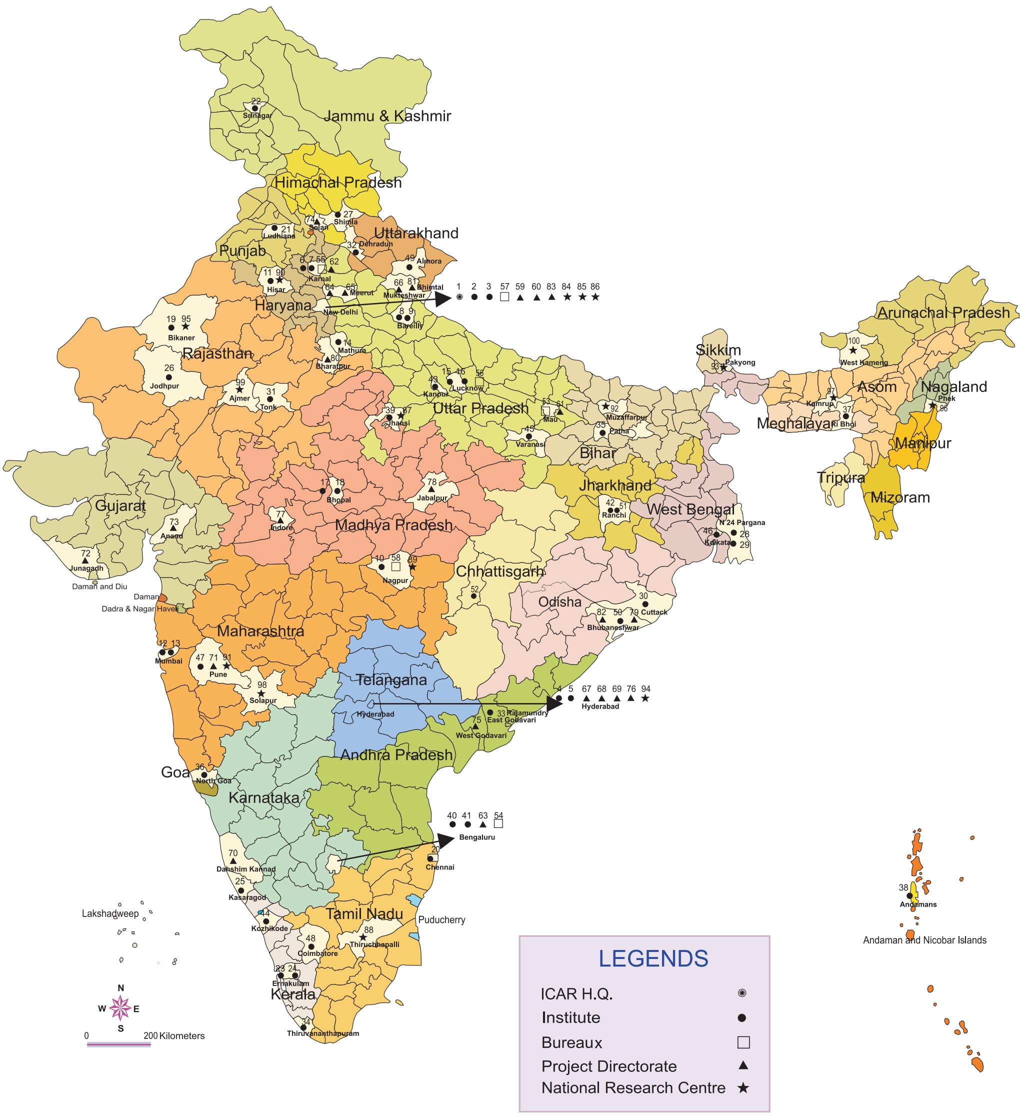
Vision 2050

Directorate of Rapeseed-Mustard Research

Indian Council of Agricultural Research

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, Directorates and National Research Centres



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Vision 2050

Directorate of Rapeseed-Mustard Research

(Indian Council of Agricultural Research)

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www.drmr.res.in

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संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Directorate of Rapeseed-Mustard Research (DRMR), Bharatpur has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

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Preface

Agriculture is fast emerging as knowledge based industry. This has led to a paradigm shift in the way agricultural production is organized and implemented. The nature and extent of emerging challenges calls for proactive thinking and creative approaches in research and development efforts in agricultural sector. Enhancing crop production and productivity, while maintaining the sustainability of the production system and profitability to the stakeholders in the value chain forms the touchstone for institutions mandated with research and development in specific crop. A strategic approach to ensure reasonable level of self-sufficiency in edible oils should consider the entire oilseed crop economy value chain where stakeholder groups with contrasting demands need to be accommodated within the overall developmental perspective of the sector. The various sub-sectors within the oilseed economy like cultivation, trading, processing and value addition, markets and the policies shaping these sub-sectors are all intimately interlinked in determining the prosperity of edible oil economy in the country. An analytical approach in problem solving and adoption of forward looking visionary concepts in research would strengthen our capability to tackle the trend of plateauing crop productivity in the backdrop of emerging challenges like climate change, shrinking natural resources, declining soil health and increasing population pressure.

Organized research in oilseed crops in India started with the launch of All India Coordinated Research Project on Oilseeds in 1967 by the Indian Council of Agricultural Research. The research programmes were further intensified by setting up the Unit of the Project Coordinator (Rapeseed-Mustard) on January 28, 1981 at the campus of the Haryana Agricultural University, Hisar. Considering the mounting imports of vegetable oils, the Government of India set up a Technology Mission on Oilseeds (TMO) in 1986 with a view to increase the production and productivity of oilseeds to make the country self-reliant in this vital sector integrating all facets of oilseeds sector. Subsequently pulses, oil palm & maize were also brought into the ambit of the technology Mission and presently the centrally sponsored scheme is known as the Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize (ISOPOM). Research in rapeseed-mustard crop got a fillip with the establishment of National Research Centre on Rapeseed-Mustard on October 20, 1993 at Bharatpur. The centre, which was elevated as the Directorate of Rapeseed-Mustard Research in 2009, has a vital role to play in addressing the challenge of meeting the edible oil requirement of the country.

Edible oil consumption in India has shown an increasing trend over the last three decades driven by increasing population and rise in purchasing power associated with economic growth. The country is looking for a comprehensive and pragmatic blue print to meet the challenge of bridging the widening gap between demand and supply of edible oil by enhancing domestic availability. Rapeseed-Mustard, because of resilience to grow under diverse agro-climatic conditions and characteristics like low input requirement has emerged as a major strategic component in enhancing domestic production of edible oils and oilseeds. The Directorate of Rapeseed-Mustard Research (DRMR), Bharatpur has the onerous responsibility to meet the aspirations of various stakeholders by making the cultivation of rapeseed-mustard, more remunerative, productive and sustainable. Exploiting the latent potential for enhancing domestic oilseed production and productivity by tackling major biotic and abiotic production constraints forms the cornerstone of the strategy to attain edible oil self-sufficiency. The policy stance has to be carefully designed taking into consideration a host of factors like the livelihood security of oilseed producers, level of desired import dependency, trade efficiency, changes in dietary standards and nutritional requirements, rising demand for vegetable oils in bio fuel production etc

The present scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. The Vision 2050 of the Directorate visualizes the future needs and challenges of the rapeseed -mustard sector. This Vision 2050 document provides a blue print for harnessing science, technology and innovation in the coming years to achieve the avowed goal of reducing huge import of edible oil through creative interventions in rapeseed-mustard crop research and development. The vision document highlighting the issues and strategies relevant for the next 40 years and provides a key to the prioritization of the research efforts in the crop. The document presents the quintessence of painstaking efforts put in by researchers at different levels in organizational hierarchy and represents a synthesis of the vision, inputs and comments received from diverse quarters. It is expected that the analytical approach and forward looking concepts presented in the 'Vision 2050' document of the directorate will prove useful for the researchers, policymakers, and stakeholders to address the future challenges in the rapeseed-mustard crop.

The guiding force behind the preparation of Vision 2050 is Dr S. Ayyappan, Secretary, DARE, Government of India and Director General, ICAR, New Delhi who initiated this idea. His vision, ideas and guidance formed the bases of present document. I place on record my sincere gratitude to Dr. J.S. Sandhu, Deputy Director General (Crop Science) for his constant guidance, encouragement and critical comments. I profusely thank Dr. B. B. Singh, Assistant Director General (O & P), ICAR, New Delhi for day-to-day guidance and instantaneous help as and when required. I do sincerely acknowledge the contribution made by Dr. V V Singh, Principal Scientist (Plant Breeding) and Dr. Vinod Kumar, Senior Scientist (Computer application) for developing this important document.

I gratefully acknowledge the help and cooperation of DRMR and AICRP-RM staff in the preparation of the present document.

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Context

Agriculture sector plays an important role in India's social security and overall economic welfare. Oilseeds crops are the second most important determinant of agricultural economy, next only to cereals. Today, the demand for vegetable oils is out pacing the supply with more than half of its annual requirements being met mainly through imports. India has the 5th largest vegetable oil economy in the world next to USA, China, Brazil and Argentina accounting for 7.4% world oilseed output; 6.1 % of oil meal production; 3.9% world oil meal export; 5.8% vegetable oil production; 11.2% of world oil import and 9.3% of the world edible oil consumption. In India, oilseeds contribute 3% and 10% to gross national products and value of all agricultural products, respectively, with 14 and 1 million people involved in oilseed cultivation and processing, respectively. India is one of the biggest importers of vegetable oils. There is a spurt in the vegetable oil consumption in recent years, both for edible purposes as well as for industrial uses. This is further likely to go up in coming years with the change in consumption patterns as well as in rising living standards.

All the nine annual oilseeds, which include seven edible oilseeds, *viz*. groundnut, rapeseed mustard, soybean, sunflower, sesame, safflower and niger, and two non edible oilseeds, *viz*. castor and linseed are grown in diverse agro-ecological situations of the country. During 1951-2010, the area, production and productivity of annual oilseeds in India showed a compound annual growth rate of 1.57%, 3.01% and 1.42%, respectively. Major gain in production came mostly from soybean, rapeseed-mustard, sunflower and castor. There has also been large regional variation in area, production and productivity changes during the last two and a half decades. Only a few states like Haryana, Madhya Pradesh, Maharashtra, Rajasthan and West Bengal increased their oilseed production through area expansion and productivity enhancement. The state like Gujarat increased oilseed production mainly through productivity enhancement. Rapeseed-mustard crops in India comprise traditionally grown indigenous species, namely toria (*Brassica rapa* L. var. toria), brown sarson (*Brassica rapa* L. var. brown sarson), yellow sarson (*Brassica rapa* L. var. yellow sarson), Indian mustard (*Brassica juncea*), black mustard (*Brassica nigra*) and taramira (*Eruca sativa/vesicaria*), which have been grown since about

3,500 BC along with non-traditional species like gobhi sarson (*Brassica napus*) and Ethiopian mustard or karan rai (*Brassica carinata*).

Table 1 Major Rapeseed-mustard producing countries in world

Year	Parameter					World
		Canada	China	Australia	India	
2011-12	Area (m ha)	7.47	7.1	1.8	5.92	33.11
	Production (mt)	14.17	13	3.19	6.78	60.66
	Yield (kg/ha)	1900	1830	1770	1145	1830
2012-13	Area (m ha)	8.59	7.2	2.4	6.3	34.99
	Production (mt)	13.31	13.5	3.09	7.4	61.14
	Yield (kg/ha)	1550	1880	1290	1176	1750
2013-14	Area (m ha)	8.01	7.52	2.66	6.4	36.15
	Production (mt)	17.96	14.46	3.76	8.02	71.09
	Yield (kg/ha)	2240	1920	1420	1262	1970

The Indian Council of Agricultural Research (ICAR) established National Research Centre on Rapeseed-Mustard (NRCRM) during VIII plan at Bharatpur and upgraded it as the Directorate of Rapeseed-Mustard Research (DRMR) during XI plan. The DRMR was also given a responsibility for planning, coordination and execution of research programmes to develop ecologically sound and economically viable production & protection technologies through a network of different centres under All India Coordinated Research Project on Rapeseed-Mustard (AICRP-RM). The AICRPRM has been implementing the multi-location, multidisciplinary, time bound and action oriented programmes such as development of varieties possessing resistance/ tolerance against biotic and abiotic stresses having high oil and seed meal quality; development of appropriate, location specific, economically viable and feasible agro-production and protection technologies to maximize the yield; identification of most remunerative and efficient cropping system suited to different areas and situations; developing techniques to protect plants against insect-pests, diseases, frost, drought and salinity; undertaking on-farm researches for demonstrating realizable potential of improved technologies under real farm situations; undertaking breeder seed production of improved varieties and monitoring of the programmes.

During XI plan a substantial headway has been made in developing suitable technologies for addressing the important and major constraints and improving the production and productivity of rapeseed-mustard. 33 varieties/hybrids of rapeseed-mustard including first CMS based hybrid (NRCHB 506) of Indian mustard were developed. Eight genetic stocks were registered with NBPGR for seed weight, salinity and high temperature tolerance during juvenile and terminal stages and high water use efficiency. Trait specific donors for drought , salinity , frost , high temperature tolerance at seedling stage and high temperature tolerance at terminal stage were identified, besides 1468 germplasm accessions of rapeseed-mustard were collected and 8864 were evaluated for agro-morphological characters.

A high frequency regeneration protocol for *Brassica juncea* cv. NRCDR 2 was developed and standardized in order to develop transgenics for aphid and Alternaria blight tolerance. Morphological, cultural and molecular diversity was observed among 17 and 30 geographic isolates of S. *sclerotiorum* and *Altetrnaria brassicae*, respectively. Using partial least square regression, calibration for non-destructive estimation of erucic acid and glucosinolate content in seeds of rapeseed-mustard by Fourier transform near infra red reflectance spectroscopy (FT-NIRS) was developed. Palladium complex method developed for estimation of total glucosinolates in seed meal to improve seed meal quality. Epidemiology of Sclerotinia rot of Indian mustard (*Brassica juncea* L.) was investigated and the forecasting models were developed. One Voice Based e-Learning Extension Module for mustard cultivation was licensed for commercialization with private seed production companies/professional societies.

Highlights of XI Plan

- 33 varieties/hybrids of rapeseed-mustard, including first CMS based hybrid (NRCHB 506) of Indian mustard were developed.
- Eight novel genetic stocks of rapeseed- mustard were registered for earliness, large seed, high temperature and salinity tolerance at juvenile stage and water use efficiency.
- 1468 germplasm accessions of rapeseed-mustard were collected and 8864 were evaluated for agro-morphological characters at various centres.
- Incorporation of mustard residue (2.5 t/ha) + Sesbania green manuring or Sesbania green manure + Azotobacter (seed treatment) enhanced the mustard seed yield up to 50% over the fallow–mustard crop sequence.
- Two white rust resistance loci have been validated in Indian mustard genotypes for white rust resistance introgression through MAS.
- 701.03 q breeder seed was produced against the indent of 386.76 q. Total 2878 frontline demonstrations on improved production and protection technologies have been conducted in 18 states of India.

In India, rapeseed–mustard is grown in diverse agro-climatic conditions ranging from north-eastern/north-western hills to down south under irrigated/rainfed, timely/late sown and mixed cropping. Indian mustard accounts for about 75-80% of the 6.6 million hectare under these crops in the country during 2013-14.

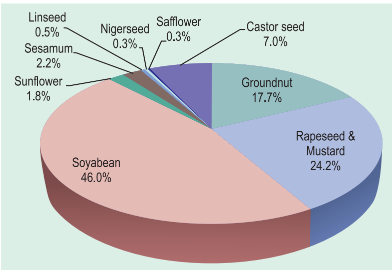

Fig.1 Contribution of rapeseed-mustard to total oilseed production during 2012-13

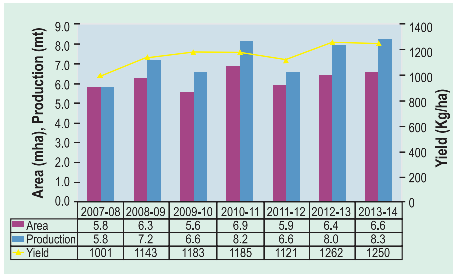

Fig. 2 Production trends of rapeseed-mustard in India

The average contribution of rapeseed-mustard to the total oilseed production in India was 24.2%, during 2012-13 (Fig. 1). Its average productivity was 1176 (kg/ha) as compared to 1135 kg/ha of total oilseeds. Though, rapeseed-mustard ranks 2nd in terms of production, after soyabean, however due to more oil content (ranging from 35-45%) rapeseed-mustard ranks 1st in terms of oil yield among all oilseeds crops. The rapeseed-mustard production trends represent fluctuating scenario with an all time high production of 8.3 million tonnes from 6.90 million hectare during 2010-11. The yield levels also have been variable ranging from 1001 (2007-08) to 1250 (kg/ha) (2013-14) during the last 5 years (Fig. 2). Highest productivity 1262 (kg/ha) level was achieved during 2012-13.

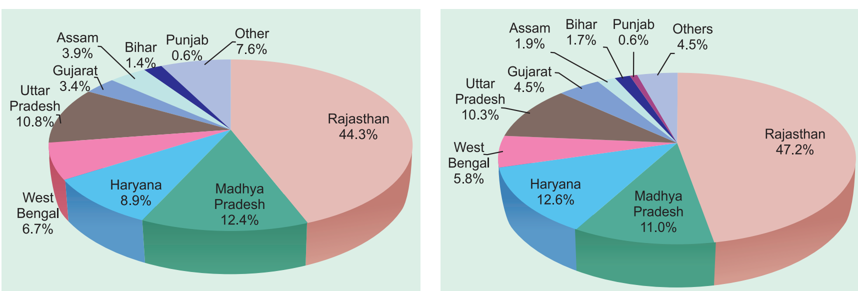

Fig.3 Contribution of states to rapeseed-mustard (a) acreage and (b) production during 2012-13

(Website: http://www.dacnet.nic.in)

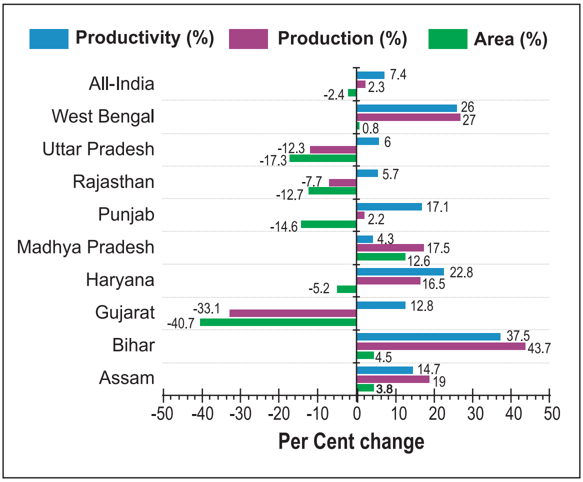

Fig.4 Per cent Change in Area, Production and Productivity in Rapeseed Mustard in 2012-13 (base year: 2006-07).

Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat and West Bengal states accounted for nearly 86.5% area and 91.4% production of rapeseed-Mustard in the country during 2012-13 (Fig. 3a & b). The productivity of Haryana, Gujarat, Rajasthan, UP and MP was above 1000 kg/ha in the descending order. There was reduction in area and production of rapeseed-mustard in Gujarat, Uttar Pradesh and Rajasthan. States like Bihar, West Bengal, Madhya Pradesh showed increase in area and production. Maximum increase in production (43.7%) was witnessed in Bihar followed by West Bengal, Madhya Pradesh and Haryana (Fig. 4). However, the productivity levels were increased in all the states. This fluctuating trend in area, production and productivity requires multi-pronged strategies and technological interventions in upcoming years. These areas need to be focused separately.

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Challenges

The demand for vegetable oil for human consumption would increase sharply up to 2030 and thereafter may increase at a decreasing rate in view of enhanced health awareness. But, the global demand for vegetable oil for substituting fossil fuel will grow steeply to meet the Inter-Governmental Panel on Climate Change (IPCC) guidelines. The total production of oil crops and products in oil equivalents for 2050 at the global level is projected at 282 million tonnes suggesting a 100 plus additional production from the current production of 178 million tonnes. The projection of *per capita* consumption of oil crops in 2050 for food and all uses is estimated to be 16 and 30 kg, respectively. In South Asia which includes India, the same is projected at 16.7 kg/capita /annum in 2050 (Nikos Alexandratos and Jelle Bruinsma, 2012*).

Major challenges

General Challenges

- Shrinking average land holding and water availability.
- Increase in CO2 concentration and temperature.
- Increased droughts, floods and heat waves.

Specific Challenges

- High temperature during crop establishment and terminal stage causes shortening of growing season.
- Fog and intermittent rains during crop growth.
- Mono cropping in most of the major areas.
- Depleting availability and deteriorating quality of water.

Climate change

Based on various simulation projections, CO2 level would reach 550 ppm by 2050, thereby increasing rapeseed-mustard production by 10-20% through higher photosynthetic rate. The mean temperature in Ganga basin and similar other mustard growing regions are expected to rise by 1.0-1.5°C by 2020 to 2030, 2.0-3.5°C by 2050. A 1°C increase in temperature may reduce rapeseed-mustard yield by 3 to 7%.The

*Nikos Alexandratos and Jelle Bruinsma. 2012. World Agriculture Towards 2030/2050. ESA working Paper No. 12-03 June 2012, Agricultural Development Economics Division, FAO, Rome (www.fao.org/economic/esa) projections of precipitation indicate a 3% to 7% overall increase in all-India summer monsoon rainfall in the 2030's with respect to the 1970's. Spatial patterns indicate a significant decrease in the monsoon rainfall in future except in some parts of the southern peninsula. It will lead to increase in rainfall intensity and dry days and consequently more floods and droughts. The overall increased droughts, floods and heat waves will results in negative impact on production variables. Length of growing period in rainfed areas is likely to reduce. The dynamics of insect-pests and diseases will pose considerable threats to rapeseed-mustard production. However, the yield losses due to frost damage will reduce in north-western India.

The concentration of ozone [O3] will also increase as a result of industrialization and this will have a negative impact on crop growth and productivity. Yield reduction due to ozone pollution can occur at concentrations as small as 20 ppb. The Intergovernmental Panel on Climate Change (IPCC) give in full Fourth Assessment Report projects an increase of 20–25% in surface [O3] across the globe by 2050. It is estimated that a 20% increase will decrease yields relative to today by 10%.

To meet the expected projections of 2050 and edible oil demand, a 4 fold increase in land productivity, 3 fold increase in water productivity, 6 fold increase in labour productivity and doubling of energy use efficiency will be required.

Deteriorated ecosystem

As per the projections of NCIWRD water demand in India will grow to 1180 billion m3 out of which 69% (807 billion m 3) would be agriculture driven. Assuming oilseed area increase up to 30 mha and 40% of the area will be irrigated by 2050, the demand for oilseed crops would be around 70 billion m3. During the last two decades agriculture lands have been converted in to residential complex, factories, development of roads and other infrastructure. The average size of land holding has declined to 1.32 ha in 2000-01 from 2.30 ha in 1970-71. It is expected that the average size of holding would be 0.68 ha in 2020, 0.32 ha in 2030 and declined further. Moreover, this scarce agricultural land resource would also be degraded by erosion, water logging and salinity.

Both extremes of temperature, high during crop establishment (mid-September to early November) and terminal stage (February to March), unpredictable prolonged cold spells leading to frost damage, fog and intermittent rains during crop growth cause considerable yield losses by physiological disorders and appearance and proliferation of white rust, downy mildew and Sclerotinia stem rot diseases, insect-pest and emerging new insect- pests and diseases. Stress caused by insect, nematodes, fungal, bacterial and viral pathogens, *Orobanche* and weeds collectively result in approximately 45 % yield loss annually. Mono cropping in most of the major areas has led to soil deficiency for nutrients and built-up of soil borne pathogens. Irrigation with saline and alkaline-blended water in most of the areas of Rajasthan and parts of Uttar Pradesh, Haryana, and Punjab resulting in salinity builds up.

It is evident that climatic, biological, natural resources, policy decisions, etc. cause uncertainty in acreage of these crops. The mitigation of these constraints requires out of the box thinking and innovative research strategies. The research approach itself needs an urgent revamp in order to harness the full potential of rapeseed- mustard crop.

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Operating Environment

Keeping in view the importance of crop to meet the edible oil demand in India, the ICAR established NRCRM in Bharatpur district of Rajasthan on October 20, 1993 with a mandate to carry out basic, strategic and applied research for five rapeseed, namely, brown sarson, yellow sarson, toria, taramira, gobhi sarson and two mustard crops, namely, Indian mustard and Ethiopian mustard. It also has responsibility for planning, coordination and execution of research programmes to develop ecologically sound and economically viable production and protection technologies through a network of 11 main - and 12 sub- centres spread over 17 states under All India Coordinated Research Project on Rapeseed-Mustard (AICRP-RM). The ICAR upgraded NRCRM as the Directorate of Rapeseed-Mustard Research (DRMR) in February 2009.

Frontier areas of research during coming years include functional genomics for drought and heat tolerance, molecular approaches for identification and introgression of Quantitative Trait Loci (QTLs) for heterosis, enhancement of water and nutrient use efficiency, and quality assurance. The other researchable areas shall be biomolecules, bio-safety, bio-remediation and bio - fertilization, bio intensive Integrated Pest Management (IPM) module development for major insect pests and diseases and induced resistance. Remote sensing for energy water balance, disease and insect pest detection, forecasting module development for climate change and crop management Information Technology (IT)

Targets for XII Plan

- Widening gene pool through pre-breeding including restructuring plant type for breaking the existing yield ceiling

  Phenotyping and Marker Assisted Selection (MAS) for white rust resistance and quality traits.
- Development of thermo and photo insensitive varieties
- Improving resource use efficiency (soil, plant, water and nutrients) under different situations and developing resource conservation technology
- survey, surveillance of major pathogens and analysis of morphological, pathogenic and molecular variability
- Development of web-based user friendly, interactive software for speedy technology dissemination.

based decision support system for technology transfer also deserve greater attention.

Technological landscape

Fifty novel genetic stocks of rapeseed-mustard Cytoplasmic Male Sterility (CMS), restorer, low erucic acid, low erucic acid & low glucosinoltes, high oil content, high oleic acid and low linolenic acid, dwarf , earliness, long main shoot, large seed, yellow seed, tetralocular siliquae, white rust resistance, tolerance to high temperature and salinity during juvenile stage, high temperature tolerance during terminal stage and high water use efficiency) were registered with NBPGR, New Delhi till 2013.

A total of 158 varieties (Indian mustard-96; toria-20; yellow sarson-15; gobhi sarson-11; brown sarson-5; karan rai-4; taramira-6 and black mustard-1) of rapeseed mustard have been released after inception of AICRP-RM in 1967 till 2014. These include six hybrids and eleven low erucic acid and low erucic acid & low glucosinolates varieties. Rapeseed-mustard varieties having tolerance to biotic stresses (white rust, Alternaria blight, powdery mildew) and abiotic stresses (salinity, high temperature) have been recommended for specific growing conditions. Improved agro-production technology both for irrigated and rainfed areas, which emphasized the need for timely sowing, line sowing, spacing, seed rate, fertilizer application, thinning at appropriate time etc. were developed and demonstrated through frontline demonstrations at the farmer's fields. The whole package technology demonstrations of rapeseed-mustard increased the average productivity by 81-137% under rainfed condition and by 87-105% under irrigated conditions over farmers' practice.

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Goals and Targets

The Vision 2050 of ICAR-DRMR aims not only at sustaining the present level of production but also to improve the productivity and quality in fragile environments across diverse agro-ecological regions. Enhancing the nutritional security of the increasing human population and providing quality feed for livestock sector are also targeted. It also aims to meet the industrial requirements and bring about substantial savings of foreign exchange through import substitution and higher export earnings. It visualizes the future needs and challenges of the rapeseed-mustard sector specially climate change and marketing in view of emerging new usages of rapeseed oil as bio fuel in Europe and prioritized researchable issues, provides strategic framework and road map by harnessing the science in the coming about 40 years.

Table 2 Estimates of annual oil seed crops by year 2050

Item/Year	2020	2030	2040	2050
Expected population (billion)	1.32	1.43	1.55	1.68
Per capita consumption (kg/annum)	15.33	15.88	16.43	16.97
Vegetable oil requirement for direct consumption(mt)	20.24	22.71	25.47	28.51
Vegetable oil requirement for non industrial use (mt)	3.57	6.34	8.88	10.65
Total vegetable oil requirement (mt)	23.81	29.05	34.35	39.16
Vegetable oil availability from secondary sources (mt)	5.05	5.89	6.85	7.18
Total vegetable oil availability from annual oilseed crops (mt)	13.33	15.30	18.16	20.36
Total vegetable oilseeds availability from 9 annual oilseed crops (mt)	50.38	63.84	79.66	92.98
Share of rapeseed-mustard to total annual oilseeds (mt)	13.47	14.29	16.13	16.41
@ 20% share	16.84	17.86	20.16	20.51
@ 25% share				
Expected area of rapeseed-mustard (mha)	7.50	7.75	8.00	8.00
Productivity of rapeseed-mustard desired (kg/ha)	1796	1844	2016	2051
@ 20% share	2245	2304	2502	2563

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Strategies for 2050

Vision 2050 would concentrate on the following key researchable areas to achieve quantum jump in production and productivity of rapeseed-mustard: Exploitation of available heterosis in mustard and toria for further enhancing the yield potential, developing high yielding varieties/hybrids with improved oil and seed meal quality using conventional as well as biotechnological approaches, restructuring of plant type of Indian mustard for irrigated ecosystem and resource conserving agriculture, development of thermo-photo-insensitive genotypes for diverse cropping systems under varied agro-ecological situations, development of resource use efficient cultivars and high photosynthetic efficiency for different agro-climatic situations having tolerance to various biotic and abiotic stresses, expansion of rapeseed-mustard crops to rice-fallow/non-traditional areas, development of IT-based decision support systems, innovations in knowledge management and technology dissemination will be the strategies adopted by ICAR-DRMR to fulfill the vision 2050.

Major Strategies for 2050
• Genetic enhancement and biotechnology
• Natural resource management and farm mechanization
• Capacity building and technology transfer
• Policies and reforms

Genetic enhancement and biotechnology

Despite attaining many highs in rapeseed-mustard crop improvement after releasing more than 150 high yielding varieties for different conditions, still there exists a gap between the achieved and achievable. When we look at the present status of yield plateau, the expected challenges in the rapeseed-mustard crop improvement programmes are; how to use wild species for developing introgressed and resynthesized lines of *Brassica juncea* with desirable attributes with respect to biotic (aphid, alternaria, sclerotinia rot) and abiotic stresses (drought, heat and salinity tolerance), restructuring plant type for various cropping system using derived *juncea* lines as donors, development of genomic resources for the genetic improvement, marker assisted backcrossing to introgress desired chromosomal segments from the wild donors etc which needs to be addressed on priority.

Heterosis breeding

The productivity of rapeseed-mustard is constrained by several prevalent and newly emerging biotic and abiotic stresses (mustard aphid, Alternaria blight, salinity, both extremes of temperature and water stress). At the onset, the potential of existing cultivars can be sustained / stabilized by exploiting the genes for resistance to these stresses to be followed by raising the genetic potential of the crop by either restructuring the plant type or by heterosis breeding. Exploitation of heterosis has been one of most successful accomplishments of the present era in rapeseed–mustard crop improvement programme. However, enhancing the heterosis level is the main challenge to make the hybrid technology competitive and remunerative. We are also now getting success in the development of genetically engineered mustard hybrid.

Biotechnological interventions

The naturally occurring fatty acid composition of Brassica oils has been extensively modified by altering biosynthetic pathways using conventional plant breeding and biotechnological approaches. The success story of development of high oleic acid and low linolenic acid lines at Delhi University South Campus and development of transgenic B. *napus* producing EPA (Eicosapantenoic acid) and DHA (Docosahexanoic acid) at NRCPBI, Canada needs to be replicated in Indian mustard.

Improvement in the nutritional quality of oil and seed meal has always been one of the key focus areas of rapeseed-mustard breeding programmes worldwide. Hence, development of designer *B. juncea* will continue to be the focus in coming years. There is now a greater need for integration of biotechnological tools like microspore culture, isolation of trait specific gene(s), especially for aphid and Alternaria blight resistance, identification of parental lines on the basis of genetic diversity, di-haploid breeding and marker assisted selection with conventional breeding. Functional genomics of drought and heat tolerance deserves priority and the breeding programmes should be reoriented accordingly. Breeding programmes should also aim at enhancing resource use efficiency, especially nutrients and water as well as adaptation to the aberrant environmental changes with special reference to the rise in atmospheric temperature due to climate change.

Phytate is the main storage form of phosphorus in rapeseed-mustard seeds. It is assumed that the amount of phosphorus present in seed is high enough to supply monogastric animals like pigs and poultry with enough phosphate.

It is envisaged that seeds with significantly reduced levels of phytate would represent a major contribution in crop improvement not only for livestock feed, but also potentially for direct human consumption.

Sinapine (sinapoylcholine) is the most abundant anti nutritional phenolic compound in seeds of rapeseed-mustard and therefore is a target for elimination in *Brassica napus* canola meal world over. Hence it is important to get rid of these antinutritional factors to add value to the seed meal for livestock feed in Indian mustard also.

Use of nanotechnology

The application of nanotechnology has tremendous potential in increasing production. Water proof nano-sand could reduce the wastage of irrigation water by 75% in excessively drained marginal soils. Nano-super sand stops water below the root level of plants and maintains a water table, giving a constant water supply. Reclamation of metal contaminated soils, preparation of controlled release fertilizers and nano bio-composite sensors are other avenues to monitor soil quality.

Natural resource management and farm mechanization

Crop diversification

Fallow-mustard is the most common cropping system in mustard growing belt of Rajasthan and Madhya Pradesh. Rapeseed-mustard crops are also grown after pearl millet/cluster bean/sorghum/sesame/maize crops depending upon the climatic conditions and availability of water. Research efforts should be geared up to identify suitable varieties and develop location specific technologies to harness this vast potential.

Studies aimed at developing organic rapeseed-mustard package of practices must keep in mind that the present day varieties are typically nutrient responsive and require the use of agro-chemicals to protect them from various pests and diseases. Varieties with high yield potential, low and slow nutrient requirement and resistance to diseases and pests may fit into the organic package. Development of appropriate cropping system for organic rapeseed-mustard crops calls for system based research.

Improving input use efficiency

Improving the input (soil, water and nutrients) use efficiency would be one of the major issues to be addressed to make the rapeseed-mustard production remunerative. Reduced dependence on chemical fertilizers and increased use of botanicals and organic farming practices along with balanced use of N, P, K, S, B, and Zn fertilizers concomitant with FYM, compost, bio-fertilizers and green manures will account for the integrated nutrient management. Promotion of all the fertilizers containing sulphur such as, Single Super Phosphate, Ammonium Sulphate, Ammonium Sulphate Nitrate, gypsum to increase the oil yield and would fetch higher returns for the farmers. Therefore, the use of sulphur @ 20-40 kg/ha may invariably be popularized across the country.

Enhancing irrigation potential

States having vast potential for enhancing rapeseed-mustard production such as Assam, West Bengal, Madhya Pradesh and Uttar Pradesh are largely rainfed, while Rajasthan and Haryana have substantial area under irrigation but with poor quality water. Therefore, development of water resources is imperative for enhancing rapeseed-mustard production in the country. In rainfed areas, rainwater harvesting plays an important role in increasing the productivity of the mustard based cropping system. Studies conducted on different methods of irrigations revealed that water application efficiency increased to 70-80% in sprinkler system and up to 90% in drip system as compare to 60-70% by surface methods. Policy interventions are required to address these issues.

Bio-fertilizers and soil microbes

Several reports have indicated positive response of *Azotobacter* and *Azospirillum* and foliar spray of phyllospheric bacteria on yield of mustard. Wider acceptability of bio-fertilizers among oilseed farmers is constrained because of their inconsistent responses which in turn are due to low soil organic matter and problems associated with the availability, transport, storage and handling. Poor quality bio-fertilizer is a big impediment in the success of bio-fertilizers. Indian Bureau of Standards has formulated quality standards for the production of *Rhizobium, Azotobacter, Azospirillum* and phosphate solubilizer cultures. However, enforcement of these standards needs to be realized earnestly.

Farm mechanization

Mechanization in rapeseed-mustard cultivation has not been exploited to its full potential. Use of improved agricultural tools, implements and machines for production and post-production operations would not only help to enhance total production and productivity but also ensures better input management and convenience to farm workers while reducing post harvest loss. Mechanization has become inevitable for sowing, spraying, harvesting and threshing particularly for small and marginal holdings. Concerted efforts are required to popularize the advantages of mechanization for saving time and drudgery keeping in view the growing scarcity of farm labors.

Bio-risk management

Climate change is emerging as one of the major factors of bio-risk in the rapeseed-mustard production system. Insect pest and disease scenario is changing due to emergence of new species as well as more resilient forms of already prevalent pests. The biology, behavior and epidemiology of existing insect pests and diseases are also affected by the climate change adversely affecting the production. The early forewarning system through remote sensing would be developed for insect pests and diseases to manage the risk and disaster through long term programme.

Post harvest and value-addition

Rapeseed-mustard has a broad diversity of oil-types in addition to canola or high-oleic and low-linolenic cultivars. Moreover, its oil contains valuable minor compounds such as tocopherols (vitamin E) and phytosterols. Enhancing such components by breeding may result in value addition. The meal obtained after oil extraction contains high-quality protein that can be used as a valuable animal feed. However, it also contains relatively high amounts of anti-nutritive fibers, phenolic acids, phytate and glucosinolates.

The future thrust in quality improvement should be to improve the nutritional and storage quality of rapeseed-mustard oil and seed meal with special emphasis on oils with low saturated fatty acid ($< 6\%$), high oleic acid ($> 60\%$), moderate linoleic acid (20-25%), low α-linolenic acid (about 9 %) and zero *trans* fatty acid; high level of tocopherols (vitamin E), low phenolic compounds.

Biscuits fortified with mustard flour were found acceptable in nutritional, sensory and textural characteristics. Defatted mustard flour replaced wheat flour at 5, 10, 15 and 20% incorporation levels in biscuit preparation. The protein content of the biscuit increased nearly about 2.5 times as a result of mustard flour incorporation, coupled with reduction in fat and increase in fibre content. Sensory evaluation revealed that the samples containing 15% defatted mustard flour scored highest in most of the attributes including acceptability. There is vast scope for value addition to seed meal of rapeseed-mustard.

Policies and reforms

Institutions and policies

During the early 1990s, Minimum Support Prices (MSPs) for food grains were kept in check relative to oilseeds and the government controlled import monopoly dramatically lowered oil imports. This contributed to a sharp improvement in oilseed prices relative to competing crops and increased the oilseed production substantially between 1987-88 and 1994-95. Hence, in order to attract the farmers towards oilseeds, in general, and rapeseed-mustard, in particular favourable support price, higher tariff rate on import of edible oil and effective market intervention would have to be looked into.

The edible oil industry comprises four segments- mechanical crushing, solvent extraction, oil refining and hydrogenation. A series of steps have to be initiated not only by the Government, but also by the domestic industry to help them to survive. A novel policy framework for the processing industry has to balance the interests of four constituents by providing an incentive price for farmers, an affordable price for consumers, reasonable profit margins for industry and reasonable conformity to public interest, ensuring satisfactory levels of employment, income, exports and public revenue.

Oil recovery up to 35% only is realized by the mechanical crushing processor, which is the largest segment of edible oil processing industries and substantial amount of oil (5-10%) is left in the seed meal of rapeseed-mustard. Even if 3-4% of this left over oil could be extracted by modernizing the mechanical crushing units, then at least 2.0-2.5 lakh tonnes additional edible oil could be made available. There exists a problem for modernization of oil expeller units, as they come under small scale industries limiting the investment to modernize them for enhanced oil recovery.

Market and trade reforms policy

There has been a shift away from oilseed cultivation the world over; also in India due to a decline in relative profitability of oilseed cultivation the farmer has switched to more market driven crops. Continuous rise in population and income would increase the demand for edible oils. Unless domestic production keeps pace with increasing demand, the dependence on imports would increase, causing international prices to rise.

If the import is inevitable, then tread the path being followed by China. China has been the topmost oilseeds producing country in the world; however, the country has been substantially importing the seed rather than the edible oil to feed its large population. Heavy imports of seed rather than the edible oil by China in comparison to India, logically favours the vegetable oil crushing industries.

Capacity building and technology transfer

Human-resource Development

Collaboration with various National and International agencies need to be effectively established to exchange the information, technical know-how and materials for timely breakthrough in various fields like biotechnology, Quality Improvement, Resource management, Integrated Pest Management, Post Harvest Processing and Prediction Models. Adequate opportunities should be provided for human resource development by means of imparting training in advance fields at the centres of excellence both in India and abroad.

Technology dissemination system

Besides generating new technologies, concerted efforts are needed to transfer the existing technologies from research laboratories to the farmers' fields through efficient and effective technology dissemination programme. The data generated from the frontline demonstrations on rapeseed-mustard clearly indicate the possibility of enhancing the production to a great extent. There exists a commercially exploitable yield reservoir to the tune of nearly 28% of the national production which could be harnessed by the adoption of currently available improved technologies.

Major Flagship Programmes

- **Marker Assisted Selection:** Marker Assisted Selection for a genetic determinant or determinants of a trait of interest (e.g. productivity, disease resistance, abiotic stress tolerance, and/or quality) to develop more efficient selection systems to replace traditional phenotypic-pedigree-based selection system. Development of recombinant inbred lines (RILs) for precision breeding and Quantitative Trait Loci mapping shall be taken up.
- **Target 30+ Productivity:** The realized productivity level of mustard varieties under best management conditions is only 25-30 q/ha. To

meet oil demand of our increasing population, a flagship programme to achieve 30+ yield will be initiated through transplanting rapeseed-mustard, system of root intensification, plant geometry, nutrient use efficiency, etc. under different management conditions.

- **Resource Conservation Techniques (RCTs):** To assess the impact of various RCTs on growth, yield and yield attributes, soil properties, soil moisture dynamics and economics of mustard based cropping systems, five cropping systems, viz., fallow-mustard, green manure-mustard, brown manure-mustard, cluster bean-mustard and pearl millet-mustard were grown under conventional tillage (CT), reduced tillage (RT), zero tillage (ZT) and furrow irrigated raised beds (FIRB). The results so far revealed that the maximum system productivity and mustard equivalent yield (2427 and 2393 kg/ha respectively) was obtained under FIRB as compared to various tillage methods. The programme will be further strengthened and intensified.

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Future Road Map

The demand for edible oil has been increasing day by day as the country needs to provide for the energy requirement of the ever increasing population. The area under cultivation, on the other hand is dwindling at an alarming rate, curbing the scope of expansion in terms of land. The only way to enhance the productivity.

Success stories of states such as Punjab, Haryana, Rajasthan and Gujarat which have reached high levels of yield should be replicated in regions which are less exploited and having high potential such as Eastern Uttar Pradesh, Madhya Pradesh, Odisha, West Bengal, Bihar, NE region, Jammu & Kashmir, Himachal Pradesh and Uttarakhand. Research and extension activities aimed at technology dissemination should be tailor-made to meet the region specific demands of such potential areas to maximize the output.

Linkage and coordination with Stakeholders

The progress of a Nation reflects its progress in science, and science would only progress concerted efforts of its citizens and by collaborating with successful overseas partners who can be potential stakeholders.

For value addition, by-product utilization, augmenting germplasm resources, genetic diversity mapping, development of molecular descriptors, developing databases of plant diseases, insect pests and basic studies related to soil-water-nutrient relationships and in the cropping systems. The potential stakeholders from India for possible linkages includes NIN, Hyderabad, CFTRI, Mysore, ICAR institutes/ PD/NRC/AICRP for IPM, micro-nutrient, weed control, pesticide residue, biological control, agricultural engineering (NBPGR, IASRI, IARI, PDWM, PDFSR, CRIDA, etc.). The foreign stakeholders that can contribute towards the expansion of ICAR-DRMR's activities include Institute of Nutrition Uppsala, Sweden; Rothamsted Research, UK; Univ. of Melbourne, Australia; University of Queensland and University of Western Australia, Parth; CSIRO, Canberra, Australia; INRA, France; Western Regional plant Introduction Station, Pullman, USA etc.

One of the major issues requiring immediate attention is the up scaling of variety/seed replacement ratio (VRR/SRR) of newly released varieties/hybrids in coordination with the state/central department of agriculture. Recent statistics indicates that the average SRR of the major rapeseed-mustard producing states such Haryana (72%), Rajasthan (60%), Gujarat (60%) and Uttar Pradesh (58%) is more than the National average (56%), which prompts us to concentrate on the states with SRR lesser than National average such as Madhya Pradesh (21%) and West Bengal (38%). Establishment of strong linkages for successful operation of "Seed Village Concept" with producers, technocrats and certifying agencies for procurement and distribution can enhance the availability of improved varieties seed in time. The bottom-line is the replacement of old varieties with newer high yielding varieties having better adaptability for the changing climatic conditions.

Crop ecological zoning

Crop ecological zoning is the ideal strategy for efficient crop production. Delineating efficient zones for the rapeseed-mustard will help in realizing potential yields with limited efforts and inputs.

Public-private partnership

The contribution of the private organizations in the development of technologies is equally instrumental in the progress of the agricultural sector. This calls for the fruitful partnership between public and private organizations, as there will be a collective utilization of resources that leads to generation of technology and its effective dissemination. A lot of avenues are open for public-private partnerships which ICAR-DRMR should utilize to the maximum. Efforts should also be made to minimize the hassles and to maintain a welcoming attitude in future Memoranda of Undertanding (MoU). ICAR-DRMR has signed, MoUs for joint development of hybrids in Indian mustard as well as seed production and marketing of technologies developed by ICAR-DRMR.

Proactive department of Agriculture

There is also a need to bring transparency in the seed production chain, as a very large quantity of breeder seed is indented every year without any feedback on the status of foundation/certified seeds given to the research organization.

Ministry of Agriculture, Govt. of India has several schemes to provide adequate and timely dissemination of production technology through its countrywide network of State Extension Services. The programme should be designed in a bottom up approach, so as to make it demand driven.

Horizontal expansion of the crop

Exploiting the full potential of Rapeseed-mustard crop in nontraditional areas particularly in eatern India and areas following rice-wheat system is a big challenge faced by ICAR-DRMR. Rice-fallow areas of West Bengal, Bihar, Odisha, Jharkhand, North Eastern states and Chhattisgarh with an estimated area of 11.65 m ha can be utilized for growing early maturing (90-110 days) mustard varieties. If all these states together adopt rapeseed-mustard cultivation in at least 10% of the existing rice fallows with the available package, oilseed production could increase by at least one million tonne.

Non-traditional areas like Karnataka (Bijapur district), South Rajasthan (Udaipur, Dungarpur and Baswara districts), Ratlam district of Madhya Pradesh and Vidarbha region of Maharashtra are ideal for horizontal expansion. With the development of early maturing (110-115 days) mustard varieties, good possibilities exist to further increase the area to the extent of 2 lakh hectares in Panch Mahal, Khaira, Dahod, Ahmedabad, Surat and Valsad regions of Gujarat. In the command areas of north Gujarat, mustard could replace irrigated wheat, as wheat requires frequent irrigations which aggravate the salinity problem. There is considerable scope to bring large areas under rapeseed-mustard through intercropping with sugarcane (1:2), potato (3:1), chickpea (4 :1), wheat (9:1) and lentil (6:1) in the UP, Punjab, Rajasthan and Madhya Pradesh.

Adaptation to climate change

Climate change is going to be a major concern in coming days. Along with spreading the awareness regarding precautions and modifications in agricultural practices, varieties suited for better adaptation also needs to be developed. As an initiative to counter the climate change, which in turn is the result of increasing green house gases in the atmosphere including CO2, breeding of varieties with better adaptability in terms of CO2 assimilation and temperature tolerance, can be considered prospective. Virtually all components of the farming system from planting-to-harvesting-to-selling needs modification to adjust to climate change. Therefore, strengthening research for enhancing adaptive capacity of varieties, resource conservation technologies, pest surveillance and development of mechanism for collection and dissemination of weather, soil, water and agricultural data for improved assessment are important for successful adaptation to climate change.

In order to improve the efficiency of water application, technologies such as drip and sprinkler irrigation should be popularized which will result in better water productivity or increased "crop per drop" ratio. Other measures intended at increasing productivity are zero-tillage farming, improved drainage, utilization of best germplasm, optimizing fertilizer use and management of biotic and abiotic stresses.

Integrated economic approach to water resource management

Agricultural water productivity measures contribute towards closing the water gap, increasing "crop per drop" through a mix of improved efficiency of water application and the net water gains through crop yield enhancement. These include the familiar technologies of improved water application, such as increased drip and sprinkler irrigation. The crop productivity measures includes, among others, no-till farming and improved drainage, utilization of the best available germplasm optimizing fertilizer use, and application of crop stress management, including both improved practices and varieties.

Green revolution to gene revolution

It is an undeniable fact that, the food requirements of today's population of nearly 1.21 billion could not have been met by the technologies of the 1940's. And it is more alarming that it would not be possible to support the expected population of 1.68 billion in 2050. It is only possible through the blending of the 'gene revolution' in the 'green revolution' so as to achieve the goal of 'evergreen revolution' and also 'nutritional revolution'. The advantage of the gene revolution is that it has a relatively neutral scale that would benefit big and small farmers alike in an environment friendly manner. Thus, it can be of great help to the small and marginal rapeseed-mustard farmers with limited resources to increase productivity by availing improved and powerful seed materials. ICAR-DRMR is bound to embrace the modern biotechnological methods that offer unlimited opportunity for enhancing genetic potential of crops, management of biotic and abiotic stresses, bio-remediation and organic recycling.

Execution

The overall programme will be coordinated under the leadership of Director, ICAR-DRMR. The Director will be responsible for the national and international network coordination and any other future collaborative project having specific mandate. The basic and strategic research will be carried out at ICAR-DRMR, Bharatpur. The work relating to location specific research programmes will be carried out under AICRP-RM or similar target oriented network under the supervision of ICAR-DRMR.

The technologies developed will be disseminated with the help of developmental and extension agencies like Department of Agriculture (both central and state), NGOs, Oilseed Growers' Federations and using appropriate IT-based decision support systems.

Programme 1: Development of high yielding varieties/hybrid

Genetic enhancement of Indian mustard for yield and quality	• Genetic enhancement of brassica germplasm for yield, quality and stresses using integrated approaches ➢ Cloning, characterization and utilization of target genes ➢ Farmers participatory varietal selection	Varieties with high yield, oil and quality
Development of hybrid technology	• Development and evaluation of *mori, ogura* or other CMS based hybrids • Diversification of parental lines (AB&R) for better heterotic combination • Marker assisted selection of restorer lines • Refinement of hybrid seed production technology	Hybrids and hybrid production technology
Genetic enhancement of toria/taramira for seed and oil yield	• Development of populations • Evaluation and standardization of different CMS / SI systems in toria	Improved populations and high yielding toria/taramira varieties
Genetic enhancement for biotic stresses in Indian mustard	• Genetic transformation, molecular characterization and generation advancement • Functional genomics of pathosystems and insect-pest tolerant traits	Genotypes having enhanced tolerance to biotic stresses
Development of Brassica ideotypes for heat, drought and frost tolerance	• Study of mechanisms of temperature extremes and drought tolerance • Integration of selected traits into a single genotype	Improved plant types for abiotic stresses

Expected outcome

High yielding and input use efficient rapeseed-mustard verities/hybrids having enhanced tolerance to biotic and abiotic stresses

Programme 2: Development of production technology

Area	Activities	Output
Agronomic management in cropping systems	• Development of suitable cropping systems for rainfed/irrigated conditions under changing mustard based climate • Long term fertility trials and enhancing fertilizer use efficiency • Crop modeling for efficient nutrient and water management	New and improved Technology for Input use efficiency
Natural resource management	• Development of location specific resource conservation technology • Development of resource efficient precision farming systems	Technology for natural resource management
Stress management	• Physio-biochemical basis of high temperature tolerance • Molecular characterization of high water use efficient genotypes for associated mapping	High water use efficient genotypes

Expected outcome

Resource conservation and input use efficient technologies

Programme 3: Development of protection technology

Area	Activities	Output
Management of major diseases and insect-pests	• Developing models for forecasting diseases and insect-pests • Diversity analysis in pathogens and insects • Development of eco-friendly technologies for diseases and insect-pests management	Technologies for disease and insect-pest management

Expected outcome

Insect-pest forecasting models and eco-friendly technologies for biotic stresses management

Programme 4: Technology dissemination & knowledge management

Rapeseed-mustard Area expansion and capacity building	• Capacity building of various stakeholders using ICT • Promotion of community institutions for growth of livelihood opportunity • Participatory research and upscaling of appropriate technology for various micro-farming situations	Increased production and strengthening livelihood of stakeholders
Development of software's for information management and technology dissemination	• Design and development of online expert system for package of practices • Development of web-based user-friendly interactive soft ware	Application software tools
Trade and marketing policy	• Impact of marketing and price policy • Market intelligence and intellectual property right	Impact assessment of technologies

Expected outcome

Competent human resources for technology dissemination and farmer's friendly web based rapeseed-mustard information system

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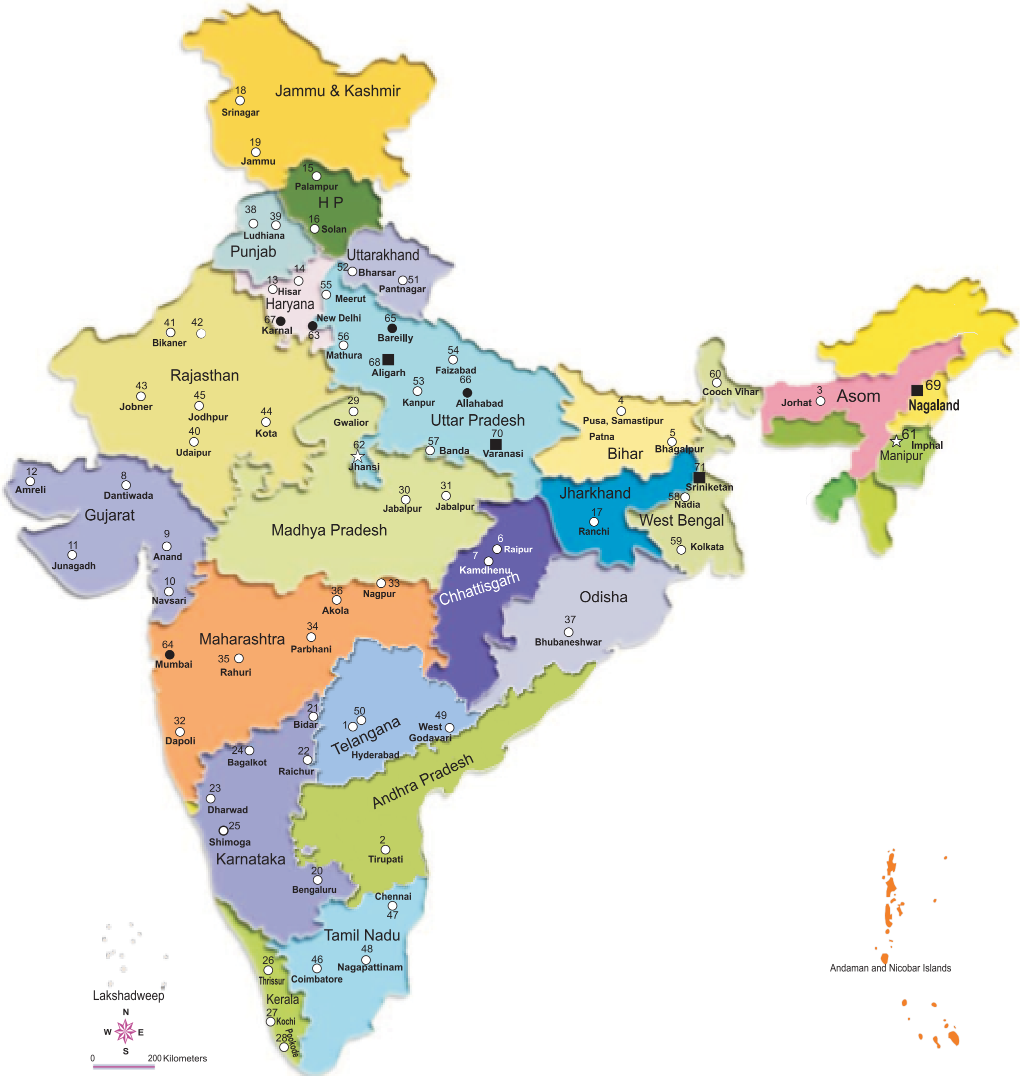
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities



LEGENDS

- State Agricultural Universities ○
- Central Universities with Agricultural faculties ■
- Central Agricultural Universities ☆
- Deemed Universities ●

हर कदम, हर डगर
किसानों का हमसफर
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Agrisearch with a human touch