



Vision 2050



Directorate of Oilseeds Research

Rajendranagar, Hyderabad - 500 030

www.dor-icar.org.in



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Compiled and Edited by :

Dr. S.N. Sudhakara Babu
Dr. S.V. Ramana Rao
Dr. V. Dinesh Kumar
Dr. D. Pati
Dr. M. Sujatha
Dr. K.S. Varaprasad

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शरद पवार
SHARAD PAWAR



कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री
भारत सरकार
MINISTER OF AGRICULTURE &
FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

MESSAGE

The scientific and technological inputs have been major drivers of growth and development in agriculture and allied sectors that have enabled us to achieve self reliant food security with a reasonable degree of resilience even in times of natural calamities, in recent years. In the present times, agricultural development is faced with several challenges relating to state of natural resources, climate change, fragmentation and diversion of agricultural land to non-agricultural uses, factor productivity, global trade and IPR regime. Some of these developments are taking place at much faster pace than ever before. In order to address these changes impacting agriculture and to remain globally competent, it is essential that our R&D institutions are able to foresee the challenges and formulate prioritised research programmes so that our agriculture is not constrained for want of technological interventions.

It is a pleasure to see that Directorate of Oilseeds Research (DOR), Hyderabad, a constituent institution of the Indian Council of Agricultural Research (ICAR) has prepared Vision-2050 document. The document embodies a pragmatic assessment of the agricultural production and food demand scenario by the year 2050. Taking due cognizance of the rapidly evolving national and international agriculture, the institute, has drawn up its Strategic Framework, clearly identifying Goals and Approach.

I wish DOR all success in realisation of the Vision-2050.

(SHARAD PAWAR)



डा. एस. अय्यप्पन
सचिव एवं महानिदेशक

Dr. S. AYYAPPAN

SECRETARY & DIRECTOR GENERAL



भरत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 114

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 114
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

The Indian Council of Agricultural Research, since inception in the year 1929, is spearheading science and technology led development in agriculture in the country. This is being accomplished through agricultural research, higher education and frontline extension undertaken by a network of research institutes, agricultural universities and Krishi Vigyan Kendras. Besides developing and disseminating new technologies, ICAR has also been developing competent human resources to address the present and future requirements of agriculture in the country. Committed and dedicated efforts of ICAR have led to appreciable enhancement in productivity and production of different crops and commodities, which has enabled the country to raise food production at a faster rate than the growth in demand. This has enabled the country to become self-sufficient in food and emerge as a net food exporter. However, agriculture is now facing several challenges that are expected to become even more diverse and stiffer. Natural resources (both physical and biological) are deteriorating and getting depleted; risks associated with climate change are rising, new forms of biotic and abiotic stress are emerging, production is becoming more energy intensive, and biosafety concerns are growing. Intellectual property rights and trade regulations impacting technology acquisition and transfer, declining preference for farm work, shrinking farm size and changes in dietary preferences are formidable challenges.

These challenges call for a paradigm shift in our research approach to harness the potential of modern science, innovations in technology generation and delivery, and enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy efficiency, agri-incubators 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.

It is an opportune time that the formulation of 'Vision-2050' by ICAR institutions coincides with the launch of the national 12th Five Year Plan. In this Plan period, the ICAR has proposed to take several new initiatives in research, education and frontline extension. These include creation of consortia research platforms in key areas, wherein besides the ICAR institutions, other science and development organizations would be participating; short term and focused research project through scheme of extramural grants; Agri-Innovation fund; Agri-incubation fund and Agri-tech Foresight Centres (ATFC) for research and technology generation. The innovative programme of the Council, 'Farmer FIRST' (Farmer's farm, Innovations, Resources, Science and Technology) will focus on enriching knowledge and integrating technologies in the farmer's conditions through enhanced farmer-scientist interface. The 'Student READY' (Rural Entrepreneurship and Awareness Development Yojana) and 'ARYA' (Attracting and Retaining Youth in Agriculture) are aimed to make agricultural education comprehensive for enhanced entrepreneurial skills of the agricultural graduates.

I am happy to note that the Vision-2050 document of **Directorate of Oilseeds Research, Hyderabad** has been prepared, based on the assessment of present situation, trends in various factors and changes in operating environment around agriculture to visualize the agricultural scenario about 40 years hence and chalk out a demand-driven research agenda for science-led development of agriculture for food, nutrition, livelihood and environmental security, with a human touch.

I am sure that the 'Vision-2050' would be valuable in guiding our efforts in agricultural R&D to provide food and nutritional security to the billion plus population of the country for all times to come.

Dated the 24th June, 2013
New Delhi




(S. Ayyappan)

PREFACE

India is the largest producer of castor, safflower, sesame and niger. These crops have also the added advantage because of their nutritional quality and industrial uses. India meets about 80% of global castor oil requirement and earns a sizeable foreign exchange through its export. However, these crops in the country are facing the challenge because of a multitude of factors *viz.*, the low and uncertainties of production and profitability due to their large acreage under rainfed cultivation by resource poor farmers in nutrient starved soils, climatic fluctuations, low processing efficiency and factor productivity and its vulnerability to market forces. Though the production and productivity of these crops during the last plan period have increased as compared to the previous plan period, the productivity with the exception of castor remained much below the global average. India being the largest consumer of edible oils, the requirement of vegetable oils is bound to increase significantly in future because of increase in population @ 1.5% per annum and spurt in economic conditions.

Formulation of appropriate strategies with a time targeted mission-mode execution to meet the domestic demand for vegetable oils in terms of quantity and quality is the need of the hour. Based on an in-depth analysis of oilseeds sector, an attempt has been made to give greater emphasis to basic and strategic research to increase productivity; improve oil quality and value addition; establishing a repository of information and genetic/genomic resources and strengthening linkages and partnerships with different stakeholders. It is my firm conviction that DOR would carry the mantle further in the years to come in pursuit of excellence in generating technologies not only to enhance the domestic vegetable oil production but also to meet the expected contribution to Indian vegetable oil economy.

I express my sincere gratitude to Dr. S. Ayyappan, Secretary (DARE) and Director General (ICAR) for his motivating and inspiring leadership. I profusely thank Dr. Swapan Kumar Datta, DDG (Crop Sciences) for his constant guidance and valuable suggestions to improve the document. I also thank Dr. B.B. Singh, ADG (OP) for his guidance and the staff of Oilseeds Section in processing the document at Headquarters. The assistance rendered by Drs. S.N. Sudhakara Babu, V. Dinesh Kumar, S.V. Ramana Rao and M. Sujatha of the Directorate for compilation of this document is greatly acknowledged. The efforts made by Dr. D. Pati for assistance in printing of the document are acknowledged. The assistance of Sri P. Srinivasa Rao for final page-setting and Sri B.V. Rao for cover page designing deserve appreciation.



(K.S. Varaprasad)

Project Director

June 24, 2013
Hyderabad

Context

Vegetable oils are critical for nutrition, energy and economy of the country and in global commodity supplies. The oilseeds sector has been vibrant and dynamic of world agriculture growing at 4.1% production per annum in the last three decades surpassing the growth of agriculture including livestock products. The demand–supply gap will widen in near future due to rapid increase in demand exceeding the moderate increase in supplies. The growth in vegetable oil supplies is constrained due to their cultivation under shrinking resource base, input supplies and uncertain profitability, while the demand increases at an increasing rate due to rise in *per capita* income and improved standard of living. The *per capita* demand for oil crops at the global level is expected to increase rapidly than that of cereals due to the diversion of vegetable oils for energy and non-food uses. Food demand in the developing countries accounted for half of the increases in world output during the last two decades, with output measured in oil content equivalent. China, India and a few other countries represented the bulk of this increase. No doubt, the strong growth of demand for protein sources for animal feed was also a major supporting factor in the buoyancy of the oil crops sector. The rapid growth of this sector reflects the synergy of the two fastest rising components of the demand for oils and livestock products favouring oil palm and soybean, respectively. In Asia, demand for meat and edible oils outstripped population growth by a wide margin over the past 15 years perhaps due to income elastic demand of these commodities.

Of all the arable crops, markets for oilseed commodities are set to undergo the greatest expansion wherein global oilseed production is likely to double the level observed in the last two decades. The *per capita* consumption of vegetable oils is expected to increase by 60% in developing countries through the first half of the century; in South Asia, this consumption is projected to be almost double (FAO, 2006). These trends are likely to continue as the food consumption levels of the developing countries are still fairly low and the income elasticity of demand for vegetable oils is still high in most countries (Alexandratos and Bruinsma, 2012).

Growing contribution of vegetable oils to food supplies and food security: World production, consumption and trade in vegetable oils sector are dominated by a small number of crops (soybean, oil palm, sunflower

and rapeseed) and countries. Vegetable oils provide the much needed food security measured as meeting calorie requirements in poverty assessments. Rapid growth of food demand in the developing countries, in conjunction with the high calorie content of oil products, has contributed to the increases achieved in calorie consumption in these countries. One out of every

Three decades ago, consumption of oil crop products (4.9 kg/person/year, in oil equivalent) supplied only 136 kcal/person/day, or 6.5% of the total availability of 2110 calories in the developing countries. By 1999/01, per capita consumption had grown to 10.4 kg contributing 272 kcal to total food supplies, or 10 per cent of the total which itself had risen to 2650 kcal.

four calories added to the consumption of the developing countries over this period originated in this group of products. In future, vegetable oils are likely to retain, and indeed strengthen, their primacy as major contributors to increases in food consumption of the developing countries. The *per capita* food consumption (kcal/person/day) is estimated to be 2980 by 2050 with 38% contribution from oil products. This reflects the prospects of increased demand for vegetable oils in the dietary composition which calls for increased productivity of edible oils on the global platform.

Growing demand for vegetable oils: The *per capita* consumption of vegetable oils, oilseeds and products (in oil equivalent) is anticipated to be around 15 and 18 kg in South Asia during 2030 and 2050, respectively. This translates to consumption of 41 and 49 g of oil per day which is higher over the recommendations of 30 g per day as per WHO and ICMR. While oils will remain an essential food item with high income elasticity in most developing countries in the short and medium term-future, it may not hold good in long term due to the growing awareness regarding health associated issues of consuming higher levels of oil products. Thus, *per capita* consumption is likely to increase at much slower rates compared to the past.

Non-food/Industrial uses: The second major driving force on the demand side has been the non-food and industrial uses of vegetable oils, with China, USA and the European Union being the major contributors to this growth. The main industrial products involved (paints, detergents, lubricants, oleo chemicals, cosmetics, etc.) are commodities for which demand can be

expected to grow faster than the demand for food uses of vegetable oil products, particularly in the developing countries. With the implementation of Kyoto protocol norms of the United Nations in reducing global emissions of green house gases, huge demand on vegetable oils as source for biofuels through many clean development mechanisms (CDM) is increasing to meet the unrelenting increase in the demand for fuels for industries and automobiles.

Structural changes in diets at the global level at 2050; towards satiety and over-nutrition:

The overall demand for agricultural products is expected to grow at 1.1% per year from 2005/07-2050, down from 2.2% per year in the past four decades. Population growth, increases in *per capita* consumption and changes in diets leading to the consumption of more livestock products are the main drivers of such expected changes. Global satiation for vegetable oils is expected to reach when

Some 4.7 billion people or 52% of world population may live in countries with national averages of over 3,000 kcal/person/day in 2050, up from 1.9 billion or 28% at present. In parallel, those living in countries with under 2,500 kcal may fall from 2.3 billion or 35% of world population at present, to 240 million or 2.6% in 2050.

population growth rate stabilizes and starts a negative trend with concomitant increase in health consciousness and over-nutrition. Negative growth rates of aggregate food demand may materialize in countries where *per capita* consumption levels are high – such as Japan, Russia or other Eastern European countries. Vegetable oils could provide 13% of total calories by 2050, up from 10% at present. The projections by FAO (Alexandratos and Bruinsma, 2012) suggest that in South Asia, the *per capita* utilization of oil crops for all uses is around 30.5 kg per annum that includes 16.2 kg directly towards food. The global production of vegetable oils is estimated to be 215.5 and 293.2 million tonnes by 2030 and 2050 with the contribution of annual vegetable oils being 150.5 and 203.4 million tonnes, respectively.

Present Indian oilseeds economy

In India, oilseeds follow cereals, sharing 14% of the country's gross cropped area and accounting for nearly 3% of the gross domestic product and 5.98% of the value of all agricultural products. Despite being the largest cultivator

of oilseeds in the world, India imports about 50% of the requirements because of the life style changes in dietary pattern and increasing *per capita* income. India grows oilseeds on an area of 26.37 million hectares, with productivity of 1134 kg/ha for the triennium ending 2011-12.

The performance of oilseeds on the domestic front during the last two decades has been commendable despite the vagaries of weather conditions, the global price aberrations and the ever increasing domestic demand. The growth rate of nine edible oils during 2000-01 to 2010-11 *vis-a-vis* 1990-1991 to 1999-2000 (Figure 1) has provided a fillip for consolidation and revitalization of the oilseed economy.

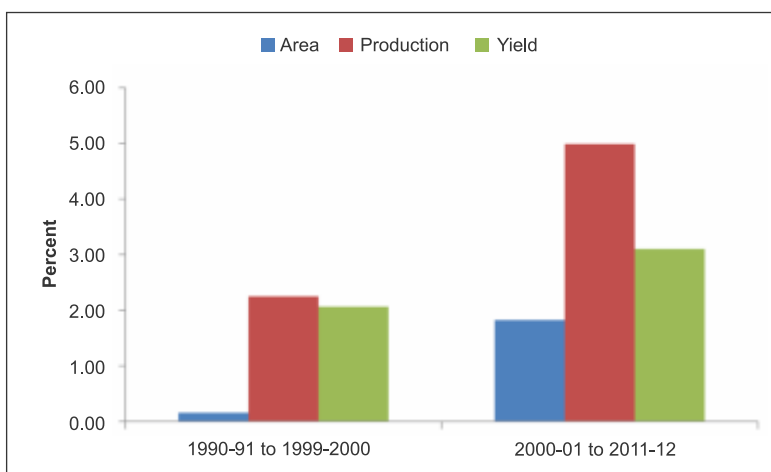


Fig 1. Comparison of compound growth rates of annual oilseed crops

Although enhanced growth rates of five per cent were evidenced on the domestic availability of edible oils for the period ending 2011-12, it could not match the rate of growth of imports of edible oils which was 6.99% and the *per capita* consumption of edible oils that grew at a rate of 5.65%. Growth analysis of individual oilseed crops during the decade 2000-01 to 2011-12 (Figure 2) suggests that there has been acceleration in area expansion under soybean, rapeseed-mustard and sesame while stagnation was observed in case of groundnut, sunflower, niger, safflower and linseed. The growth in area under castor crop although negligible resulted in tremendous production enhancement through substantial productivity improvement.

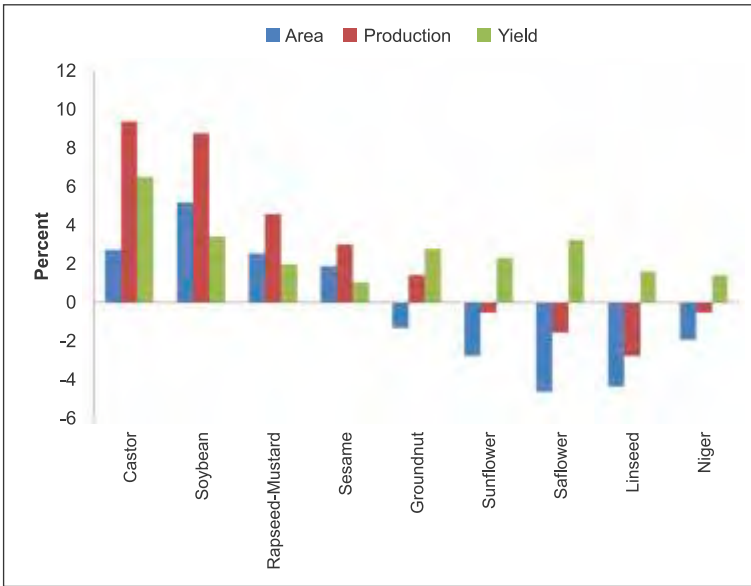


Fig 2. Compound growth rates of different oilseed crops in India (2000-01 to 2011-12)

The average production of edible oils in the country for the period between 1960-61 and 1984-85 was 8.82 million tonnes. The average *per capita* consumption during this period was 3.8 kg per annum that translated into 10.4 g of oil/day which was much lower than the minimum desired level of 30 g/day. The import bill on oilseeds was on a continuous rise from the mid 70's as the domestic production was not able to cater to the requirements of the consumption. It jumped steeply from ₹14.2 crores in 1975-76 to ₹921 crores by the year 1984-85. Facing the concern of edible oil imports, the Government launched the Technology Mission on Oilseeds during 1986 with the objective of enhancing the domestic availability through a multi-pronged approach which paid rich dividends as evidenced by doubling the oilseeds production to 17.45 million tonnes (decadal average ending 1995-96). The imports were reduced to ₹71 crores for the triennium ending 1993-94. The average *per capita* consumption of edible oils also increased to 6.3 kg per annum for the period 1985-86 to 1999-2000. The period post 2000 that witnessed globalization, the changes in dietary styles of the people, the rising *per capita* income, increased out-of-house food consumption pattern had its impact on the consumption pattern of the edible oils in India wherein the average *per capita* consumption of edible oils for the period 2001-02 to 2011-12 escalated to 29.4 g/day (10.7 kg from edible oils and 1.2 kg from vanaspati). The increase in average *per capita* consumption of the edible oils

was 5.25% between 2001 and 2012. The consumption levels of edible oils are beginning to increase at alarming levels as against the recommended 30 g per day to meet the physiological needs that indicated a desirable under 30% of total calorie from fats (Narasinga Rao, 2010). The country evidenced a steep rise in the *per capita* consumption during the last two decades, wherein, the edible oil consumption increased at a 4.3% growth rate and is expected to continue to increase though at a slower rate. A study by FAO (Alexandratos and Bruinsma, 2012) suggests that the increase in *per capita* consumption of edible oils would be at a decreasing rate of growth indicating the possibility of pegging the consumption of edible oils. To meet the increased demand of edible oils, the country has to devise a combination of research and development mechanism ably supported by inclusive policy support for fostering the domestic oilseeds production.

Challenges

Edible oil consumption in India is chiefly driven by the market forces and the country needs to have a strategic/pragmatic blue print for increasing the production of edible oils to meet the projected requirements by 2050. Various estimates are available for the bare minimum requirements of edible oils production considering various indicative and suggestive parameters. It is estimated that by 2050, India needs to produce 17.84 million tonnes of vegetable oils to meet the nutritional fat needs of projected population of 1685 million (Hegde, 2012). This estimate is based on the doctrine of a 'WELL FED AND HEALTHY INDIA'.

As per the projections made by DAC-Rabo Bank (2011), per capita consumption of vegetable oils in India is likely to rise to 14.57, 16.38, 19.45 and 23.10 kg/year by 2015, 2020, 2025 and 2030, respectively necessitating production of edible oilseeds to 56.37, 66.80, 84.60 and 102.30 million tonnes by 2015, 2020, 2025 and 2030, respectively to meet the vegetable oil requirement of 18.79, 22.27, 28.20 and 34.10 million tonnes, with a projected population of 1.29, 1.36, 1.42 and 1.48 billion, respectively.

On the other hand, estimated total demand for the edible oils in 2050 would be 11.19 and 40.89 million tonnes, respectively by considering the access to calorie requirements recommended by ICMR and by capturing the changes in food consumption pattern in relation to the population growth, *per capita* income and expenditure pattern and relative prices of food items, etc. (Singh, 2012). These estimates are the lower and upper limits of edible oils production in the country by 2050. However, a newer dimension that has taken genesis is the utilization of vegetable oils as biofuel. Current projections indicate that the derived demand for vegetable oil in biodiesel production could represent 20% of global vegetable oil consumption. The country has to be prepared for stocks required for the consumption on the biodiesel front besides the protein requirement from oilseeds towards the livestock feed component as well while pegging the lower limits of production. This sets the lower and upper limits of production at 13.49 and 49.07 million tonnes of vegetable oil by 2050 according to the projections made by Singh (2012).

By taking into consideration a host of factors *viz.*, domestic production, import dependency, trade buoyancy, *per capita* consumption levels, changes

in dietary standards, rapid strides of out-of-house consumption, swiftly rising demand for vegetable oils for non-industrial uses and the emergence of biofuel; projections are made for the Indian vegetable oilseeds from the annual oilseed crops (Table 1).

Table 1. Demand projections of vegetable oils for India

Demand source	2020	2030	2040	2050
Projected population (billion)	1.32	1.43	1.55	1.68
<i>Per capita</i> consumption considering 50, 60, 70 and 75% above the prescribed consumption levels during 2020, 2030, 2040 and 2050, respectively				
<i>Per capita</i> consumption (kg/annum)	16.43	17.52	18.62	19.16
Vegetable oil requirement for direct consumption (million tonnes)	21.69	23.13	24.58	25.29
Vegetable oil requirement for non-industrial uses (million tonnes)	3.57	6.34	9.69	10.61
Total vegetable oil requirement (million tonnes)	25.26	29.47	34.27	35.90
Vegetable oil availability from secondary sources (million tonnes)	5.05	5.89	6.85	7.18
Total vegetable oil requirement from annual oilseed crops (million tonnes)	20.21	23.58	27.42	28.72
Total vegetable oilseeds requirement from nine annual oilseed crops (million tonnes)	67.37	71.45	80.65	82.06

The projections are based on the assumptions that the *per capita* consumption would be increasing annually at 3% till 2015, followed by an increase at a declining rate of 2.5% from 2015 to 1.75% in 2020, with a further decline in the incremental consumption to negligible levels by the year 2050. The estimated *per capita* consumption is placed at 16.43, 17.52, 18.62 and 19.16 kg/annum for the years 2020, 2030, 2040 and 2050, respectively. The *per capita* consumption is pegged at 50, 60, 70 and 75% above the optimum requirement of 30g/day considering the health of the nation.

A newer emerging dimension of vegetable oil requirement towards non-industrial uses is estimated to grow by 15% in 2020, 20% in 2030 and 25% post 2040 which requires 3.57, 6.34, 9.69 and 10.61 million tonnes, respectively in 2020, 2030, 2040 and 2050. The Indian trade industry predicts that this industry is poised for greater expansion. The total vegetable oil requirement is thus estimated at 25.26, 29.47, 34.27 and 35.90 million tonnes during 2020, 2030, 2040 and 2050, respectively which is a gigantic task for the

country for increasing its domestic production. The contribution of vegetable oils from secondary sources including arboreal tree species (20%) is estimated at 5.05, 5.89, 6.85 and 7.18 million tonnes by 2020, 2030, 2040 and 2050, respectively. Thus, the total domestic vegetable oilseeds requirement from nine annual oilseed crops is placed at 67.37, 71.45, 80.65 and 82.06 million tonnes by 2020, 2030, 2040 and 2050, respectively.

The major issues of significance in visualising the challenges in running up to 2050 are presented hereunder.

Small holders' agriculture

The country's agrarian sector continues to be dominated by small and marginal farmers. The size of the holdings is dwindling and the number of holdings is getting fragmented. As per the National Sample Survey Organization survey of 2003, 88% of the total holdings are less than 2 ha.

These constitute approximately 44% of the total area and 51% of production. This is a concern of equity and productivity which widens the Rural-Rural divide that goes against the Millennium Development goals. The production technologies in the oilseed sector should primarily

The average size of holding that was 2.06 ha during the 70's has reduced to 1.06 ha during 2009-10. It is estimated that by 2030 and 2050, the average size of holdings would shrink to 0.29 and 0.28 ha, respectively while increasing the number of total holdings preventing the economies of scale to operate.

focus on low cost external input approach so that the technologies evolved under the oilseed umbrella are scale neutral that can be adopted by the oilseed farmers irrespective of the scale on which they operate. The paradoxical situation of labour shortage for agriculture and the limited opportunity for mechanization of small farm holdings is a challenge under the shrinking holding size and fragmentation. Land consolidation with voluntary participation with enabling policies could provide for reaping benefits of mechanized and cooperative/contract farming.

Climate change and its impending effects

The global climate change is no more considered an uncertainty but is a reality. Several forecasts for the coming decades project an increase in

atmospheric CO₂ temperature increase by 1.8 to 4 °C, changes in precipitation resulting in more frequent droughts and floods, wide spread runoff causing accelerated erosion leading to loss of nutrients and biota, physical crop damage and loss that threaten livelihood security of majority of farm holdings. Tropical storms, wide fluctuations in monsoons due to violent global atmospheric circulation changes would challenge all current recommendations and understanding of crop responses and biotic stresses of their validity. Oilseeds are cultivated in different agro-ecological regions of the country. Semi-arid ecosystem is an important region covering more than 50% of the total oilseeds area. The inconsistency in annual oilseed production in the country is directly related to the annual variability of rainfall pattern as they are mostly grown under rainfed conditions. The projected increase in these events will result in greater instability in oilseed production and influence the farmers' livelihood security. Technology development to adopt climate change should be dynamic of its short term modifications and focus on long term stability.

Over and above declining *per capita* availability of arable land, the quality in terms of soil health will be challenging to grow agricultural crops. Drastic changes in pest complex and intensity can occur and need preparedness through development of forecasting models.

Shifts in pest scenario

The changes in climate parameters affect the biology and ecology of pests (insects, diseases, weeds, other parasitic and non-insect pests) besides the challenges of resistance and resurgence as a consequence of indiscriminate pesticide use. The wide host range of oilseed crop species further accentuates the pest complexity.

Biosecurity and plant health management concerns

The worldwide increase of trade in oilseeds, the introduction of new crops and the continued expansion of trade-blocks result in increased threats of introduction of new plant pests (insects, mites, nematodes, pathogenic fungi, bacteria, viroid, viruses, phytoplasmas, weeds, etc.). According to the International Plant Protection Convention (IPPC) and the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary

Measures (WTO SPS Agreement) (Stanton, 2010), any measure against the introduction and spread of new pests must be justified by a science-based pest risk analysis (PRA). As a result, PRA is an essential component of plant health policy, allowing trade to flow as freely as possible, while minimizing to a reasonable and justifiable extent the risk of introduction of plant pests. Appropriate disease forecasting models need to be developed and validated. Pest risk analysis and pest forecasting are to be identified for managing the invasive pests which may hamper the production critically.

Operating Environment

The Directorate of Oilseeds Research (DOR) is a premier national institute under the aegis of the Crop Science Division of Indian Council of Agricultural Research, New Delhi. The establishment of the All India Coordinated Research Project on Oilseeds (AICORPO) in April 1967 based on the recommendations of a sub-committee appointed by the Government of India was the most significant event in the history of oilseeds research in India. The project had its beginning with one Project Coordinator to coordinate and monitor the research programmes of groundnut, rapeseed-mustard, sesame, linseed and castor operating at 32 research centres. Later during 1972, safflower, sunflower and niger were brought under the umbrella of AICORPO and the number of research centres increased to 40. Realizing the need for one national institute for oilseeds, the AICORPO was elevated to the status of Directorate of Oilseeds Research on August 1, 1977 with the Project Director as its administrative head and seven Project Coordinators for these oilseed crops. Subsequently, groundnut and rapeseed-mustard were delinked from the Directorate with the establishment of National Research Centre for each of these crops during 1979 and 1993, respectively. In April 2000, the AICRP on Sesame & Niger and Linseed were separated from the administrative control of DOR. Currently, DOR has the responsibility to plan, coordinate and execute the research programmes to augment the production and productivity of sunflower, safflower and castor crops in the country through the All India Coordinated Research Project (AICRP) operating at 31 locations spanning over 14 states.

Oilseeds have always received secondary importance compared to food crops in production environment and policy support. The inherent tolerance of oilseeds to drought and other edaphic stresses is construed as their low or no requirement of inputs or resources. On the contrary, oilseeds need higher inputs for increased productivity and thus need better enabling environment in input supply and management. Considering the imminent climate changes, quality of production environment is expected to be harsh for most crops in edaphic and climatic conditions.

Significant achievements in the mandate crops

- Developed world's first castor hybrid (GCH-3) under AICRP (Castor) programme and India's first safflower hybrid (DSH-129).
- Facilitated the development and release of 21 varieties and 14 hybrids in castor, 28 varieties and 5 hybrids in safflower; 18 varieties and 31 hybrids in sunflower and 84 varieties in sesame.
- Maintaining 3417, 7476, 1496 and 2700 germplasm accessions of castor, safflower, sunflower and sesame, respectively. Stable sources of resistance to major biotic stresses and quality traits were identified.
- First sterile cytoplasm of sunflower developed in India that has been assigned the International FAO Code 'ARG-6'.
- Registered 15 castor, 1 safflower and 3 sunflower germplasm lines with PGRC, NBPGR, New Delhi.
- Succeeded in genetic transformation of castor through *Agrobacterium tumefaciens*- mediated and direct gene transfer methods incorporating Bt gene for resistance to lepidopteran pests in castor. Sunflower transgenic events (T₄ generation) harbouring TSV-CP gene were developed and tested by virus challenging and found resistant to sunflower necrosis disease (SND).
- Successfully demonstrated the proof of concept of using heterologous *orfH522* gene for induction of male sterility through transformation of tobacco with male sterility induction gene cassette.
- Developed and recommended region and crop-specific remunerative cropping systems, cultural practices and nutrient management packages for maximizing the productivity on a sustainable basis.
- Registered two bio-pesticides *viz.*, DOR Bt-1 (KNOCK) to control lepidopteran pests and DOR *Trichoderma viride* B-16 (TRIVIR) to control soil borne diseases in castor, pigeonpea, chilli and groundnut with the Central Insecticides Board and commercialized these technologies to 37 and 2 private entrepreneurs, respectively. Licensed biopesticide, *Beauveria bassiana* 30% SC to manage capitulum borer in sunflower to 3 firms.

The factor productivity of oilseeds is on a decline indicating the need for higher input supply for maintaining a steady level of production. There is also a high degree of variation in annual production of oilseeds owing to their cultivation predominantly under low and uncertain rainfall situations and input starved conditions coupled with poor crop management by a majority of small and marginal farmers. The major biotic limitations of *Botrytis* in castor and *Alternaria* leaf spot in sunflower occur due to the continuous rainy and cloudy weather conditions at flowering and cause serious crop losses. Sustainability of the enhanced oilseeds production is as important as enhancing the production.

Rainfed farming: Oilseeds and rainfed farming are synonymous as most of the annual oilseed crops are grown rainfed. The productivity of all annual oilseeds crops (except castor) is much lower than the world average due to their cultivation under predominantly dryland situations with low input management. Only 28% of area under oilseeds is irrigated and specifically for *rabi*/summer groundnut, mustard and castor in Gujarat and Rajasthan. Almost entire safflower and castor in Andhra Pradesh, *khari*f sunflower in peninsular India, are grown under rainfed conditions. Early, mid and end season droughts reduce crop yield and quality significantly. Drought proofing technologies are the urgent necessity for stable and successful oilseeds production.

Inadequate and imbalanced nutrition: Oilseeds are energy rich crops and demand higher nutrition. The general declining soil fertility for major nutrients (NPK) and increasing multi-nutrient deficiencies of secondary (especially S) and micronutrients (Zn and B) in the country are seriously affecting oilseed productivity. On a national average for all oilseed crops currently, only 52.5 kg/ha nutrients (NPK) are applied as against 140 kg/ha for rice and 160 kg/ha for wheat (Pasricha and Tandon, 1993) and the national average of 117 kg/ha (Tiwari, 2008). The high genetic potential of newer genotypes can be realized only when optimum agro-ecological conditions are provided. Low fertilizer application due to uncertain economic response to fertilizers under rainfed conditions further deteriorates the soil fertility under favourable rainfall distribution wherein better crop growth and yield remove larger amount of nutrients and this further aggravates the problem of soil fertility and balance. Availability and use of organic manures is very low or disappearing for oilseeds cultivation leading to a higher degree of risk to drought, holistic crop nutrition and soil fertility maintenance. The low fertilizer use efficiency of major and secondary nutrients as well as the micronutrients is a continuing challenge that needs improvement across crops and cropping systems.

Emergence of agri-business: Oilseeds, unlike other food crops depend on other enterprises for its ultimate purpose of consumption. The necessity of extraction of oil from seeds provide inter-dependence of industry and oilseed producers in between consumers, thus making success in vegetable oil production business inter-dependent and affected in variations under each stage of production, processing and pricing policies.

The edible oil industry is largely dominated by the bulk segment which creates an opportunity for the Agri-Business sector. The unbranded segment accounts for anywhere between 80 and 90% of the total consumption which can be targeted for better value addition and thus, minimize the health hazards that otherwise occur on account of adulteration of edible oils. The share of raw oil, refined oil and vanaspati in the total edible oil market is estimated at 35%, 55% and 10%, respectively. The former group is a viable Agri-Business venture. The shift in consumer preference for branded edible oils has resulted in the corporates targeting the packaged edible oil segment in the last few years. India's *per capita* income grew 10.5% from ₹40,141 in 2008-09 to ₹44,345 in 2009-10 while adding 20 million people annually at a growth of 1.4% to its population. The Indian middle-class population is expected to touch one billion over the next two decades. About 55% of the world's middle class will be in Asia by 2030, up from 25%. This middle class would be a large consumer of edible oils in the country. Further, the urban population in the country is increasing by more than 3% annually. The report by McKinsey Global Institute (2010) predicts that 590 million people or 40% of India's population will live in cities by 2030, up from 340 million today. This would have a tremendous effect on increased consumption of edible oils looking down to the social status and the size of the strata to the total population in the country. Higher economic growth and concomitant rise in incomes, coupled with change in tastes and preferences in both urban and rural areas are translating into higher demand for high-value commodities especially, the edible oils.

The recent shift in the consumption pattern of edible oils for blended / designer oils is on the rise primarily due to increasing awareness about the quality consciousness. This is an opportunity for increased agri-business opportunity for enhancing the volume of branded oils. This would cascade and gradually erode the availability of adulterated oils. The blending technology in the country is in the nascent stage and it is of paramount importance at this juncture that technology for developing blends through **“Joint Venture”**.

The value addition of oilseeds is a virgin area and has to be explored in a big way. The opportunities of value addition as a business activity exists on a

wide range to meet the energy sector, pharmaceutical including medicinal, nutraceutical, industrial and other sectors. The grey areas of Public-Private People Partnership can be exploited to the advantage of the Indian oilseed economy.

Targets for XII Plan

- Trait specific germplasm for SND, *Alternaria*, powdery mildew, high oleic content and high oil types in sunflower; capsule borer, reniform nematode and drought, sources for high oil, high ricinoleic, low ricin in castor and *Alternaria*, aphids and high oil in safflower; phyllody and *Antigastra* in sesame.
- Hybrids for high seed and oil yield coupled with tolerance to SND, powdery mildew and *Alternaria* in sunflower; capsule borer and wilt complex in castor and CMS based hybrids with resistance to wilt in safflower and CMS based hybrids in sesame and improved oil quality for diversified uses.
- Development of genomic resources, constitution of frame work linkage maps and development of appropriate mapping population for mapping genes for major biotic stresses and WUE traits in castor, safflower and sunflower and transgenics for SND in sunflower.
- Cloning and characterization of genes involved in sex phenotype of castor, oil biosynthesis in safflower.
- Increasing resource (nutrient/ water) use efficiency in oilseed-based cropping systems and reducing cost of cultivation.
- Mitigation strategies for climate change including conservation agricultural practices.
- Bio-intensive integrated pest management packages for major biotic stresses such as necrosis, *Alternaria* leaf spot and head borer in sunflower; wilt, *Botrytis* and capsule borer in castor; *Alternaria* leaf spot, wilt and aphids in safflower; *Antigastra*, phyllody and *Macrophomina* in sesame.
- Oil quality improvement for diversified uses.
- Knowledge management and other effective mechanisms for access to stakeholders.
- Participatory strategies involving farmers, seed and processing industries to accelerate dissemination of improved technologies.

Flagship Project: Multipronged/multidisciplinary approaches to ameliorate yield losses caused by grey-mold in castor.

Opportunities and Strategies

The futuristic demand for vegetable oils has thrown a challenge as well as an opportunity to the oilseed researchers and development agencies. The improvement on the productivity front to meet the target demand is the need of the hour which has to be done with the existing agricultural scenario in the country, such as, limited scope of increase in oilseeds acreage, changes in rainfall pattern and associated climatic changes, depletion of soil nutrients and emergence of new pests.

Harnessing science

The Directorate of Oilseeds Research would strive to harness the power of science for increasing productivity, enhancing input-use efficiency, reducing cultivation costs and post-harvest losses, minimizing risks and improving quality of oilseeds and its products through conventional and new scientific approaches and tools. The Directorate would evolve mechanisms for accelerating innovations through institutional and policy support. It would also devise appropriate strategies to realize diverse interests of different stakeholders in the oilseed supply chain.

Potential of genetic resource enhancement

Till date, the gains in productivity of oilseed crops have been achieved primarily through exploitation of the genetic variability existing in the cultivar germplasm. Conventional breeding coupled with modern tools will be the primary focus in genetic improvement programmes aimed at enhancing the productivity *per se* as well as in introgressing tolerance to biotic and abiotic stresses from donor germplasm lines. To facilitate better exploitation of the available gene pools and overcome the production constraints, research emphasis will be on (i) augmentation of trait specific germplasm; (ii) prebreeding and genetic enhancement; (iii) allele mining; (iv) functional genomics, proteomics, metabolomics, and interactomics; (v) marker assisted breeding and gene pyramiding; (vi) input and output trait improvement through genetic engineering.

Power of biotechnology

The two main options of biotechnological approaches for crop improvement include molecular marker based selection and transgene manipulations. Both these approaches, though not mutually exclusive, have distinct niches with respect to their role in crop improvement. At present, biotechnological research on minor oilseed crops (safflower, castor, niger, sesame, linseed and sunflower) is scattered and is in its infancy. Therefore, concerted and focused efforts are essential to take mileage from the tools of biotechnology and genetic engineering in these crops. Some of the crop-specific key concerns that could be addressed through biotechnological interventions include pests like bud fly in linseed; *Antigastra* and phyllody in sesame; necrosis, leaf spot and powdery mildew in sunflower; wilt and *Alternaria* in safflower; *Botrytis* and lepidopteran pests in castor; quality aspects such as presence of anti-nutritional compounds (oxalic acid and phytates) in sesame; toxic proteins (ricin and *Ricinus communis* agglutinin) in castor. Apart from these crop-specific issues, there are research areas of generic nature such as, abiotic stress tolerance, increased oil content, altered fatty acid profiles to suit different industrial and human consumption requirements that could be applied across oilseed crops. Identification and validation of genes involved in metabolic processes through functional genomics approaches shall be an important area to be explored. Understanding the molecular basis of trait manifestations such as stress tolerance, oil accumulation, etc and interactions among different metabolic pathways under varied environmental conditions and crop growth, as enumerated in different crops, are expected to pave way for developing designer oilseed crops to meet both domestic and industrial requirements. Advent of several 'omics' throughput platforms are expected to be harnessed in the oilseed crops to answer a myriad basic questions that would pave way for holistic and precise improvement of these crops.

Transgenic research: With the advent of genetic engineering techniques, the phylogenetic barriers for transfer of useful genes across organisms have been removed. The main prerequisite for exploiting the power of transgenic technology is developing efficient and preferably genotype independent, transformation protocols. Modifying the fatty acid profile of the oil to suit industrial, pharmaceutical, nutritional, cosmetological requirements using

genetic engineering approaches should assume priority in oilseed crops. Similarly, imparting biotic and abiotic stress tolerance, improved resource use efficiencies through transgenic approaches should be of greater importance to bring in sustained productivity levels under changing as well as challenged environmental situations. Identification of key genetic regulators of metabolic processes is expected to provide a better chance for manipulating the phenotype of plants through transgenic approach.



Transformation protocol in sunflower

On the technology front, concerted efforts are being made to develop methods and strategies to have the transgene(s) inserted in targeted regions of the genome to avoid positional effects as well as insertional inactivation of unintended genes. Also, it is envisaged that technologies for cisgenesis, intragenesis, gene-stacking, marker-free transgenesis, zinc-finger nucleases, RNA dependent DNA methylation, etc being perfected in model crops could be exploited in oilseed crops.

Molecular marker based research: Genomic resources (markers/maps/genes/alleles) in the mandated oilseed crops are scanty and developing these resources will be a priority. Cost effective and highly efficient next generation sequencing (NGS) technologies would also be used to accelerate the development of genomic resources in castor and safflower with limited investment. Also, these resources would be used to map the quantitative trait loci (QTLs) controlling important traits like biotic and abiotic stress tolerance and seed quality. NGS coupled with the availability of a reference genome sequence of castor, would pave the way for 'genotyping-by-sequencing' platforms and more importantly, producing aligned genomic sequence of global germplasm collections that would overcome the inherent limitations of 'candidate-gene' approaches. The useful alleles and genes would be mined using NGS approaches, especially the proposed third generation sequencing technologies. Plant selection based solely on whole-genome genotypes will aid to significantly increase genetic gains per unit of time. Genome-wide association studies (GWAS)

based on linkage disequilibrium (LD) provide a promising tool for the detection and fine mapping of QTLs underlying complex agronomic traits. GWAS coupled with phenomics, would be used more effectively in oilseed crops to establish association of genotypic variability with phenotypic data.

Synergies of frontier sciences

Significant innovations in other frontier sciences such as nano-science; space science; mechanization and robotics; energy sources development and management; material and mineral science; synthetic lipid science and technology; food science, health and fitness; information science and modeling, simulation and forecasting; silicon technology; earth and atmospheric sciences; hydroponics, vertical farming and protected agriculture; precision agriculture systems; sensors and automation; storage, seed and plant health; biological diversity, crop modification and potential including newer species of crops and pests, etc., provide unlimited opportunities for supporting higher production and product development to meet the changing requirements of the humanity with precision and protection/conservation. Post production, developments in dynamic integration of production, processing, quality with global trade would make vegetable oils production profitable and competitive. Oilseeds research will also take benefit of innovations in industrial sector for oilseeds' processing and small farm mechanization, and *ex-ante* approaches for quantification of economic output. These frontier sciences and techniques would be integrated in the ongoing and future oilseed research programmes for improvement of productivity; resources use efficiency, processing, value addition, diversified uses, better targeting of technologies and also identifying production and marketing environments which includes supply chain mechanism. The traditional knowledge will be valued for its wisdom and timeliness for technology generation and refinement.

Management of natural resources

With the current practices of crop cultivation under sub-optimal management especially of nutrition, significant soil nutrient mining is occurring leading to vast hidden hunger situation in most crops. Correcting the present limitation with proper diagnosis is the urgent short term goal

that not only gives rich immediate dividends through reaping highest marginal rate of returns but also provides a sound footing for addressing the future issues of sustainability.

Declining *per capita* arable land and extending oilseeds cultivation to poor and marginal soils result in low productivity besides higher investments through input use. Productivity of oilseed crops is limited owing to their cultivation under rainfed conditions with currently only 28% of area under irrigation. Water requirement for irrigation is the key for stable higher production. With dwindling water resources both in quantity and quality, water for irrigation will be expensive and face severe competition from different enterprises within agriculture sector. Castor in Gujarat and Rajasthan is cultivated under irrigation while in Andhra Pradesh it is mainly cultivated under rainfed condition. Safflower cultivation is limited to Vertisols and *rabi* season under receding soil moisture conditions. Sunflower is cultivated in all seasons and soil types. Forty percent of area under sunflower during *khariif* is rainfed. The soil fertility in such areas in general is low and deteriorating due to inadequate and imbalanced fertilization of crops, reduced use of organic manures, intensive cultivation with high yielding varieties/hybrids of crops, etc., leading to nutrient mining and soil quality exhaustion and a decline in factor productivity. Watershed management with appropriate rainwater harvesting both *in situ* with proper disposal and storage farm ponds provides excellent opportunity to mitigate the expected dual problems of long droughts and floods with advantage. Site specific land configuration and management for effective soil and moisture conservation and its economic use can operationalize the mitigation strategy. Enhancing drought tolerance of oilseed crops is a priority with associated practices to improve profitability through achieving 'more crop (oil) per drop' of water to stand competition and preference.

Global nutrient supply through fertilizers is limited and the demand – supply gap will be widened or become wide. Fertilizer will be costly and the reserves are finite, besides dependence on externalities. The nutrient use efficiency is low and thus, the investments are not remunerative due to the inevitable losses. Improving nutrient use efficiency of fertilizers through better product development and method of application is a priority for

achieving profitable oilseeds production. Improving soil fertility to reduce external applications is achievable through site specific nutrient management. Exploiting nutrient interactions as per the soil test and crop response results in higher efficiency and reduced cost. Organic manures are central in the integrated nutrient management (INM) of oilseeds under rainfed situation along with other components such as, secondary and micronutrients, bio-inoculants, crop residues, etc. Soil biota holds the key in managing sustainable soil and crop quality. Bio-fertilizers have opportunity as components of INM especially to reduce fertilizer use both under rainfed and irrigated conditions. Fertilizer management on a cropping system basis leads to holistic nutrient supply with economy in fertilizer use. Precision crop management with conservation agricultural practices and customized fertilizer application schedules would usher higher efficiency and profitability. Application of fertilizers also imparts drought tolerance by way of better plant establishment, canopy coverage and yield. Fertilizer application under the opportunity of using harvested rain water will provide benefits in terms of increased crop yield, water and factor productivity. Profitability of oilseed crops shows highest response to limited irrigation.

Absence of monetary quantification of environmental and ecosystem services is resulting in their indiscriminate use and choking of buffering capacity leading to a point of no return and is a catastrophic future. Replacing the environmental resources that are being consumed at a faster rate with public volunteerism, enabling policies and investments in mitigation strategies is the need of the hour and much emphasis for future for the very survival of humanity. Regulation of every input use (water, nutrient, energy, etc.) in agriculture is to be regulated with suitable green accounting and costing.

Diversification and value addition

Profitability of oilseeds solely from the primary product of seed and oil will not be sustainable. Besides the primary product oil, oilseed crops provide immense scope for diversified uses with high value specialty products and derivatives. Major opportunities for oilseed crop diversification and value addition include catch crop in paddy fallows to utilize residual moisture and fertility; component crop in major wide spaced field crops such as

pigeonpea, cotton, maize, etc. for sunflower; and as main crop with groundnut, soybean, finger millet, pigeonpea, cluster bean, short duration pulses, etc. for castor and sunflower; with chickpea and coriander for safflower; *rabi* castor under limited irrigation protection and sunflower for Indo-Gangetic plains of Punjab, Haryana, Western Uttar Pradesh in spring and Bihar, Odisha and West Bengal in *rabi*/summer.

From the point of view of vegetable oil consumption either for edible or for fuel purpose, the situation is envisaged towards valuing oil for its intrinsic value for calorie or for desired fatty acid that is beyond the realm of individual crop as perceived now. Designer oils with requisite blends can meet the expectation and to that extent individual oilseed crop's potential would be seen for the yield of oil or the desired fatty acid and not as oil from specific crop. Thus, the present wide diversity of oilseeds crops may narrow down to a few high oil yielding crops. As for unique non-oil value aspects for specific aroma or non-oil uses (medicinal, ornamental or other uses), individual oilseed crops would be grown for specialty purposes irrespective of their productivity level.

The existing form for majority of vegetable oils processed and produced in the country does not include the components of value addition thus, depriving the potential exchequer considering the huge demand potential for higher order value addition of vegetable oils.

Considering the paradigm changes of consumer behavior, there exists immense potential for inclusive value addition of edible oils with the Directorate to play a major role as a change agent by triggering the change for value addition through PPP to make it more sustainable and vibrant.

Quality and diversified uses

Sunflower in India is mainly used for high quality edible oil and the demand is increasing due to increasing health consciousness among population. Apiary associated with sunflower production is a bonus for win-win situation for sunflower production. In developed economies, sunflower is finding many economical uses beyond oil for culinary purpose. High oleic sunflower is in great demand both for specialty edible uses and for development of biodegradable products. Designer fatty acid profiles of sunflower oils are made possible. Sunflower for development of insulin and

tocopherols (alpha, beta and gamma) is a new area for pursuit. Apart from oil, sunflower seed is being considered as 'functional food' that provides benefit beyond basic nutrition. Sunflower biomass is also finding use in gasifiers for generation of energy. The thalamus after seed separation is a good source of feed supplement with high protein and dietary fibre which can reduce feed shortages in the country. 'Sunflower butter' is a safer alternative to peanut butter. Confectionary sunflower has big market in the USA, China and Europe. Sunflower as bird feed is in high demand in Europe and all the sub-standard seeds for oil are utilized as bird feed. Sunflower can make quality silage when harvested under aberrant weather conditions at seed setting and filling. The stalks form a good component of INM as source of nutrients. Sunflower stalk has value in making particle boards. Sunflower for cut flower industry is a big business in Mexico and Europe. Other uses such as source of rubber, oil as biofuel, epoxy resins, surfactants, pigments from petals for vegetable dye, etc. provide greater opportunity for higher growth of sunflower crop in future.

Safflower has highly valued edible oil. Genetic engineering techniques would be commercially exploited and used for recombinant protein production and metabolic engineering. This offers a great opportunity for exploiting safflower transgenic system on industry scale. The use of safflower petals for herbal medicine/tea is growing as pharmaceutical value and thus, safflower has become a dual purpose crop.



Safflower diversity for dyes

Besides, petals as a source of vegetable dye are competing. Young plants of safflower after thinning are used as vegetable in traditional areas. The biomass of safflower in early stages forms good quality silage.

Castor oil and its derivatives (of different classes) have been used immensely in many industrial applications dominated by lubrication oils followed by pharmaceutical and cosmetic uses. With growing energy crisis of fossil fuels, castor oil though has highest viscosity, is also a strong contender for conversion into biodiesel. The plant biomass has use in gasifiers for generation of energy. Castor oil is also being modified to use in paints, coatings and specialty nylons, polymers, etc. Castor plant is the only

source of eri-silk production, and its demand is on a rise. Thus, the dual purpose castor has bright future especially at times of *Botrytis* occurrence wherein the foliage can be profitably used for eri-silk production. Managing excess sink in the currently available genotypes and development of dual purpose genotypes for eri-silk would be profitable opportunity for preference of the crop and growth of cottage industries.

Risk management

Oilseeds production is constrained by several biotic stresses like insect pests and diseases that are being further aggravated by changing climatic conditions. *Botrytis*, root rot and capsule borer have emerged as major threats to castor production. Sunflower production is limited by diseases like *Alternaria* leaf blight, sunflower necrosis, downy mildew and powdery



Screening for castor *Botrytis*

mildew while mealy bug is an emerging pest. The foliar diseases *Alternaria* and *Cercospora* leaf spots and *Macrophomina* root rot are becoming increasingly important while wilt and aphid continue to challenge safflower production. *Antigastra*, *Macrophomina*

and phyllody are major limitations for profitable cultivation of sesame. Global warming induced climate change is expected to trigger major changes in population dynamics of pests, their biotypes, activity and abundance of natural enemies and efficacy of crop protection technologies. Studies on the epidemiology of plant diseases including variation in pathogen population in the light of climatic change are the key for development of integrated disease management (IDM) modules for emerging pests. Etiology of reniform nematode in castor and sunflower and root knot nematode in sunflower coupled with identification of sources of resistance for including in integrated pest management (IPM) modules deserve attention. There is a need to generate information on the likely effects of climate change on pests so as to develop robust technologies that will be effective. Pest behaviour studies on transgenics are crucial considering the prospects of their inclusion in IPM modules.

The approach to pest management has seen a significant change over the years from chemical control to IPM with emphasis currently on bio-intensive integrated pest management (BIPM) involving use of pest-resistant varieties, bio-agents, bio-pesticides and natural products like botanical pesticides and pheromones. Several eco-friendly products of biological origin have been



***Beauveria bassiana* 30% SC formulation - A Biopesticide**

developed at the Directorate for management of important pests of oilseed crops like castor semilooper, sunflower head borer, tobacco caterpillar as well as wilt of castor and safflower. However, the relative efficacy of many of these pest control measures is likely to change as a result of global warming necessitating identification of temperature tolerant strains.

Institutions and policies

The major area of concern is the disposal of the produce by the farmer. Asymmetry in information, poor bargaining power, forced sales, low marketable surplus at farmer level are some factors that result in low or no capital formation. This is an outcome of the failure of the existing delivery mechanisms despite having a network of institutions. The institutions are not equipped to address the problems of transaction costs, perception of risk and absorption capacity of the farmers. Technological and innovative bodies that can play a pivotal role in addressing the socio-economic problems confronted in the production of oilseeds are to be created and strengthened. Further, these institutions should play advisory role to the policy and developmental agencies and serve as linkage between farmers and different stakeholders to exploit the emerging opportunities at the national and global level leading to a vibrant economy with a healthy trade balance.

Human resource development and knowledge integration

Upgrading the quality and skills of human resource is a focal point for planning and implementation of appropriate research programmes which

have a direct bearing on the production of oilseeds by way of developing appropriate technologies, creating novel ideas for technology adoption and assessment and to tackle the impediments on the oilseeds front. Enhancing the professionalism and state of art of technology to meet the challenge of global competitiveness in the field of value addition of oilseeds is the need of the hour. The enormous opportunities in the Agri-business sector of oilseeds calls for quality improvement in the agricultural education system that can cater to the IPR and sanitary and phytosanitary sectors. The vertical integration of knowledge base of all the stakeholders involved in the value chain of oilseeds is to be stepped up through development of oilseeds' knowledge portal for enhancing the global competitiveness of the Indian oilseed sector.

Technology transfer systems

Concerted efforts are required for developing and disseminating the technologies. New approaches on a participatory mode are to be strengthened for effective delivery mechanism by show-casing the potential technologies/products. The Farmer-Institution-Industry linkage mechanism should be strengthened besides the existing formal delivery mechanisms so that, the gap between the potentially attainable yield and the yield realized on the farmers' fields is reduced and it makes the industry more vibrant and profitable on account of assured quality supply, reduced supply chain, enhanced capacity utilization and increased economic surplus with benefits to both the producer and the consumer. The potential Information and Communication Technology (ICT) tools should be harnessed on a dynamic and interactive mode. This can minimize the asymmetric flow of information and provide benefits to all the stakeholders involved in oilseeds.

Strengthening stakeholder linkages

The existing formal and informal linkages would further be strengthened with farmers, international and national institutes, SAUs and other organizations involved in oilseed research and development. Opportunities for linking relevant KVKs, Project Coordinating units would be explored for further formalizing the relations. Linkages with other

important players *viz.*, seed producers, NGOs, processing industry, marketing institutions would be strengthened to visualize research results in a developmental perspective. Besides, collaboration with leading institutions dealing with cutting edge technologies will foster the utilization of frontier areas of research in improving oilseed production. Therefore, substantial fillip is needed in developing the critical human resource for adopting high-end research tools in improving marginal and neglected crops of economic importance such as oilseeds.

All inclusive direct linkage mechanism should be made perpetual between the farmer and the industry to reduce the supply chain, thereby providing a higher output price to the farmers through direct purchase.

Goals and Targets

To accomplish the Vision and to enhance the efficiency and effectiveness of the research programmes envisaged by the Directorate, the following strategies would be adopted.

Goal 1. Introduction and crop expansion in new niches

- Development of short duration varieties and hybrids in castor, photo and thermo insensitive varieties in sesame and safflower.
- Development of ideal genotypes suited for prevailing cropping systems in newer areas.
- Characterization of production environment for oilseeds with the help of GIS and satellite imageries; comparative assessment of oilseeds profitability, factor productivity and sustainability with competing crops.
- Development of agro-technology for extension of oilseeds cultivation in paddy fallows to utilize residual moisture and fertility.
- Extension of castor cultivation to non-traditional areas and for newer ecosystems.
- Facilitate linkages with industry for ensuring stable market for area expansion of sunflower in the spring season in Indo-Gangetic plains and during rabi-summer in eastern India and for safflower in Gujarat, M.P., Chhattisgarh and Odisha.
- Development of efficient and profitable intercropping and production systems involving sunflower, safflower and castor either as base crop or as component crop in the major crops of the region.
- Promoting oilseed crops as contingency crops to harness short season resources in many rainfed cropping systems.

Goal 2. Improved productivity

- Identification of germplasm resources for agro-economic traits and resistance to major abiotic and biotic stresses.
- Development of castor, safflower, sesame and sunflower hybrids/varieties for high seed and oil yield with short duration and resistance to major biotic stresses.

- Develop transgenics for resistance to *Botrytis* in castor and necrosis disease in sunflower.
- Develop molecular marker systems for critical traits to apply marker assisted selection in breeding.
- Incorporate inbuilt resistance to major biotic stresses in the improved varieties/hybrids through genetic engineering tools.
- Broaden the genetic base of the parental lines of castor, sunflower and safflower hybrids to reap the full benefit of hybrid vigour and safeguard the hybrids from vulnerability to major biotic stresses.
- Develop breeding strategies as well as biotechnological approaches for oil quality improvement.

Goal 3. Production enhancement through sustainable low input cost management practices

- Adoption of recommended soil and moisture conservation practices and development of conservation agriculture practices for oilseed based cropping systems.
- Climate resilient strategies for different agro-eco regions.
- Adequate and balanced fertilizer application especially S, B, Zn, Mo in addition to NPK.
- Site specific sustainable crop management through integrated nutrient packages on cropping system basis.
- Soil quality indexing and its assessment with minimum data sets for different agro-ecological regions.
- Develop low input cost soil fertility improvement, efficient resource management and increased input use efficiency practices.

Goal 4. Mitigate biotic stresses and climate change

- Develop forecasting and forewarning models to enable the farmers to take precautionary measures against the incidence of diseases and insect pests.
- Develop and promote eco-friendly bio-pesticides.
- Develop diagnostic tools based on pest diversity and variability.
- Identification of genotypes for terminal heat, drought and excess moisture.

Goal 5. Improve oil quality and value addition

- Reduction of ricin in castor, increase oleic acid content and develop confectionery types in sunflower and increase gamma linolenic acid content in safflower.
- Explore the possibility to develop high value products such as bio-diesel and oleo-chemicals and higher order derivatives (Nylon-11, undecylenic acid, sebacic acid, etc) from castor oil, pharmaceuticals from safflower petal, bio-fuel from crop biomass and anti-nutritional cream oil meals. Identification of efficient value chain for each of the major oilseeds.

Goal 6. Dissemination of improved technologies

- Develop knowledge portal and other effective mechanisms for knowledge dissemination to stakeholders.
- Conduct frontline demonstrations to showcase the potential of the improved technologies under real farm situations.
- Adopt ICT tools for effective dissemination of agro-technology on large scale.
- Popularize the economic value of by-products *viz.*, safflower petals, eri-culture from castor, thalamus use and apiary from sunflower for higher profitability to compete over traditional low value crops.
- The Directorate with the network of AICRPO, KVK's and NGO's should play a proactive role in bringing the industry in direct contact with the oilseed farmers. The supply chain linkage between the public and private sector needs to be strengthened on various aspects *viz.*, quality seed production, outreach of the existing technologies, research on value addition, quality and farm mechanization.
- Cluster approach initiatives from DOR for expansion path of oilseeds linking the farmers and the industry for a level playing platform considering the economies of scale in both production and processing.
- Develop participatory extension strategies involving farmers, seed producers, processing and bio-pesticide industries.
- Train identified stakeholders on improved technologies.
- Commercialization of IPR enabled technologies.

Way Forward

The priority of achieving sufficiency in vegetable oils for human and industrial needs of the country as per the projected growth is the endeavour of the Directorate through providing technological backstopping to enhance the share of its mandate oilseed crops to meet the dynamic demand of vegetable oil. The greatest challenges would be the high *per capita* demand for vegetable oils to be met under the situations of imminent climate change effects besides, the declining resources in quantity and quality. The research programmes would be strengthened and reoriented to effectively overcome the limitations for increasing oilseeds productivity and quality to ensure increased availability of vegetable oils and to improve the income generation of the farming community. Soil health and environment protection would receive due attention. The frontier scientific tools would be selectively tapped particularly to solve major biotic stresses and improving oil quality for which the traits of interest are not available in the genetic resources. With innovation and technology led increased productivity and quality, these crops would be more competitive over other crops. Further, by creating the opportunity to improve the economic output through value addition, it is envisioned for sustained growth in oilseeds sector in the country.

Pro-active efforts would be made to associate all the stakeholders with major intent of catering to the needs of majority of small and marginal farmers associated with oilseed crops through strong supply and value chain linkages. The Directorate would focus on basic and strategic research and take assistance of private partners in delivering the final product to stakeholders. The strategies of the Directorate would be reviewed and reoriented periodically based on the national and international situations.

It is envisaged that this Directorate will have higher and expanded mandate to provide effective leadership and pivotal role on issues related to oilseed research and development.

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