भाकृअनुप
ICAR

Vision 2030

Directorate of Rapeseed-Mustard Research
(Indian Council of Agricultural Research)
Bharatpur 321 303
Rajasthan

www.drmr.res.in

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FOREWORD

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging 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. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

It is a great challenge to attain self-sufficiency in edible oil production which is presently 50% only. The country is looking for a comprehensive road map to meet the challenge of bridging the widening gap of demand and production of edible oil. Rapeseed-Mustard because of resilience to grow under diverse agro-climatic conditions has gained momentum in India and among all the annual oilseed crops, occupies the premier position as the largest oil producing one. In this context, the Directorate of Rapeseed-Mustard Research (DRMR), Bharatpur has the responsibility to meet the aspirations of various stakeholders by making the rapeseed-mustard cultivation more remunerative and sustainable keeping in view the degrading and depleting resources, climate change and global competitiveness.

It is expected that the analytical approach and forward looking concepts presented in the '*Vision 2030*' document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

Dated the 17th June, 2011
New Delhi

(S. Ayyappan)

Preface

Rapeseed-mustard group of crops has diversified domestic and industrial uses. It is an important source of edible oil, condiment and vegetable in the Indian diets. These crops have to play an important role in Indian oil economy considering their suitability to grow under diverse agro-ecological situations. The ICAR established National Research Centre on Rapeseed-Mustard (NRCRM) on October 20, 1993 at Bharatpur and upgraded it as Directorate of Rapeseed-Mustard Research (DRMR) in February 2009 to provide a strong leadership to the rapeseed-mustard research activities in the country. The concerted systematic and organized research efforts have paid rich dividends. In 2009-10, the productivity of rapeseed-mustard was about 2.4 times more (1159 kg/ha) as compared to that of 1967-68 (483 kg/ha).

Considering the population growth rate and increased per capita edible oil consumption from the present 13.4 kg/annum to 23.1 kg/annum by 2030 due to improvement in standard of living, about 102.3 million tonnes (mt) of oilseeds will be required. In view of the current contribution of rapeseed-mustard (20-25%) to the oilseed production in India about 16.4-20.5 mt rapeseed-mustard need to be produced from the present level of 7 mt to make country self sufficient in edible oil sector. The **Vision 2030** document identifies the prioritized researchable issues, strategic framework to harness science to address them, programmes to achieve the envisaged goal and initiatives to revitalize the rapeseed-mustard research in the country to meet the expected demand for edible oil in the next two decades.

I deem it a privilege to express my gratitude to Dr. S. Ayyappan, Secretary, DARE, Govt. of India and Director General, ICAR, the force behind the preparation of Vision 2030. His vision and ideas have been the guiding principles for the present document. My sincere thanks to Prof. S. K. Datta, DDG (CS) for his encouragement, critical comments and valuable suggestions. I wish to place on record my appreciation for the useful suggestions given by Dr. B. B. Singh, ADG (O&P), the Chairman Dr. D. P. Singh and other members of Research Advisory Committee. Finally, I thank Dr. P. Kumar, NCAP, New Delhi and all my colleagues at the Directorate and All Indian Coordinated Research Project on Rapeseed-Mustard (AICRP-RM) centres for their immense contribution in the preparation of the present document.

June 15, 2011 (J. S. Chauhan)
DRMR, Bharatpur Director

Preamble

Although research work on the improvement of rapeseed-mustard started in 1910 with the collection and purification of land races, but oilseed research programme started in an organized way when the Indian Council of Agricultural Research (ICAR) launched a comprehensive multi-disciplinary research project for the improvement of oilseeds in the country in 1967 under the banner of the All India Coordinated Research Project on Oilseeds. The research programme on rapeseed mustard was further strengthened by setting up the unit of the Project Coordinator (Rapeseed-Mustard) on January 28, 1981 at 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 integrating all facets and sectors of oilseeds, under the common programme for breaking the stagnation on the oilseed front, reduce the drain of valuable foreign exchange and to achieve self–sufficiency in the edible oil sector.

In order to provide a strong leadership to the rapeseed-mustard research activities in the country and for promoting mission oriented basic, strategic and applied research, the ICAR established National Research Centre on Rapeseed-Mustard on October 20, 1993 at Bharatpur which represents the confluence of principal rapeseed-mustard growing areas of Rajasthan, Madhya Pradesh, Utter Pradesh and Haryana states accounting for about 80% cropped area in the country. The objective of establishing NRCRM was to promote mission oriented basic, strategic and applied research. In February 2009, ICAR upgraded it as DRMR.

The **Vision 2030** of the Directorate visualizes the future needs and challenges of the oilseed sector, in general, and rapeseed-mustard in particular and suggests appropriate strategies to meet them including ways to harness the science and prioritisation of the programmes to achieve the avowed goal of self-sufficiency in edible oil in the coming two decades.

Contents

Rapeseed-Mustard Scenario

Rapeseed-mustard crops in India comprise traditionally grown indigenous species, namely toria (*Brassica campestris* L. var. toria), brown sarson (*Brassica campestris* L. var. brown sarson), yellow sarson (*Brassica campestris* L. var. yellow sarson), Indian mustard [*Brassica juncea* (L.) Czernj & Cosson], black mustard (*Brassica nigra*) and taramira (*Eruca sativa/vesicaria* Mill.), which have been grown since about 3,500 BC along with non-traditional species like gobhi sarson (*Brassica napus* L.) and Ethiopian mustard or karan rai (*Brassica carinata* A. Braun).

Rapeseed–mustard crops in India are grown in diverse agro-climatic conditions ranging from north-eastern/north-western hills to down south under irrigated/rainfed, timely/late sown, saline soils and mixed cropping. Indian mustard accounts for about 75-80% of the 5.8 million hectare (mha) under these crops in the country during 2009-10. The cultivation of brown sarson which once dominated the entire rapeseed-mustard growing region is now shadowed by Indian mustard. There are two different ecotypes of brown sarson: lotni (self-incompatible) and tora (self-compatible). The 'lotni' is predominantly cultivated in colder regions of the country particularly in Kashmir and Himachal valley. The 'tora' on the other hand is cultivated in limited areas of eastern Uttar Pradesh. Yellow sarson is now mainly grown in Assam, Bihar, north-eastern states, Orissa, eastern Uttar Pradesh and West Bengal. Toria is a short duration crop cultivated largely in Assam, Bihar, Orissa and West Bengal in the east mainly as winter crop. In Haryana, Himachal Pradesh, Madhya Pradesh, Punjab, Uttarakhand and western Uttar Pradesh, it is grown as a catch crop. Taramira is grown in the drier parts of north-west India comprising the states of Rajasthan, Haryana and Uttar Pradesh. Gobhi sarson and karan rai are the new emerging oilseed crops having limited area of cultivation. Gobhi sarson is a long duration crop confined to Haryana, Himachal Pradesh and Punjab. Rapeseed-mustard crops because of their low water requirement fit well in the rainfed cropping system of resource poor farmers.

The contribution of rapeseed-mustard to the total oilseed acreage and production in India is 23.7% and 26.0%, respectively (Fig. 1). During 2009-10, rapeseed-mustard contributed 25.9% and 22.0% to the total oilseeds production and acreage. The yield of rapeseed-mustard was 1159 kg/ha as compared to 955 kg/ha of total oilseeds.

The rapeseed-mustard production trends represent fluctuating scenario with an all time high production of 8.13 mt from 7.28 mha acreage during 2005-06. The yield levels also have been variable ranging from

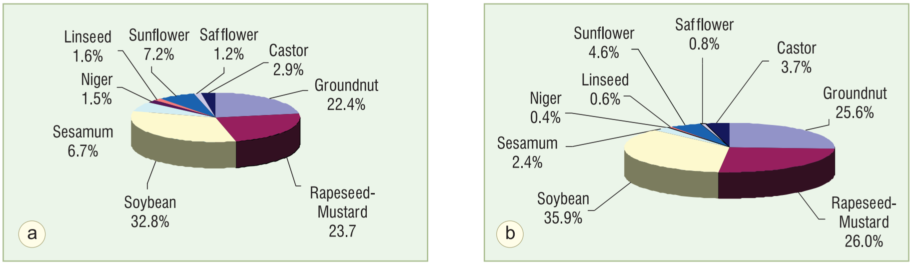
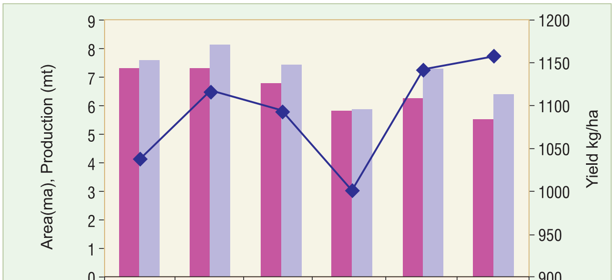


Fig.1: Contribution of rapeseed-mustard to India's total oilseed crop (a) acreage and (b) production during 2005-06 to 2009-10

Source: Agricultural Statistics at a glance 2010, Website: http://www.dacnet.nic.in

1001 (2007-08) to 1159 kg/ha (2009-10) during the past six years (Fig.2). Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat and West Bengal states accounted for nearly 90% area of rapeseed-mustard in the country. Rajasthan alone contributed 45.5% to the total area under rapeseed-mustard followed by UP, MP and Haryana and 48.6% to the total rapeseed-mustard production followed by UP, Haryana, MP, Gujarat and West Bengal. Together these states accounted for 94% of the rapeseed-mustard production in the country (Fig. 3). During the period 2005-06 to 2009-10, the productivity of Haryana, Gujarat, Rajasthan, Punjab and UP was above 1000 kg/ha in the descending order.



	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Area	7.32	7.28	6.79	5.82	6.30	5.53
Production	7.59	8.13	7.44	5.83	7.30	6.41
Yield	1038	1117	1095	1001	1143	1159

Fig 2: Production trends of rapeseed-mustard in India.

Source: Agricultural Statistics at a glance 2010, Website: http://www.dacnet.nic.in

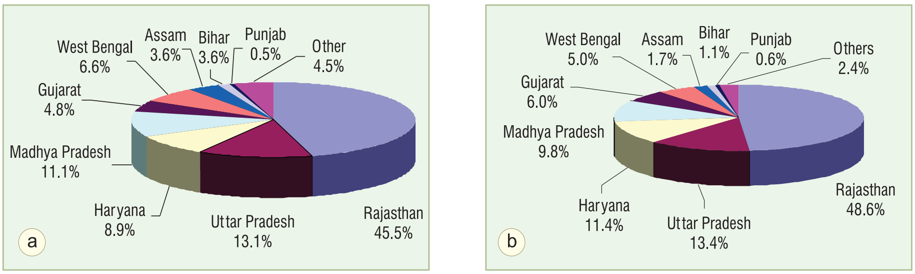


Fig. 3: Contribution of different states of India to rapeseed-mustard (a) acreage and (b) production during 2005-06 to 2009-10

Source: Agricultural Statistics at a glance 2010, Website: http://www.dacnet.nic.in

The current growth trend during 2008-09 and for the last 15 years showed that mustard had a positive trend of area expansion, while groundnut followed by rapeseed-mustard had better growth for yield than the average of nine oilseed crops. Among all the oilseed crops, rapeseed-mustard has the highest area (74.3%) under irrigation, which offers enormous scope for yield enhancement on long term basis.

Recent trend of comparative growth rate of area, production and yield of rapeseed-mustard and other oilseed crops during 2008-09 (Base T.E. 1993-94=100)

Crop	2008-09			1994-95 to 2008-09		
	Area	Production	Yield	Area	Production	Yield
Rapeseed-Mustard	6.25	26.30	18.88	0.88	4.71	3.66
Sunflower	-4.07	-14.46	-10.83	-1.00	1.08	3.02
Groundnut	-1.15	-20.08	-19.15	-1.67	6.38	7.02
Soybean	7.16	-9.73	-15.76	5.50	7.39	1.68
Nine oilseeds	2.86	-5.37	-8.00	0.32	3.74	3.05

Source: Agricultural Statistics at a glance 2009, Website: http://www.dacnet.nic.in

Domestic production and consumption of edible oil

The domestic production of edible oil has remained almost stagnant during the last five years. It was 8.3 mt in 2005-06 and 8.2 mt in 2009-10. However, the consumption has increased from 12.6 mt in 2005-06 to 17.0 mt in 2009-10. The gap in demand and supply is being bridged by import of edible oil, which has increased from 4.3 mt in 2005-06 to 8.8 mt in 2009-10 (Fig. 4).

Fig. 4: Production and consumption of edible oil in India

Source: SEA News Circular, 14(1), April 2011; http://www.dacnet.nic.in

Constraints in production

The rapeseed-mustard, which contributes nearly 80% of the total *rabi* oilseed production, is a vital component in edible oil sector. The rapeseed-mustard crops are diverse in their agro-climatic requirements and crop management practices. The production constraints facing each of the crops are also diverse in nature. The objective of raising domestic availability of edible oil can be realised only by increasing the productivity of these oilseed crops. Enhancing the production and productivity of the crop assumes significance; not only from the farmers' viewpoint but also for the edible oil industry and other vertically and horizontally linked enterprises. The major constraints faced by these crops are:

- Uncertainty of acreage of the crops due to several factors: climatic, biological, natural resources and policy decisions.
- Low and erratic rainfall leading to continuous moisture stress/ drought over the years. Seedling stage is most sensitive to moisture stress followed by flowering. Farmers are also not well versed with the moisture conservation techniques.
- Irrigation with saline and alkali-blended water in most of the areas of Rajasthan and parts of UP, Haryana and Punjab resulting in salinity builds up.
- Mono cropping in most of the major areas has led to soil deficiency for nutrients and built-up of soil borne pathogens.
- Stress caused by insect, nematodes, fungal, bacterial and viral pathogens, *Orobanche* and weeds collectively result in approximately 45% yield loss annually.
- High temperature during crop establishment (mid-September to early-November), cold spell, fog and intermittent rains during crop growth cause considerable yield losses by physiological disorder and appearance and proliferation of white rust, downy mildew and *Sclerotinia* stem rot diseases and aphid pest.
- Farmer's reluctance in using balanced dose of fertilizers, poor adoption of plant protection measures to control pest, diseases and weeds and harvesting at improper time.
- Timely availability of seeds of improved varieties suitable for various micro-farming situations.

The mitigation of these constraints requires out of the box thinking and innovative research strategies. The research approach itself needs an urgent revamp to harness the full potential of rapeseed-mustard crop.

Future projection for edible oil demand

India has ever increasing population. According to an estimate, it is going to reach 1.29, 1.36, 1.42 and 1.48 billion by 2015, 2020, 2025 and 2030 from 1.21 billion in 2011. Similarly, the living standard is also

increasing resulting in enhanced per capita edible oil consumption. The annual growth of demand for edible oil would be 3.54% during 2011-2030. Accordingly, it is estimated that the per capita edible oil consumption would be 23.1 kg/annum by the year 2030 from the present level of 13.4 kg. Therefore, to attain the self-sufficiency in edible oil 34.1 mt of edible oil equivalent to about 102.3 mt of oilseeds would be required (see below).

Projection for edible oil demand until 2030

Item/Year	2015	2020	2025	2030
Expected population (billion)	1.29	1.36	1.42	1.48
Per capita consumption of edible oil (kg/ annum)	14.57	16.38	19.45	23.10
Total edible oil requirement (mt)	18.79	22.27	28.20	34.10
Total oilseeds requirement (mt)	56.37	66.80	84.60	102.30
Expected contribution (80%) from annual oilseeds (mt)	45.10	53.40	67.70	81.80
Share of rapeseed-mustard to total annual oilseeds (mt)				
at 20% share	9.02	10.70	13.50	16.40
at 25% share	11.30	13.40	16.90	20.50
Expected area of rapeseed-mustard (mha)	7.00	7.50	7.75	8.00
Productivity of rapeseed-mustard desired (kg/ha)				
for 20% share	1314	1427	1742	2050
for 25% share	1614	1787	2180	2562

Source: Personal communication with Dr. P. Kumar, NCAP, New Delhi

Considering about 20% contribution from sources like rice bran, cotton seed, palm oil, coconut and other tree-borne oilseeds, the edible oil requirement from annual oilseeds to meet the domestic demand would be 81.8 mt by 2030. If the contribution of rapeseed-mustard to the total annual oilseeds production is considered 20-25%, then production of 16.4-20.5 mt rapeseed-mustard would be required. This target could be achieved through area expansion and/or increase in productivity of rapeseed-mustard.

There is very little scope for area expansion in the country as some expansion in few places would be offset by reduction in other places. It is estimated that rapeseed-mustard area could reach to the maximum 8.0 mha by 2030. Therefore, production would be increased mostly through increase in productivity per unit of land. Thus, a productivity of 2050-2562 kg/ha for rapeseed-mustard would have to be achieved by 2030 under the changing scenario of climate, decreasing and degrading land and water resources, costly inputs, government priority for food crops and other policy imperatives from the present level of nearly 1200 kg/ha.

Climate change

The rapeseed-mustard farmers are being increasingly subjected to the fury of nature in the form of drought, unseasonal and heavy rains and floods, and climate change. Based on various simulation projections, the CO_2 level would reach 410 ppm by 2020 and 450 by 2030. The greater concentration of CO_2 generally results in higher photosynthesis rates and may also reduce water losses from rainfed crop thereby increasing rapeseed-mustard production by 10-20%.

Indian annual mean temperature showed significant warming trend of 0.5°C per 100 year, during the period 1901–2007. Accelerated warming has been observed in the recent period 1971–2007, mainly due to intense warming in the recent decade 1998–2007. 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 and 3.0-5.5°C by 2080. A 1°C increase in temperature may reduce rapeseed-mustard yield by 3 to 7%.

The 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. However, on a seasonal scale, except for the Himalayan region, all other regions are likely to have lower rainfalls in the winter period as well as pre-summer period. Spatial patterns of monsoon rainfall 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. With the recede of Himalayan glaciers the irrigation in Indo-Gangetic plains would gradually become less dependable. 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.

Limiting water resources

By 2030, under average economic growth scenario and if no-efficiency gains are assumed, water demand in India will grow to 1498 billion m^3 out of which 80% (1195 billion m^3) would be for agriculture driven demand for rice, wheat and sugarcane for growing population. The demand for oilseed crops would account for 137 billion m^3. Against this demand, India's current water supply is approximately 744 billion m^3.

Shrinking land resources

During the last one decade agriculture lands have been converted in to residential houses and factories. Many marginal lands were put to cultivation. 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 and 0.32 ha in 2030. Moreover, this scarce agricultural land resource would also be degraded by erosion, water logging and salinity

Technology landscape

Of the 14,722 germplasm accessions of rapeseed-mustard in India, the Directorate has 6,201 accessions through acquisition from national/international agencies and collection. A total of 5605 accessions have been evaluated/characterized for agro-morphological traits. 42 accessions having novel traits (CMS, low erucic, low glucosinolate, tetralocular siliquae, earliness, yellow seed, salinity, high oleic, Alternaria blight tolerant, low linolenic acid, white rust resistant, short stature, high oil content) have been registered with NBPGR till 2010.

Donor for drought (RH 819, Aravali mustard, Vaibhav, RH 30), salinity (CS 54, CS 52, Narendra rai, BPR 541-4, BPR 540-6, RM 11, RGN 48, RH 8814, SKM 9927), frost (RH 781, Urvashi, RGN 48, DHR 9701), high temperature tolerance at seedling stage (NRCDR 02, RH 8814, BPR 543-2, NPJ 92, NPJ 93, DHR 9701) and high temperature tolerance at terminal stage (BPR 541-4) were identified.

130 varieties of rapeseed-mustard under the AICRP-RM have been notified till 2010. First CMS based hybrid (NRCHB 506) and three varieties (NRCDR 02, NRCHB101, NRCDR 601) of Indian mustard and one variety of yellow sarson (NRCYS 05-02) were developed at DRMR. 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 the farmers' practice.

Directorate of Rapeseed-Mustard Research

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 crops 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).

In February 2009, the ICAR upgraded NRCRM as the Directorate of Rapeseed-Mustard Research (DRMR) with a position of a Director, 34 scientific, 13 technical, 14 administrative and 5 supporting staff at the head quarter at Bharatpur and 83 scientific, 89 technical, 9 administrative staff at various AICRP-RM centres.

Mandate

- National repository for rapeseed-mustard genetic resources.
- Basic, strategic and applied research to improve the productivity, quality of oil and seed meal.
- Development of ecologically sound and economically viable agro-production and protection technologies for different situations.
- Generation of location specific interdisciplinary information based on multilocational testing and coordination.
- Establishment of linkages and promotion of cooperation with national and international agencies to achieve objectives envisaged.
- To extend technical expertise and consultancies.

Salient R&D achievements of DRMR & AICRP-RM

- Since the inception of All India Coordinated Research Project on Oilseeds in 1967, 130 improved varieties/hybrids of rapeseed-mustard have been released till December 2010. First CMS based hybrid (NRCHB 506) and three varieties (NRCDR 02, NRCHB 101, NRCDR 601) of Indian mustard and one variety of yellow sarson (NRCYS 05-02) were developed at DRMR.
- 2516.89 q breeder seed was produced under the AICRP-RM from 1984-85 to 2009-10 against the indent of 1059.01q.
- A total of 5605 accessions have been evaluated/characterized for agro-morphological traits and 4114 accessions were distributed to various national/international government and non-governmental organizations.

- Of the 42 accessions registered with NBPGR till 2010, 4 were from DRMR, Bharatpur.
- Donor for drought (RH 819, Aravali mustard, Vaibhav, RH 30), salinity (CS 54, CS 52, Narendra rai, BPR 541-4, BPR 540-6, RM 11, RGN 48, RH 8814, SKM 9927), frost (RH 781, Urvashi, RGN 48, DHR 9701), high temperature tolerance at seedling stage (NRCDR 02, RH 8814, BPR 543-2, NPJ 92, NPJ 93, DHR 9701) and high temperature tolerance at terminal stage (BPR 541-4) were identified.
- Palladium complex method developed for estimation of total glucosinolates in seed meal of rapeseed-mustard using ELISA READER.
- FT-NIRS calibrations developed for determination of oil, protein, fatty acid and total glucosinolate content in intact seed of rapeseed-mustard.
- Glucosinolate profiling of thirty seven rapeseed-mustard cultivars using HPLC was carried out.
- 114228, 105408, 27958, 10395 and 400 samples of rapeseed-mustard were analyzed for oil, protein, glucosinolate, fatty acid and crude fibre content, respectively up to March, 2011.
- A high frequency regeneration protocol for *Brassica juncea* cv. NRCDR 2 has been standardised using cotyledonary petiole explants. The best result was obtained on MS medium supplemented with BAP and NAA, where it gave 86.66% explants regeneration. The highest percentage of root regeneration (100%) was obtained on MS medium supplemented with 0.30 mg/l IAA.
- Pearl millet + cluster bean (fodder) – mustard and pearl millet + black gram–mustard cropping systems under rainfed and pearl millet – mustard and black gram – mustard under irrigated conditions were found most remunerative.
- Application of vermicompost @ 5.0 t/ha or FYM @ 10.0 t/ha + 75% recommended fertility level (80:40:0) gave 5-10% higher seed yield over recommended fertility.
- 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.
- Zinc application increased seed yield by 20% in Indian mustard at 37.5 kg ZnSO4/ha. Average response of Aravalli, Laxmi and Vardan varieties of Indian mustard to boron ranged from 21-31% at 20 kg borax/ha.

- Significant cultural and molecular variability was observed among the 25 and 19 geographical isolates of *Sclerotinia sclerotiorum* and *Alternaria brassicae* respectively.
- Critical stages for Alternaria blight outbreak was reported as 45 and 75 days after sowing (DAS).
- 2% neem oil and 5% neem seed kernel extract (NSKE) were found effective against the mustard aphid.

- Seed treatment with imidacloprid 70 WS @ 5g/kg of seed provided good control to painted bug up to 30-35 DAS.
- Seven out of eight major constraints affecting the rapeseed-mustard productivity in Bharatpur district of Rajasthan were related with the lack of crop resistance for the biotic stresses (Sclerotinia rot, *Orobanche*, Alternaria blight, painted bug, mustard aphid, white rust and termite).
- The DRMR has carried out 23 radio *krishi shiksha* programmes serials from seven radio stations (Agra, Mathura, Najibabad, Rampur, Jaipur, Kota and Sawai Madhopur) with 425 episodes, 48 video stories, two video films, 13 *beej pakhwada*, 40 exhibitions, 43 *kisan diwas*, 367 frontline demonstrations, 17 *sarson vigyan mela*, 8 technical seminar on agriculture, animal husbandry & fishery, 179 visiting groups' advisory sessions and 9 study tours as transfer of technology programmes and benefitted thousands of stakeholders across the country up to March 2011.

- In 64 training programmes, 394 extension personnel and 2032 farmers, farmwomen and youth were trained on the improved production technology of rapeseed-mustard.

DRMR 2030

Vision

Farmers are empowered and adapted to eco-friendly and cost-effective precision rapeseed-mustard farming and to enhance an access to quality edible oil.

Mission

To develop and provide knowledge based resource management technology to different stakeholders to enhance rapeseed-mustard productivity, improve oil quality and livelihood of the people.

Focus

The **Vision 2030** on rapeseed-mustard 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 market for livestock sector are also targeted. It also aims at meeting the industrial requirements and bring about substantial savings of foreign exchange through import substitution and higher export earnings. It would concentrate on the following key researchable areas to achieve quantum jump in production and productivity of rapeseed-mustard:

- Efficient utilization of rapeseed-mustard genetic resources.
- 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 for food, feed and industrial uses using conventional as well as biotechnological approaches.
- Development of thermo-photo-insensitive genotypes for diverse cropping systems under varied agro-ecological situations.

- Development of cultivars with high water and nutrient use and photosynthetic efficiency for different situations.
- Development of designer *Brassica* for different fatty acids profile & value-added product.
- Development of rapeseed mustard genotypes tolerant to various biotic (Alternaria blight, Sclerotinia rot, white rust, *Orobanche,* mustard aphid, painted bug) and abiotic stresses (drought, temperature and salinity).

- Expansion of rapeseed-mustard crops in rice-fallow/non-traditional areas
- Production technologies for mustard based cropping systems under climate change scenario.
- Bio-molecules, bio-remediation and bio-fertilization for environmental safety.
- Survey and surveillance of insect-pests, diseases and weeds under climate change.
- Remote sensing for energy-water balance, disease and insect-pest surveillance, forewarning and crop modelling.
- Bio-intensive integrated pest management (IPM) module development for major insect pests and diseases.
- Host-pathogen interaction and induced resistance for management of diseases.
- Impact of pesticide residues on the dynamics of soil flora, fauna and environment.
- Socio-economic, operational and institutional constraints in the transfer of technology, yield gap analysis and farmer's perceptions.
- Development of information technology (IT) based decision support systems, innovations in knowledge management and technology dissemination.
- Impact of policies (procurement, price, export-import, storage, incentives etc.) and development programmes on area and production of rapeseed-mustard.

Harnessing Science

Potential of genetic–resource enhancement

Rapeseed-mustard crop is quite vulnerable to many diseases and insect pests and as a first approach, potential of the existing cultivars can be sustained/stabilized by insulating the crop by incorporating gene(s) for resistance to biotic (diseases and insect pests) and abiotic (drought, high & low temperature and salinity) stresses. In the second approach, per se ceiling to the genetic potential of the crop could be raised either by restructuring plant type or heterosis breeding. There is a need to diversify the genetic base of varieties by extensive and vigorous utilization of exotic germplasm as well as other related species/genera.

Exploitation of heterosis has been one of most successful accomplishments of the present era in the rapeseed–mustard crop improvement programme. Three hybrids NRCHB 506, DMH 1 and Coral PAC 432 have now been identified for cultivation in the mustard growing areas of the country such as Rajasthan, Haryana, Punjab and UP since 2008. However, enhancing the heterosis level is the main challenge to make the hybrid technology competitive and remunerative.

Genetic manipulation of rapeseed-mustard for better oil quality through biotechnological interventions is an important aspect of crop improvement. The naturally occurring fatty acid composition of Brassica oils has been extensively modified by altering biosynthetic pathway using conventional plant breeding and biotechnological approaches.

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 including India. The primary focus has been to develop canola seed with < 2% erucic acid in oil and < 30 μ-moles of glucosinolates in seed meal. A systematic programme to develop canola quality Indian mustard and gobhi sarson resulted in the development of 5 low erucic varieties in Indian mustard and 5 double low varieties in gobhi sarson. The efforts now should be on to recombine low erucic acid with low glucosinolate content in Indian mustard and refine the agronomic base to improve yield potential of double low gobhi sarson strains. Hence, development of double low Indian mustard will continue to be the focus in coming years.

Power of biotechnology

The productivity of rapeseed-mustard is constrained by several biotic and abiotic stresses (mustard aphid, Alternaria blight, salinity, drought/ water stress). Unavailability of suitable donors tolerant to most of these stresses and time and labour-intensive traditional breeding programmes have opened the window for adoption of biotechnological approaches and development of transgenic plants for improved and sustainable production of the crop. We are also now getting success in the development of genetically engineered mustard hybrid.

Phytate is the main storage form of phosphorus in rapeseed-mustard seeds. However, due to the lack of suitable enzymes in the digestic tract of pigs and poultry animals phosphorus is not liberated from phytic acid. Therefore, additional phosphorus is often added to the fodder. With the advent of the modern tools and techniques of molecular biology it is possible to reduce the levels of phytate in growing seed itself. 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 gobhi sarson canola meal world over. Recent understanding of the phenyl propanoid pathway although complex has enabled the scientists to perturb the sinapine biosynthesis pathway genes in gobhi sarson. These improvements are important to add value to the seed meal for livestock feed. Breeding efforts for meal quality are therefore required at reduction of anti-nutritive components.

Use of nanotechnology

Use of nanotechnology in agriculture and food industry can revolutionize the sector with new tools for disease detection, targeted treatment, enhancing the ability of plants to absorb nutrients, fight diseases and withstand environmental pressures and effective systems for processing, storage and packaging. The fertilizer and herbicide application through nano-particles may help to attain higher input use efficiency. Moreover, establishment of baseline information on safety, toxicity and adaptation of nanoparticle in soil and plant is also required for its safe and ecofriendly use. Water proof nano-sand could reduce the wastage of irrigation water by 75%. Reclamation of metal contaminated soils, preparation of controlled release fertilizers and nanobiocomposite sensors are other avenues to monitor soil quality.

Management of natural resources

Natural resource management to improve the input (soil, water and nutrients) use efficiency would be one of the major issues to be addressed in **Vision 2030** to enhance the rapeseed-mustard production with reduced

production cost. With the monsoon remaining sub-normal year after year and recharge of ground water becoming difficult, promoting the use of sprinklers in the moisture deficient areas of mustard cultivation needs a close look. Applying two-irrigations by sprinkler system for seven hours each time, keeping the nozzle at 12 meter distance saves 38% water without any reduction in yield. Use of tractor drawn seed-cum-fertilizer drill suitable for sowing and basal fertilization is desirable. With reduced dependence on chemical fertilizers and increased importance of botanicals and organic farming, nutrient stress requires to be managed by balanced fertilization with N, P, K, S, B, and Zn along with FYM, compost, bio-fertilizers (*Azotobacter* and phosphate solubilizing bacteria) and green manures (*Sesbania*, *Cyamopsis tetragonolobus*) and integrated nutrient management. Promotion of all the fertilizers containing sulphur like single super phosphate, ammonium sulphate, ammonium sulphate nitrate, gypsum so as to increase the quantity of oil in mustard seed and higher return for the farmers as the trading of mustard oil is done on the basis of oil content. Therefore, use of sulphur @ 20-40 kg/ha should invariably be done across the country.

Bio-fertilizers and soil microbes

Bio-fertilizers such as plant growth promoting rhizobacteria (PGPR) and vesicular arbuscular mycorrhizal (VAM) fungi offer a cheap, low capital intensive, non-bulky and eco-friendly source of nutrients which help in increasing crop productivity due to enhanced availability of nutrients, stimulation of plant growth through hormonal action or antibiosis, or by decomposition of organic residues. Several reports have indicated positive response of *Azotobacter* and *Azospirillum* and foliar spray of phyllospheric bacteria on yield of mustard. Wider acceptability of biofertilizers among oilseed farmers is constrained because of their inconsistent responses 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 solubilizers cultures. However, enforcement of these standards needs to be realized earnestly. Apart from the availability of genetically potential strains indigenous to soil, there is a great scope to improve their action by biotechnological manipulation.

Organic farming

The cultivation of organic rapeseed-mustard and its ultimate acceptability to the farmers will depend upon how fast the packages are developed with profitability and sustainability perspectives. Though contributions of different organics, bio-fertilizers and bio-pesticides have been demonstrated in rapeseed-mustard is under inorganic input agriculture, organic package of rapeseed-mustard yet to be developed. The researches to develop organic rapeseed-mustard package of practices in future must keep in mind that the present day varieties are 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 resistant to diseases and pests or which can avoid them may fit into the organic package. Development of appropriate cropping system for organic rapeseed-mustard crops calls for system based research. The certification and marketing is another area to be looked into for organic cultivation.

Farm mechanization

Mechanization in rapeseed-mustard cultivation is very low. Use of improved agricultural tools, implements and machines for production and post-production operations of rapeseed-mustard would help to enhance its total production and productivity through timely agricultural operations; better inputs management and comforts to farm workers; post harvest loss reduction, value addition and economic utilization of by-products. Rapeseed-mustard has unique requirement of farm machineries for sowing, spraying, harvesting and threshing particularly for small and marginal holdings. Concerted efforts are required to address the issue of farm mechanization for rapeseed-mustard for saving time and drudgery in view of growing scarcity of farm labours and need for conservation agriculture.

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. However, vast areas under diara land in Bihar, *utera*/paira cropping and agroforestry, sugarcane etc. are still untapped. Research efforts should be geared up to identify suitable varieties and develop location specific technologies to tap the vast potential of inter/mixed cropping.

Post harvest and value-addition

Rapeseed-mustard seed have been mainly used for oil extraction. However, their chemical composition offers wide possibilities for utilization of this valuable crop for preparation of a number of value added products. Rapeseed-mustard has a broad diversity of oil-types in addition to canola or high-oleic and low-linolenic cultivars. Moreover, it contains valuable phytochemicals such as tocopherols (vitamin E) and phytosterols. Increase of such chemicals by breeding may lead to value-added edible oils. After oil extraction, the meals contain a high-quality protein that can be used as a valuable animal feed. However, it also contains relatively high amounts of anti-nutritive fibre compounds, 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 by emphasizing the issues like "oil with low saturated fatty acid ($\leq$ 6%), high oleic acid ($\geq$ 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 to improve protein quality and large seed size with thin and yellow seed coat. For making rapeseed-mustard oil healthier, it can be fortified with squalene, phytosterols, ω-3 fatty acids like eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA) by blending with edible oil like *Amaranthus* oil.

Presence of high phenolic content makes mustard seed meal effective against yeast and microbes. This anti microbial property could be suitable for special end use. Mustard seed contains mucilage, a linear hydrocolloid consisting of a variety of polysaccharides, having different molecular weight and solubility. Mucilage effectively lowers the interfacial tension of water-oil and water-air emulsions. Addition of 1-2% of mustard meal is reported to improve the cooking and slicing characters of products because of its good colloid-chemical properties like water and fat binding capacity as well as emulsifying characteristic. Biscuits fortified with mustard flour were found acceptable in nutritional, sensory and textural characteristics. There is vast scope for value addition to seed meal of rapeseed-mustard. A number of nutritional supplements and fortified product can be produced utilizing the nutraceuticals present in seed meal.

Bio-risk management

The climate change is emerging as one of the major factors of bio-risk in the rapeseed-mustard production system as with other crops. The insect-pest and diseases scenario changing and the new pests are emerging. The biology, behavior and epidemiology of existing insect-pests and diseases are also affected by the climate change adversely affecting the production and income of the farmers. 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. The survey and surveillance system would be developed to explore the migration and dispersal of the pests and pathogen to contain their initiation in the new areas. The effective technology dissemination system for the stakeholders should be developed to overcome the bio-risk. The IT based information system may be useful to inform the agencies at the local, regional & national level.

Modernization of oil extraction facilities

The rapeseed-mustard varieties/hybrids contain oil in the range of 40-45% but the oil recovery up to 35% only is realized by the mechanical crushing processor (oil expeller), which is the largest segment of edible oil processing industries. Under this process of oil extraction, substantial amount of oil (5-10%) is left in the rapeseed-mustard seed meal. 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 tones additional edible oil could be made available. There exists a problem for modernization of this oil expeller unit, as they come under small scale industries, therefore, have a limit for investment to modernize them for enhanced oil recovery. Modernization/upgradation of this important segment of edible oil industries is also required to produce edible oil at a competitive price, in the light of huge imports of cheap edible oil.

Human resource development

Human resource development is a continuous process and to achieve the envisaged targets, the matching expertise should be available. With an objective to upgrade and augment technical competence of the personnel of the Directorate and NARS, collaboration with various national and international agencies need to be effectively established to provide /exchange the information, staff, technical know-how and capacity building for timely breakthrough in various fields like bio-technological research, quality improvement, resource management, IPM, post harvest processing, prediction models and nanotechnology. 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.

Enhancing irrigation potential

India's irrigated area expanded at a steady rate during the last few decades. The net irrigated area has increased by 24% during 1980-81 to 1990-91 and by 18% from 1990-91 to 2000-01 indicating a very slow pace of growth and is expected to be 61 mha of the total 140 mha net sown area in 2050. Further, over exploitation of groundwater, however, could lead to lower level of projected net irrigated area (NIA) and lower

irrigation intensity. States having vast potential for enhancing rapeseed-mustard production such as Assam, West Bengal, Madhya Pradesh and Uttar Pradesh are largely rainfed. Rajasthan and Haryana although have substantial area under irrigation but with poor quality of water. Poor ground water recharging due to inadequate and erratic rainfall has led to drastic reduction in the ground water table. 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. Policy interventions are required to address these issues.

Technology dissemination system

To enhance rapeseed-mustard production, besides generating new technologies, concerted efforts are needed to disseminate the existing technologies. The data generated from the frontline demonstrations on rapeseed-mustard clearly indicated the possibility of enhancing the production to a great extent. Different components like improved varieties, nutrient management, need based plant protection, weed control, irrigation management, thinning etc. have profound influence on the productivity of rapeseed-mustard. There exists a vast exploitable yield reservoir to the tune of nearly 25% of the national production which translates into additional 2.0 mt of rapeseed-mustard seed. This could be harnessed by the adoption of currently available improved technologies.

For speedy adoption of technology and creating awareness among the stakeholders, DRMR has taken up several measures for human resource development. The present era is emphasizing the use of information and communication technology (ICT) for the education of stakeholders with less dependence on the human resources for the extension work. The DRMR, Bharatpur has developed two PC-based expert tools (software) named "Fertilizer Application Recommendation Manager" and "Disease Management System" to help and guide the farmers, extension personnel, researchers, etc. Greater expertise would be required to enhance the effective use of ICT to establish close linkages of DRMR with stakeholders.

Strategy and Framework

The strategy of DRMR should be focussed to sustain production in Rajasthan, Gujarat and Haryana; raise productivity substantially in Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Orissa, Jharkhand, Chattisgarh, Uttarakhand, Himachal Pradesh, Jammu and Kashmir and NE region. Possibilities of areas under *diara* land, paira cropping, mixed cropping in different cropping systems and extending cultivation to new niches could also be explored to expand and promote rapeseed-mustard production. The states/region, which have reached high level of yield and offers little scope for further increase in productivity have well developed system of research and development (R&D). This includes Punjab, Haryana, Rajasthan and Gujarat. Efforts are essentially required to improve the R&D and technology dissemination in less advantaged region like eastern/north-eastern region of low rapeseed-mustard yield with high potential.

Linkage, coordination and execution arrangements

To realize the **Vision 2030,** DRMR would require strengthening the linkages with existing stakeholders and establish linkages with many new ones. It already has linkages with 22 states and central agricultural universities, 6 ICAR institutions, 4 R&D concerns of the state and central government and 14 prominent private sector R&D companies under AICRP-RM umbrella through out the country for generating location specific technologies. This group has played an all important role in increasing the productivity of rapeseed-mustard through seed and fertilizer revolution. It has developed 130 high yielding varieties/hybrids along with the matching crop management technologies suited to various agro-climatic conditions of the country and is expected to continue the same.

The other major areas for establishing linkages with various stakeholders from India and abroad would be development of value added products and by-product utilization, quality improvement, development of component technologies for mutual benefits, augmenting germplasm resources, genetic distance and molecular mapping, developing software for database of plant diseases, insect-pests, soil-water-nutrient relationships and integrated nutrient management (INM) in the cropping systems. The stakeholders from India for possible linkages could be NIN, Hyderabad, ICAR institutes/project directorate/national research centre/AICRP for integrated pest management (IPM), micro-nutrient, weed control, pesticide residue, biological control, development of farm machinery. The foreign stakeholders may be Rothamsted Research, UK; University of Melbourne, Australia; University of Western Australia, Perth; CSIRO, Canberra, Australia and INRA, France.

Up scaling of seed replacement ratio (SRR) of newly released varieties/ hybrids in coordination with the state/central department of agriculture need immediate attention. As per the latest available data, the average national SRR was about 56% and four major states such as Haryana (72%), Rajasthan (60%), Gujarat (60%) and Uttar Pradesh (58%) had higher SRR. Madhya Pradesh (21%) and West Bengal (38%), the other two major states of rapeseed-mustard had poor SRR, which needs to be improved by the concerned states. Establishment of strong linkages for successful operation of "Seed Village Concept" with producers, technocrats, certifying agencies for procurement and distribution can enhance the availability of quality seed in time.

Energizing AICRP-RM

The work relating to location specific research programmes will be carried out under AICRP-RM with headquarter at DRMR. To have the focused research, the target oriented programme will be developed in mission mode approach.

Proactive department of agriculture

The state/central department of agriculture is required to place indent for newly released varieties/hybrids well in advance. The issue of non-upliftment of the indented breeder seed by the department has added to the problem. 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. Foundation and certified seed production need to be strengthened for availability of quality seed to the farmers. The programme of Ministry of Agriculture, Government of India should be designed in a bottom up approach to make it demand driven. The "Frontline demonstrations in Oilseed Crops" sponsored by Department of Agriculture and Cooperation since 1989-90 should have focused approach and without any administrative hassles.

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 through optimization of resources. Six states in India namely Rajasthan, UP, MP, Haryana, Gujarat and West Bengal contribute 90% to rapeseed-mustard cropped area and 94% to the production. Therefore, the programmes of R&D centres working in these states need to be restructured and strengthened to acclerate the growth of the crop.

Public-private partnership

To meet the challenge of attaining self sufficiency in edible oil production which is presently 55% and also to face a greater challenge of changing climate, integration of public and private sector organizations is imperative to rapidly harness the benefits of generated technology and to harmonize and synergize the efforts of both the sectors. The public-private partnership (PPP) for commercialization of technologies may generate good amount of resources for strengthening the research in public funded organizations. DRMR has signed a memorandum of understanding (MoU) of joint collaboration for development of hybrids in Indian mustard. It is just the beginning of PPP in rapeseed-mustard, we may need to develop models of MoUs for various purposes in the coming years especially for pre-breeding, product development and technology dissemination.

Other issue of immediate concern under the paradigm of public-privete partnership would be to arrest the depletion of genetic diversity and also to find sources for resistance to biotic/abiotic stresses for the crop improvement programme. There is an urgent need to focus on pre-breeding like CGIAR institutes, evaluation of germplasm, development of core set and exchange of germplasm under the aegis of different legislations like Biological Diversity Act 2002 on germplasm exchange. In this regard, a two-way approach for accessing germplasm and benefit sharing and IPR for pre-breeding programme needs to be stressed upon. Harmonization of guidelines for participatory seed production, technology generation and dissemination are the other important areas for PPP. The industries/private houses should support target oriented basic and strategic research to enhance R&D activities in areas of biotechnology and nanotechnology.

Fiscal incentives for motivating the farmer

Since the late 1990s, minimum support price (MSP) for oilseeds have stagnated due to the liberalization of edible oil imports initiated in 1994 and that for pulses and major cereals have been raised substantially. The government regularly provides incentives to rice and wheat through price support operations but oilseeds have not been supported to that extent. As a result of increasingly favourable returns from the competing crops like wheat and *rabi* pulses rapeseed-mustard area has been diverted.

Policy framework for the processing industry

India's oilseed processing sector is fragmented, small scale and suffers from low capacity utilization. To sustain oil processing industry and

subsequently farmers growing rapeseed mustard, there is a need for appropriate policy intervention to encourage modernization of the processing units, ensuring availability of sufficient raw material in the local market and discourage the import of cheap edible oil. The policy for liberalization of the small scale oil processing sector may also be adopted to use the ultra-modern extraction technology for enhanced oil recovery, which will require huge investment. In the scenario of inevitable import of edible oil, importing the oilseeds rather than the edible oil is a better option to help out the oil crushing industries and also to meet growing edible oil demand. A novel policy framework for the processing industry has to balance the interests of four stakeholders by providing an incentive price for farmers, an affordable price for consumers, reasonable profit margins for industry and conformity to public interest, ensuring satisfactory levels of employment, income, exports and public revenue.

Market and trade reforms policy

Policy support and measures requires to be extended to utilize the by-products in an efficient and economic way and also to extend the value addition before exporting the oilseeds, for increasing the profitability. Industrial development should be focused for *inter alia* better utilization of protein rich oil cakes.

There has been a shift away from rapeseed-mustard cultivation in India due to a decline in relative profitability of cultivation. The farmers switched to more market driven crops like wheat wherever possible. More dependence on the international market for large quantity of oils/oilseeds would be risky as variable production scenario, diversion of oilseeds for production of bio-fuels and rising demand for edible oils in some major exporting countries would result in scarcity of edible oil in the international market. Further, dependence on edible oil imports harms the interest of farmers too.

Horizontal expansion of the crop

Rapeseed-mustard group of crops is capable of performing well under diverse agro-climatic zones and has a lot of potential to enhance its production particularly in the rice-fallows of eastern India, non-traditional areas and rice-wheat system. Rice-fallow areas of West Bengal, Bihar, Orissa, Jharkhand, Chhattisgarh and NEH states which is estimated to be 11.65 mha can be harnessed by growing early maturing (90-110 days) mustard varieties. If all these states together adopt mustard cultivation in at least 10% of the existing rice fallows with the available package, rapeseed-mustard production may increase by at least one mt.

Other important areas for horizontal expansion could be some selected districts of non-traditional areas like Andhra Pradesh (Kurnool and Guntur districts), Karnataka (Bijapur district), South Rajasthan (Udaipur, Dungarpur and Banswara districts), Ratlam district of Madhya Pradesh and Vidarbha region of Maharashtra. Good possibilities exist to further increase the area in Panch Mahal, Khaira, Dahod, Ahmedabad, Surat and Valsad regions of Gujarat. In the command areas of north Gujarat, mustard may replace irrigated wheat, as wheat requires frequent irrigations which aggravates the salinity problem. There is considerable scope to bring large areas under rapeseed (toria/yellow sarson)-mustard (Indian mustard) through intercropping with sugarcane (1:2), potato (3:1), chickpea (4:1), wheat (9:1), lentil (6:1), etc. in the northern states of UP, Punjab, Rajasthan and Madhya Pradesh.

Adaptation to climate change

Farmers will need to adapt broadly to changing conditions in agriculture, of which changing climate is only one factor. Farming system from planting to harvesting and marketing needs modification to adjust to climate change. Therefore, strengthening research for enhancing adaptive capacity of varieties, resource conservation technologies, pest surveillance, development of mechanism for collection and dissemination of weather, soil, water and agricultural data for improved assessments are important for successful adaptation to climate change.

Breeding rapeseed-mustard varieties for response to enhanced CO_2 will increase the rapeseed-mustard productivity as has been reported. Some of the possible adaptations more directly related to climate include development of rapeseed-mustard varieties and production technologies for adjusting sowing dates. Conservation agriculture and resource conservation practices that incorporate crop residues in the soils would likely to compensate the loss of organic carbon due to warmer climate.

An 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. The emphasis should be on the micro-irrigation system (MIS) like drip irrigation, sprinklers and furrow irrigated raised bed (FIRB) technology.

Epilogue

The **Vision 2030** for rapeseed-mustard research work will result in the development of high yielding varieties and hybrids in rapeseed-mustard coupled with improved quality and resistance to major biotic and abiotic stresses for commercialization. The system-based eco-friendly crop production and protection technologies shall also be made available. The new technologies, processes and products, which will be developed under different programmes will be published and commercialized. The new approaches and frontier areas of research along with the on-going efforts through conventional breeding, resource management, resource conserving technologies, integrated nutrient and pest management, forecasting/forewarning models would help in enhancing the rapeseed-mustard productivity, quality of its by-products and development of value-added products. The research in frontier areas will require IPR protection. The varieties will be protected as per the provisions made in PPV&FR act.

The location specific research work carried out under AICRP-RM shall result in development of location specific varieties and need based crop production and protection technologies. With the enhanced production, the potential of oil processing industry will be adequately utilized and increased availability of seed meal can offer greater opportunity for development of value-added products. The increased production will enhance the farmers' income and result in the socio-economic upliftment and inter-regional disparities. The development of value-added products (oil with better quality and nutritional value, etc.) will generate additional employment potential besides expansion of the industrial base and improved health standards.

With the increased production of rapeseed-mustard, the country will not only keep pace with increasing demand of vegetable oil but will also be in a position to export the value-added products. The programme on successful completion will also limit the process of the degradation of natural resources to promote sustainability by standardization of low input and environment-friendly technologies. The technologies would reduce the use of agro-chemicals, thereby limiting the risk of environmental pollution and residues to minimize the health hazards.

Finally, it is to reassure that plant based oils are indispensable in the human food as also in several industrial uses. Therefore, all the stakeholders with the oilseed sector must join hands for production, post-harvest management, commercialization and future trading to the best advantage of small and marginal rapeseed-mustard farmers.

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Annexure

Strategic framework

Goal	Approach	Performance measures
Programme 1: Development of high yielding varieties/hybrids		
Genetic enhancement of Indian mustard for yield and quality	• Wide hybridization using identified donors for drought and high temperature tolerance • Development of hybrid oriented germplasm for drought tolerance • Generation of breeding materials and selection of low erucic/ glucosinolate • Marker assisted selection for quality traits • Cloning, characterization and utilization of genes for improved fatty acid profile • Farmers participatory selection of varieties in target environment	• Thermo/drought tolerant and improved oil and seed meal quality genotypes/ varieties/ hybrids • Improved and efficient analytical techniques for quality traits • Varieties for non-traditional areas
Development of hybrid technology	• Development and evaluation of *mori* or other CMS based hybrids • Seed production of hybrids and multiplication of stable A, B & R lines • Marker assisted selection of restorer lines • Development of double haploid restorer lines • Development of hybrid seed production technology	• New hybrids and parental lines • Conversion of CMS / restorer lines • Standardized hybrid seed 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 population and hybrids
Genetic enhancement for biotic stresses in Indian mustard	• Introgression of diseases and pests resistant / tolerant traits from *Brassica* and related species • Molecular profiling of genetic stocks of economically important traits • Cloning, characterization and utilization of genes for tolerance to diseases and pests • Genetic transformation, molecular characterization and generation advancement • Functional genomics of pathosystems and insect-pest tolerant traits	• Improved varieties and hybrids insulated from diseases and insect- pests • Transgenics for aphid pest and Alternaria blight disease • Database of disease-pest resistant and tolerant traits
Programme 2: Development of production technology		
Agronomic management in mustard based cropping system	• Identification of suitable cropping systems for rainfed/irrigated conditions under changing climate • Long term fertility trials • Identification and assessment of principles and approaches for enhancing fertilizer use efficiency • Bio-sensing and nanotechnology for enhancing nutrient & water use efficiency (WUE) • Integrated nutrient management (INM) • Micro-irrigation and fertigation strategies • Crop modeling for efficient nutrient and water management	• Remunerative cropping systems • Technology for enhanced water and nutrient use efficiency • Improved soil health • Validated model and INM package

Goal	Approach	Performance measures
Integrated weed management	• Population dynamics in different environments • Bio-chemical basis of herbicide action	• Weed management technology
Natural resource management	• Development of location specific resource conservation technology • Development of resource efficient precision farming systems	• Resource conservation technology • Precision farming systems
Stress management	• Physio-biochemical basis of high temperature tolerance • Molecular characterization of high water use efficient genotypes for associated mapping	• High temperature tolerant and water use efficient genotypes
Programme 3: Post harvest and value addition		
Post harvest product development	• Investigating secondary metabolite of high commercial value • Utilisation of seed meal & straw for product development • Development of nutritionally superior oil blends • Impact of feeding mustard cake obtained from conventional and quality material on milch animals	• Value added product
Programme 4: Development of protection technology		
Management of major diseases of rapeseed-mustard	• Collection of major pathogen cultures from different crop species and geographical zones and analysis of their variability • Epidemiological studies for forecasting diseases and multi-location testing of models for validation • Development of user-friendly software for forecasting diseases using satellite-sensed data • Development of web-based user-friendly interactive software for bio control based eco-friendly integrated disease management (IDM)	• Software for forecasting diseases • Interactive software for bio control based eco-friendly IDM • Interactive software for bio control based eco-friendly integrated disease management (IDM)
Management of major pests of rapeseed-mustard	• Survey, surveillance and recording of new emerging pests and development of forecasting models for their infestation • Collection of major insect-pests from different crop species & geographical zones and characterization of their variability • Development and validation of user-friendly software for forecasting of insect-pests· • Development of web-based user-friendly interactive software for integrated pest management (IPM)	• Software for forecasting of insect-pests • Web-based user-friendly interactive software for bio control based eco-friendly IPM
Programme 5: Technology dissemination & knowledge management		
Development of online multilingual expert system for package of practices	• Compiling information on package of practice for rapeseed-mustard • Design and development of online expert system for package of practices • Updating and redesigning digital photo library software and germplasm and variety database	• Online expert system for package of practices and germplasm database • Digital photo library software

Goal	Approach	Performance measures
Area expansion in rice-fallows of eastern India & non-traditional state	• Participatory varietal selection for identification of suitable genotypes • Capacity building of various stakeholders about technological interventions • Documenting ITK & traditional wisdom • Identification of research and extension priorities	• Enhanced acreage
Capacity building for livelihood security	• Capacity building activities with emphasis on ICTs • Promotion of community institutions for growth of livelihood opportunity • Socio-economic impact of interventions	• Mustard based livelihood opportunity
Model village for mustard based intervention	• Participatory research and extension of appropriate technology for various micro-farming situations • Strengthening livelihood opportunity and empowerment of stakeholders	• Model village
Trade and marketing policy	• Impact of price policy and marketing behaviour • Market intelligence and intellectual property right	• Policy guidelines
Forecasting model for production	• Development of area, production and productivity database • Development of forecasting models and their validation	• Forecasting model

हर कदम, हर डगर

किसानों का हमसफर

भारतीय कृषि अनुसंधान परिषद

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