Social and Economic Impact Assessment of Mutation Breeding in Crops of the RCA Programme in Asia and the Pacific – a summary

IAEA Technical Cooperation Programme

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

RCA

The Regional Cooperative Agreement

The Regional Cooperative Agreement (RCA) is an intergovernmental agreement for IAEA Member States in East Asia and the Pacific region in which governments work, in cooperation with each other and the IAEA, to promote and coordinate cooperative research and development as well as training projects in nuclear science and technology through their national institutions.

From 10 to 22 State Parties since RCA's establishment in 1972

Membership of the RCA has expanded to 22 parties since 1972. RCA's projects have contributed significantly in a number of priority areas vital to regional socio-economic development, these include: human health, industrial applications, water resource management, nuclear and radiation safety, environmental protection, and food and agriculture.

There are 22 State Parties to the RCA:

Australia
Bangladesh
Cambodia
China
Fiji
India
Indonesia
Japan
Korea
Laos
Malaysia
Mongolia
Myanmar
Nepal
New Zealand
Pakistan
Palau
Philippines
Singapore
Sri Lanka
Thailand
Viet Nam

RCA Mutation Breeding Programme

The negative impact of climate change on crop production is becoming increasingly severe all around the world. Many agricultural systems are becoming less productive with some plant and animal species disappearing. These environmental changes are directly affecting agricultural production, with detrimental economic and social consequences and impact on food security worldwide.

The RCA's mutation breeding programme works to improve crop productivity through the effective application of radiation-induced mutagenesis and related biotechnology with the enhanced capability of RCA's State Parties for the development of improved crop varieties. Mutant varieties have improved the quality traits of crops such as improving grain size, shape and colour, milling quality, taste, and mineral, oil and seed protein content as well as becoming gluten-free. These quality traits have collectively improved the nutritional value and market prices of crops, thus serving to enhance food security and agricultural production and quality in countries in the Asia and the Pacific region.

Additional benefits of mutant crop varieties have helped decrease the use of pesticides (due to increased disease resistance), a reduction in using fertilizers and consumption of water (due to the highly efficient nutrient intake and better tolerance to drought), superior quality, and higher crop yields. The Social and Economic Impact Assessment of the RCA Mutation Breeding Programme, over the period of almost 20 years, found that it has supported a significant body of research, including over 7300 promising breeding lines with superior quality traits to local crop varieties. Additionally, 254 new and improved mutant varieties of crops were also certified and officially released.

What is plant mutation breeding?

- Plant mutation breeding uses a plant's own genetic resources and mimics its natural process of spontaneous mutation rather than modifying its genes.
- It uses induced genetic variability and associated biotechnologies to improve crop varieties through the identification of plants with improved genetics that consequently perform better.
- It is a technique which involves exposing seeds, cuttings or tissue-culture material to radiation (such as gamma rays) or other mutagen sources (like an X-ray or gamma ray source).
- It propagates healthy offspring from the irradiated plant material.
- New and useful traits are then subsequently advanced and selected for better:
  - crop yields under optimal growth conditions
  - improved nutritional quality
  - reduced need for pesticide, fertilisers and irrigation.

Improved crop varieties and their impact

China

China is home to 19 per cent of the world's population with only seven per cent of arable land to grow food. Food security therefore lies at the core of the country's socio-economic policymaking. Research on mutation breeding in wheat has focused on the improvement of desirable traits of the new crop species.

Wheat Mutant Variety Luyuan 502 which was developed by the Chinese Society of Nuclear Agricultural Sciences with IAEA support (Photo: CSNAS)

Luyuan 502 was the second most widely used wheat mutant variety in China in 2018. Its average yield has been certified to be 11 per cent higher than the traditional variety and also has a higher tolerance to drought and key diseases. Between 2012 and 2018, this variety was planted on over 5 million hectares of land. This increased productivity by 3.89 million tonnes, generating an additional income of about US$1.31 billion for farmers.

Indonesia

Sorghum is a relatively newly introduced but sparsely cultivated crop in Indonesia. Recently developed improved varieties of the cereal in the country show significant potential for increasing food security and improving farmers' incomes as well as helping support more sustainable agricultural practices due to its more efficient need for water compared to other crops in Indonesia. This is crucial for efforts to mitigate the threats and demands of climate change, population growth, increasing water scarcity and land degradation. The Food and Agriculture Organization of the United Nations estimates that in order to meet the demand for food by 2050, the world annual production of crops will need to be 60 per cent higher than it was in 2006.

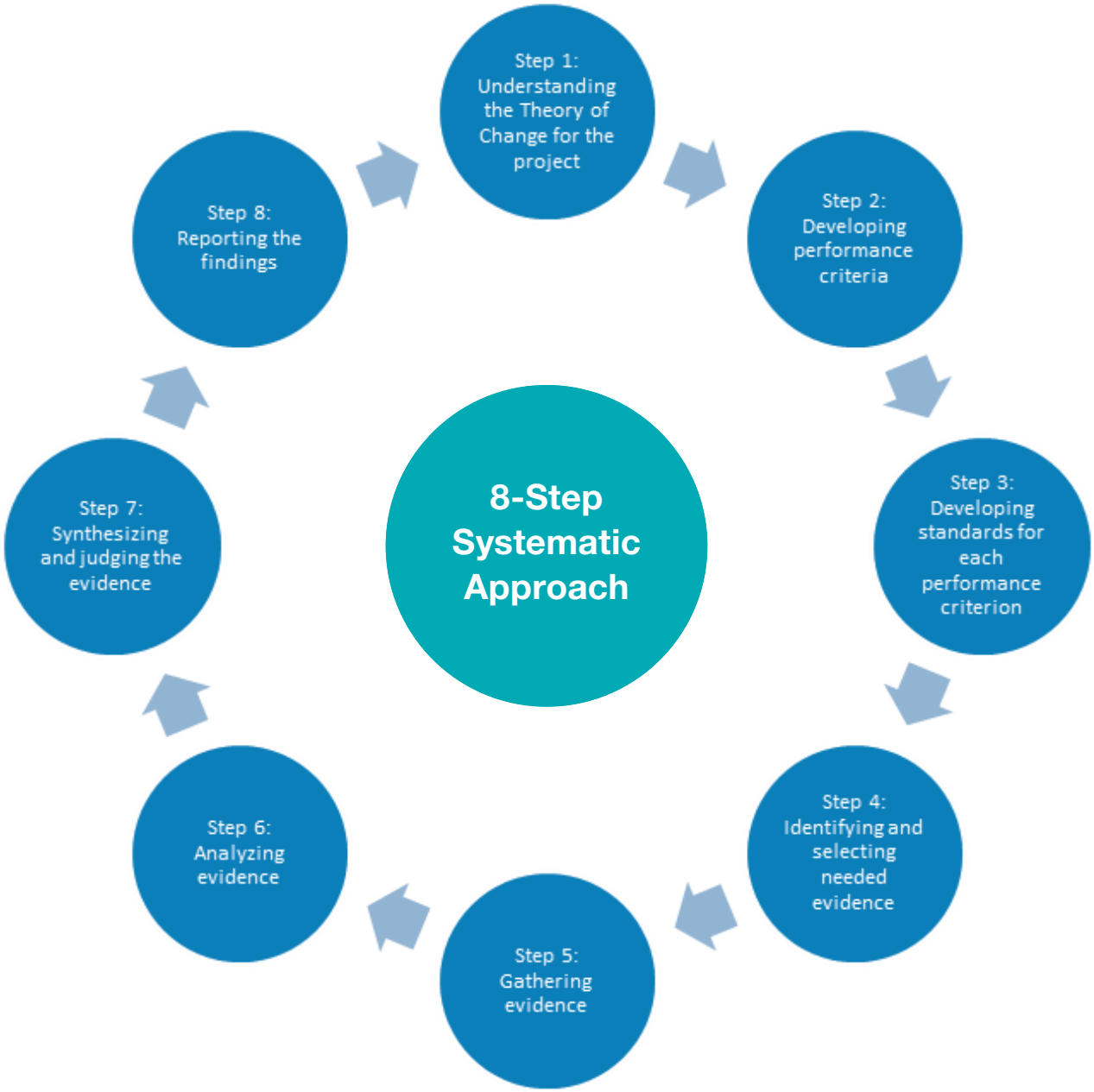
Mutant varieties of sorghum have proven to be early maturing, high yielding and drought tolerant, making them ideal for cultivation in the dry season. This means that they have a better potential to increase productivity of land with little or no agricultural value and promote economic growth. Sorghum mutant varieties developed under the RCA programme yields were around 30 per cent higher than Kawali, the national sorghum control variety grown since 1995. This characteristic, together with the possibility to grow and sell sorghum during the dry season, could to lead to an average increase in farmers' income between 20 and 30 per cent.

Seed multiplication of the released mutant varieties for distribution to seed companies (Indonesia)

Viet Nam

Mutant varieties of rice in Viet Nam have a yield that is, on average, eight per cent higher than varieties from where they originated. It is estimated that between 2000 and 2019, the 30 mutant varieties of rice, cultivated on a total of about 2.2 million hectares across the country, increased rice yield harvest by 1.1 million tonnes. This increase in yield translated into US$480 million, which benefited roughly 1.7 million farmers across the country.

A systematic approach to the assessment



To conduct the assessment of the social and economic impact of RCA mutation breeding projects from 2000 to 2019, a systematic approach was developed, which consists of an eight-step process.

This approach was piloted to assess the social and economic impact of RCA mutation breeding projects that will also be developed for other fields of activity in the future.

Results and findings

The social and economic impacts of the mutation breeding projects are diverse and contribute to:

- Increased food availability, diversity and accessibility
- More nutritious food supply
- Increased income for farmers
- Reduced use of agricultural inputs
- Reduced environmental pollution
- Enhanced national capacities in mutation breeding research and development supported technically by the Joint IAEA/FAO Division and leveraged through regional collaboration
- Positive impacts for women and girls

1. Economic impact

Between 2000 and 2019, the RCA delivered excellent economic outcomes. The main way the RCA generated economic benefits was by accelerating the mutation breeding process from variety selection to production and commercialization of successful mutant varieties, which successfully contributed to higher market prices due to improved nutritional and environmental quality traits. Additionally, the analysis estimated that the RCA created significantly more economic value than it consumed.

For each 1 euro spent between 2000 and 2019 €11.1 were gained in economic benefits

Crops varieties had various superior characteristics (compared to locally grown control varieties) that generated economic benefits through some or all of the following:

- Increased crop yield
- Increased market price
- Changes in cost of production associated with the decreased use of chemical fertilizers and pesticides

2. Increased food production and improved quality traits

mutant varieties reflect a greater yield of 32.7% over commonly grown varieties

Since 2000, over 7300 mutant lines and 254 mutant varieties have been developed under RCA. There was an average yield increase of 32.7 per cent over commonly grown varieties and a total accumulated growing area of 38 826 hectares. Together with increased crop yields and improved quality traits, the mutation breeding programme directly contributes to the United Nations Sustainable Development Goals (SDGs) targets for 2030 aiming to end hunger (SDG 2) and ensure access to nutritious and sufficient food (SDG 3).

3. Enhanced environmental protection

All crop varieties developed in the programme through mutation breeding or induced genetic diversity contribute to at least one environmental protection trait without a significant reduction in production. Improved traits enable farmers to use less chemical fertilizer and pesticides, which reduce environmental pollution, and increase their water efficiency. Together these superior characteristics contribute to SDG 13: Climate Action and SDG 6: Clean Water and Sanitation.

- The use of chemical fertilizer was r educed by 21%
- The use of pesticides was reduced by 17%
- Water efficiency was increased by 12%
- Reduced environmental pollution

4. Strengthened regional capacity and sustainability

Since 2000, the regional capacity and capability in Asia and the Pacific were strengthened with ground-breaking knowledge sharing, an increase in regional training courses, workshops and expert missions under the RCA, the establishment of national mutation breeding teams and facilities in most participating countries and the substantial increase of publications on mutation breeding research in 19 of the 22 participating countries.

Ground-breaking knowledge sharing

Networking and collaboration

470 individuals trained regionally

26 expert missions

23 workshops

73.7% MSs have national teams

89.5% MSs have field facilities

1801 mutation breeding publications

For more information

For more information on IAEA support for crop breeding nuclear techniques, email:

TCAP.contact@iaea.org

IAEA technical cooperation programme

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