mini-lab is responsible for preparation of about 20% soil health cards in the country. Soil health card scheme has phenomenal impact in reducing the cost on fertilizers (8-10%) and increasing the production (5-6%) in the country. Mridaparikshak mini lab has generated a royalty of about Rs. 30 million to ICAR-Indian Institute of Soil Science, Bhopal.

Improved Direct Paddy Seeder (Drum Seeder)

Profile of Technology

Change in the method of paddy planting from manual transplanting to direct seeding has occurred in response to increasing labour scarcity and water non-availability in time, resulting into high production cost. Direct seeding of rice (DSR) involves sowing of pre-germinated seeds on to a puddled soil surface. The improved direct paddy seeder popularly known as Drum Seeder makes uniform distribution of pre-germinated seed and plant population thereby significant saving in quantity of seeds. The improved Drum Seeder was modified and introduced by CIAE Regional Centre in association with M/s. Mysore Engineering Company by redesigning of models developed at IRRI, Philippines and other models developed during 1980s, which were bulky and required more than recommended seed quantity. Considering the capability and limitations of farm workers (especially farm women) the manual drawn 4-rows Direct Paddy Seeder was redesigned by Coimbatore Centre of AICRP on Ergonomics and Safety in Agriculture with reduced weight and material. The puddle land should be perfectly leveled and standing water should be drained from the field prior to seeding. The first irrigation after three days from seeding and weeding after 15th day of sowing using cono-weeder is recommended.

Adoption Domain

The field level adoption of this machine took place in 2009-10 with over 1200 units. Presently, above 65,000 units of improved Direct Paddy Seeder are in field and mainly being used in the states of Tamil Nadu, Kerala, Assam, and Puducherry. The machine is also being used in other states like Andhra Pradesh, Telangana, Odisha, West Bengal, and North-eastern states of the country. This shows rapid adoption of technology in the paddy growing regions of India. The successful commercialization of Drum Seeder has resulted in fast spread of this technology not only in India, but in some African countries as well. Studies revealed the yield gain of 5-10% over manual transplanting using this technology. The field capacity of the unit is 1.40 ha/day.

Drum Seeder on farmer's field

Economic Benefits

Direct seeding with improved Direct Paddy Seeder is now emerged as an alternate method to transplanting of paddy seedlings. Adoption of this machine saves cost of nursery raising over seedling planting on account of saving of 25-30 days duration along with 3-4 irrigation and less drudgery. The health issues of farm workers are also addressed in this method of paddy cultivation. The cost of 4 row direct paddy seeder (women friendly) is Rs. 3,600/ unit, as compared to Rs. 4,800 for 8-rows. Operating cost of seeding using Drum Seeder is Rs. 400/ha as compared to Rs. 6,250/ha in manual transplanting. Thus, there is a saving of Rs. 5,850/ha over manual transplanting. The economic surplus is estimated at Rs. 3,020 crore during TE 2018-19 (at 2018 prices). The total economic surplus accrued from adoption of technology is estimated at Rs. 16,472 crore during the period 2009-10 to 2018-19. Drum Seeder is also generating 1.01 million mandays annually on account of labour employment in the form of labour/operator engaged in seeding of paddy as well as in production/manufacturing of the machine.

Manual Cono-weeder

Profile of Technology

Weeds are worst pests and compete with crop plants for nutrients and water from the field and provide shelter to destructive insects too. Management of weeds is an important activity of crop production process which is expensive and difficult. With the increasing scarcity of labour during cropping season, mechanical weeding is the only viable option as it is an alternative to reduce use of herbicides for weed control and environmentally safe. The ICAR-Central Institute of Agricultural Engineering (CIAE)–Regional Centre has redesigned and introduced the IRRI model single row and double row manual cono-weeder developed during 1980s. The earlier model could be adopted only in line planted paddy in wet lands, hence, its demand was limited. Also, IRRI designed cono-weeder was heavier and required cumbersome procedure of sheet metal work, welding, etc. in making of cones. The CIAE Regional Centre has simplified the manufacturing process by making the cones out of plastic injection moulding and reduced the overall weight of the machine. The improved design helped the manufacturers to increase their production manifold. Today, a number of manufacturers making of manual cono-weeder in thousand numbers and are being used across paddy growing states of the country. The equipment is used both in line sown/direct seeded wetland paddy field with minimum spacing of 20 cm and is also suitable for paddy field grown using System of Rice Intensification (SRI) method.

Adoption Domain

With the promotion of System of Rice Intensification (SRI) and mechanical transplanting / seedlings, the demand for cono-weeders started rising in geometric progression. The fast adoption and diffusion made this technology most successful. The machine is largely being used in the states of Tamil Nadu, Kerala, Assam, and Puducherry and has covered about 1.25 Mha area so far. Besides, machine is also being used in other states of Andhra Pradesh, Telangana, Odisha, West Bengal, and North-eastern states of India. Presently, more than 2.5 lakh units of cono- weeders are being used in managing weeds in paddy fields. The improved cono-weeder has field capacity of about 0.15 ha/day. The cost of equipment is only Rs. 1,900/unit.

Cono-weeder in farmers' field

Economic Benefits

This is a low cost technology, easy to operate, less drudgerous, facilitates good aeration, promotes better development of root system and conserves soil moisture. The operating cost of weeding with cono-weeder is Rs. 1,890/ha, over to Rs. 4,170/ha with traditional method (i.e. manual weeding). Thus, there is a saving of Rs. 2,280/ha in operating cost. The economic surplus generated using cono-weeder is estimated of Rs. 2,617 crore during TE 2018-19 (at 2018 prices). The approximate economic benefits to the country from adoption of technology are estimated at Rs. 13,685 crore during the period of 2009-10 to 2018-19. Development and spread of cono-weeder has generated employment to the tune of 8.98 million mandays annually on account of labour/ operator engaged in weeding operations as well as in production / manufacturing and assembling of equipment.

Inclined Plate Planter/Bt Cotton Planter

Profile of Technology

Field crops such as wheat, maize, cotton, mustard, soybean, etc. are required to be sown in the rows at desired spacing for better crop establishment and proper growth. Seed drills technology being operated manually or drawn with animal and power sources are capable of maintaining overall seed rate, while plant to plant and row distances vary. This is more important in case of high quality seeds like Bt in cotton crop, which is costly. The inclined plate planter is designed to pick-up single seed and maintains seed to seed spacing. The singulation of seed helps in maintaining proper seed rate and plant spacing. The machine designed and developed at ICAR-Central Institute of Agricultural Engineering during 2002-03 with six row of tractor operated (35 hp) is suitable for planting of groundnut, gram, soybean, mustard, etc. However, the machine became very popular after its refinement for planting of Bt-cotton seed in Haryana and adjoining areas after feasibility testing in these states under AICRP on Farm Implement and Machinery. The inclined plate planter is now popularly known as Bt Cotton planter in Haryana and adjoining areas in Punjab.

Adoption Domain

The machine was commercialized in collaboration with local manufacturers and custom hiring centres and have played key role in providing the services to small and marginal farmers for planting of cotton in Haryana and Punjab. Inclined plate planter served the purpose of precise planting of Bt Cotton seeds by using suitable size of cell plate, adjustment of seed hopper height and suitable furrow opener. More than 18,000 units of Bt cotton planters are working in the Haryana state.

Inclined plate planter in farmer's field

Cotton planting by inclined plate planter

Economic Benefits

Sowing of Bt cotton seeds was being performed by conventional seed drills used for cotton, but the performance of these seed drills are not very effective, as more quantity of seed (3.5 kg/ha) was required than recommended level (1.5 kg/ha). The operating cost of improved Bt-cotton planter for cotton planting is Rs. 660/ha, while it was Rs. 1,190/ha by the traditional Seed Drill. Thus, there is a saving of Rs. 530/ha in operating cost. There was also a seed saving of 2 kg/ha (cost Rs. 4,400) and 12 labour saving cost (Rs. 2,400) to thinning of excess plant by planting through traditional Seed Drill. The annual economic surplus is estimated as Rs. 1,157 crore (at 2018 prices). The total economic surplus estimated from adoption of Bt Cotton Planter is estimated at Rs. 7,180 crore during the period 2009-10 to 2018-19.

Measuring Impact of Technology

Improved technologies are capable in achieving the objectives of enhancing food and nutrition security, reducing poverty and provide food at cheaper prices to poor people, conserving natural resources such as water, soils, and vegetation, and improving overall living standards. A number of agricultural technologies (developed by ICAR) related to crops, horticulture, livestock, fisheries, farm machineries and natural resource management have been selected in this exercise to assess their impact.

Studies on impact assessment of technologies generally use analytical techniques like partial budgeting, regression analysis, factor productivity and economic surplus method. Selection of the method depends upon the context in which impact study to be done, i.e. whether single or multiple commodities, availability of data, etc. Generally, in case of a single commodity, economic surplus method is considered to be more appropriate for assessing the impact at national level. In this exercise, economic surplus model has been applied to assess economic impact due to the adoption of technologies developed within the ICAR system.

Economic Surplus Method

Economic surplus method measures the changes in total economic surplus (societal welfare), which is defined as the sum of changes in consumer and producer surpluses in an economy. Consumer surplus is the gains obtained by consumers when they are able to purchase a product for a price that is less than the one they are willing to pay, while producer surplus is the benefits gained by producers when they are able to sell their commodity at a market prices that is higher than once they are willing to sell their product. Technical change brought through research may cause a shift in the supply curve through increase in yield/or decrease in the cost or both, which in turn, induces gains to economy.

The case of linear supply and demand curves with parallel shifts has been chosen. The figure below shows that gross annual research benefits are measured by the area *pabcd* beneath the demand curve. This area represents the total increase in economic welfare (change in total surplus) and comprises both the changes in producers and consumers surplus resulting from shift in the supply. Consumers are better off because they consume more at a lower price. The distribution of benefits among the producers and/ or consumers depends of the structure of the market and the rate of change in the supply curve.

The algebraic manipulations of the basic supply and demand equations in the system allow derivation of formulas and allow estimation of total surplus and its distribution into producer and consumer surplus. The

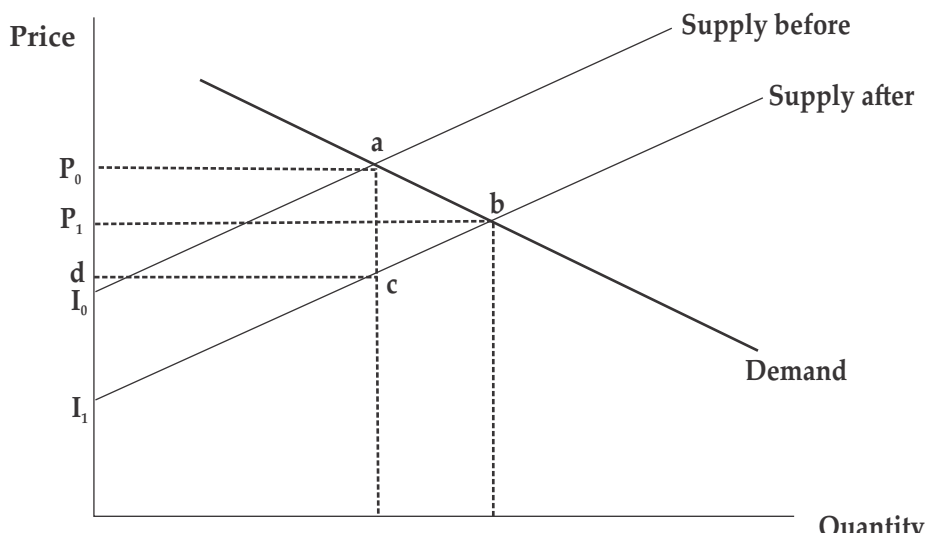


Figure: Measuring change in total economic surplus

following is the formula to estimate the change in the total surplus:

$$\text{Change in Total Surplus} = P_0 Q_0 K (1 + 0.5 Z \varepsilon)$$

Whereas, P_0 is the base price and Q_0 is the quantity supplied, K is the supply shift due to technical change (directly tied to the yield and cost of production changes), Z is the change in price and ε is the elasticity of supply. So, to calculate change in total economic surplus, we need to obtain information on their market prices and technical parameters.

Data Need and Source

Estimation of economic surplus model requires data on a set of parameters like demand and supply elasticities, change in yield/ cost, adoption rate, production, and price level to estimate the benefits. Information on size and economy (closed economy), shift in supply curves, and development and adoption years are also needed. Data on technological benefits and adoption rates of selected key technologies were obtained from respective institutes dealing with technology and where it was not available, opinion of experts was used.

The benchmark data of important technologies was collated from ICAR institutes using a postal questionnaire. A workshop was organized to verify these data. The workshop was attended by economists and experts from subject matter divisions of ICAR. Two meetings were also held to review the progress made. Finally, results of impact studies on ICAR technology were shared in a National Workshop on Impact of ICAR Technologies organized at NIAP and it was attended by Secretary, DARE and DG, ICAR, Deputy Director Generals and senior officers of ICAR Headquarters, Directors of ICAR institutes, and scientists.

Reference Period and Price

The economic gains from the selected technologies were assessed for two decades (2000-2018) and valued at market prices for the year 2018-19. The technologies which were released later, expected gains were examined from the year of adoption.

Limitations

The study suffers from several data and analytical limitations. Since data on cost of technology development, maintenance and diffusion was not available, net benefits from the technology could not be estimated and the benefits are gross benefits. Apart from economic benefits, technologies provide other benefits like environmental, social welfare, nutrition, etc. These dimensions are not considered due to paucity of information and time.

[1] Alston, J. M., G. W. Norton, and P. G. Pardey. 1995. *Science under scarcity: Principles and practice for agricultural research evaluation and priority setting*. Cornell University Press. Ithaca and London.

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