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Present status and future strategies for management of Brassica oilseed crop diseases

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Brassica oilseed crops have a very significant role in Indian agriculture since almost each part of the plant is consumed either by human beings or animals depending upon the crop and its growth stage. The production and productivity of these crops is limited by a number of biotic and abiotic stresses. More than twenty five diseases are known to affect the Brassica oilseed crops all over the world**.** However, diseases like Alternaria blight [*Alternaria brassicae* (Berk.) Sacc.], white rust [*Albugo candida* (Pers. ex. Lev.) Kuntze], downy mildew [*Peronospora parasitica* (Pers. ex Fr.) Fr.], powdery mildew (*Erysiphe cruciferarum* Opiz. ex. Junell) and *Sclerotinia* rot [*Sclerotinia sclerotiorum* (Lib.) de Bary] are of major consequences because of their widespread distribution in heavy intensity causing significant yield losses. During the recent past diseases scenario has been changed from minor to major because of intensive cropping. Heavy irrigation and fertilization and rapid change in environmental conditions. Lot of information has been generated on major diseases relating to geographical distribution, losses incurred, symptoms, diagnostics, disease cycle, epidemiology, resistant sources, physiological specialization and integrated disease management but still much more is required to over come the annual losses caused by these diseases in the years to come. Are we sitting at cross-roads and looking for right path? No we are not. We have clear vision and can achieve the goal as per out requirement through integration of technology available with us. However, with the dwindling human resource in the SAU's the path is difficult but not impossible. The future lies in the inter/ intra institutional network research projects for validation of research results to manage Brassica oilseed crop diseases more effectively. The areas which need in depth study are epidemiology and forecasting, host resistance including nature and mechanism, physiologic specialization using conventional and molecular tools, rapid diagnostic biotechnological techniques and integrated disease management. It has been experienced that disease management technology has very slow percolation to the end users. Rapid it is more we are sound and safe. Some future priority research areas of Brassica Plant Pathology are : standardization of host differentials and nomenclature of pathogenic races; identification of broad-spectrum sources of resistance, resistant loci and resistant genes in each locus; identification of slow blighting, slow mildewing, slow rusting, tolerant, partial resistant, strong and weak genes with suitable combinations; genetics of virulence and virulence spectrum; Mapping, cloning, characterization and identification of genes for resistance and virulence; biochemical basis and genetics of *Albugo- Peronospora* association and best use of IPM and IDM technology for integrated Brassica crops management.

Oilseed *Brassica* Research: Present Scenario and Future Strategies

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India is amongst the largest producer and consumer of vegetable oils in the World. Oilseeds have been the backbone of agricultural economy of India since long. Indian vegetable oil economy is the fourth largest in the world next to USA, China and Brazil. Oilseeds hold a premier position in the agricultural economy in India and are important next to food grains in terms of area, production and value. Soybean, rapeseed - mustard and groundnut crops are the most important source of vegetable oil in

India and these crops occupy 35.64, 24.34 and 22.34 per cent, respectively of total oilseed crops acreage in the country. The soybean, rapeseed-mustard and groundnut contributed 41.62, 24.52 and 23.43 per cent, respectively in total oilseed production in the country during 2010-11. Among different rapeseed-mustard growing states Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat and West Bengal account for about 90 % area of these crops in the country. However, the states Rajasthan, Madhya Pradesh, Haryana, Utter Pradesh, West Bengal and Gujarat contributed 52.14, 10.59,10, 23, 9.18, 6.20 and 4.10 % of total production of rapeseed-mustard during 2010-11. Haryana has achieved the highest productivity of 1869 (kg/ha) followed by Gujarat 1401 (kg/ha), Rajasthan 1211 (kg/ha) against the national productivity of 1197 (kg/ha) during 2010-11. The impressive enhancement in production and productivity has been primarily due to availability of improved rapeseed-mustard technology and its adoption, expansion in cultivated area, price support policy and institutional support. Despite all these developments, the country is still importing 40 % of the domestic oil needs. 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 living standard, about 102.3 million tons of oilseed will be required. Keeping in view the future requirements, the current contribution of about 7 million tons rapeseed-mustard need to be increased about 16.4-20.5 million tons. The Chaudhary Charan Singh Agricultural University, Hisar, is the lead center of All India Coordinated Rapeseed-Mustard Research Improvement Programme since, 1967. The center has released a number of promising varieties and developed suitable production and protection technologies for achieving the higher yield and sustainability in the state. The concerted efforts of the team research and technology transfer have given the new life particularly to the farmers of southern Haryana where the mustard crop has attained the status of life line in *rabi* season. Since, there is no crop other than mustard which can be grown successfully with highest returns on an area of about 5 lakh hectare. Therefore, the present paper reviews the research scenario and future strategies for further improvement.

Managing abiotic stresses in Oilseeds *Brassicas*

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In general drought, salt, heat and frost are the chief abiotic stresses, determining productivity of oilseed *Brassicas*. Management of these stresses is therefore, paramount in realization of full potential of *Brassicas*. Several approaches are available to combat the adverse effects of the same. Mechanical approaches for example, being energy intensive, costly, and cumbersome, therefore show little acceptance. On the other hand, seed based technology representing genetic tolerance and improved WUE have greater acceptability. Flowering to pod formation stage is understood more prone to drought and frost; whereas seedling emergence being more prone to salt adversity; and atmospheric temperature more than 30°C may prove quite fetal to seedlings leading to considerable mortality of germinating seedlings. Early maturing *Brassica* cultivars may prove useful in realization of high seed yield potential in low rainfall regions. Use of anti-transpirants (PMA, Kaolin etc.), spray of growth hormones (Phosphon-D, Succinic acid etc.) have proved useful in drought amelioration approaches. Adequate supply of P and Zn nutrients, operating in synergistic manner are crucial for dry lands. Supplementary irrigation at pod formation stage and sprinkler system of irrigation have proved economic and help increased yield on dry lands. Salinity is tackled by many approaches: use of tolerant genotypes, reclamation of such soils, and frequent watering with less quantity and increased fertilization status. In Indian context *juncea* with shorter growth period and low water requirement is considered better salt tolerant than long duration *napus* and *carinata* sp. Salt tolerant varieties DIRA-337, CS-52, NDR-8501, P-5/80 etc. of *juncea* are available for cultivation. On moderate to highly sodic situations (> 40 ESP and pH 9.5). *Brassica* crops may not be recommended without required reclamation measures. Use of fine grade (85% passing through 100 mm sieve) and gypsum to the extent of 12-15 t ha^{-1} are required on worst affected soils (pH 9.5). For saline soils leaching with 25% more water than evapotranspiration is required. Mulching which may improve soil structure, water conservation and microbial properties, has proved quite effective. Drip system of irrigation or the substitution of saline water to good quality water and cyclic use of water have been very effective approaches avoiding accumulation of salts in effective root zone. Long or short duration varieties may escape frost injury. Smoking/smudging, irrigation, chemical sprays (Dithan Z-78, Gibberellic acid, Ethephon etc.) have been found effective in lowering the adverse effects of frost. High concentration of free proline, amino acid in pollen grains than anther wall before 5-7 days of anthesis may indicate heat tolerance potential of a variety. Moreover, the varieties having longer and thicker leaves with thicker palisade tissues, more number of leaves per plant with taller stature, hairy and waxy leaves are known heat tolerant. CS-54, PCR-7, NDR-8501 and JN-31strains have shown promising performance to high temperature at seedlings emergence stage. Pre-hardening treatments following restoration of turgidity may lead to tolerate these stresses against higher intensity of stresses than given during pre-treatment. Still there are many approaches leading to biotechnological interventions and transferring stress tolerant genes in an otherwise appropriate leading and ruling varieties in *Brassicae* are on the card and glaring examples are available.

Impact of climate change on pests and diseases of Oilseeds Brassica-the scenario unfolding India

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Effect of climate change on agriculture or more precisely on insect pests and diseases of agricultural crops is multidimensional. Magnitude of this impact could vary with the type of species and their growth patterns. The elevated production could be off-set partly or entirely by the insect pest or pathogens. It is, therefore, important to consider all the biotic components under the changing pattern of climate. World over research on effect of climate change on pests and diseases of crops is inadequate. It is being opined that climate change could lead to a changed profile (variants) of pathogen, insect-pest with future climates activating 'sleeper' pathogens', whilst others may cease to be of economic importance. Several diseases and insect-pests have been noted to be showing higher level of infestation on Oilseeds Brassicas in India, which have been discussed. Root rot is an emerging threat for rapeseed-mustard production system, recently reported from the farmers' field in some pockets of the country. Some isolates of *Alternaria brassicae* sporulated at 35^{o}C and several isolates had increased fecundity under higher RH, it seems that as per recent changes towards warmer and humid winters, being in line with current projections for future climate change, existence of such isolates could pose more danger to the oilseed Brassicas due to Alternaria blight in times to come. Bihar hairy caterpillar (*Spilarctia obliqua*) surprisingly on mustard has been noted to be on the rise. In view of changing climate, the devised and to-be-born models need to be oriented to dynamic mode. The models already developed are based on some observations on meteorological parameters, insect-pests, diseases recorded in the past and hence are based on previous pest-weather correlation. However, with change in climate, the pest-weather relationship is also bound to change apart from behaviour of the hosts, newer varieties, cropping practices, etc. Dynamic models incorporate the recorded data of each crop season for a particular pest to suitably revise itself and thus remain stable, relevant enough to continue providing accurate forecast. The article also looks at different strategies to cope with effects of climate change on insect-pests and diseases of rapeseed-mustard crops with a proposal for *Integrated Decision Support System (IDSS) for Crop Protection Services* that suggests the operational focus, research priorities and aspects of capacity building.

Genetic management of major abiotic stresses in rapeseed-mustard

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Rapeseed-mustard group of crops 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. The productivity of these crops is greatly influenced by abiotic stresses such as drought, salinity, frost and heat. Water stress causes heavy yield losses in Indian mustard (17-94%). Drought reduces yield levels by affecting plant growth which is a genetic character. N2 assimilatory enzyme activity, plant water relation, root depth, leaf area index, crop growth rate, total dry matter , harvest index, partitioning coefficient, translocates assimilation etc. have also been greatly affected by drought. Mustard genotypes having drought tolerant traits performed better under water stress conditions in comparison to genotypes without such traits. Seed yield is a complex character and largely dependent upon component traits which are quantitative in nature and influenced by environment such as branches /plant, seeds/siliqua, siliqua length, main shoot length and 1000 seed weight. Breeding for drought tolerance, involves screening of high yielding and drought tolerant lines, separately and hybridizing them, selecting drought tolerant lines in drought conditions and predicting yields in targeted environments. Creation of drought conditions and appropriate drought tolerance parameters/ methodologies are required for success of drought breeding. Terminal drought also causes heavy yield losses due to soil moisture depletion and increased transpiration ending in forced maturity, shriveled grain and poor harvest. Thus, escape mechanism leading to early flowering and partitioning of dry matter towards sink can be a practical approach for drought. Many drought tolerant varieties have been bred for cultivation in rain fed areas using high seed yield and other key characters as selection parameters. High temperature is second most important stress for realization of optimum growth, and economic produce of rapeseed mustard. *Brassica* species are known heat susceptible particularly at seedling emergence. Breeding for heat tolerance requires evaluation of germplasm under high temperature at seedling and terminal stage and use of these donors in hybridization programme. Under AICRP RM many useful potential donors have been identified on the basis of multi location testing. Two genetic stocks BPR 541-4 and BPR 543-2 have been registered for high temperature tolerance at terminal and seedling stage respectively. Many varieties viz; Kanti, Pusa Agrani, RGN 13, Urvashi and NRCDR-02 have also been developed having thermo tolerance at seedling stage. High temperature at terminal stage causes pre mature ripening of crop and causes heavy reductions in yield. Breeding programme involves evaluation and selection under late sown conditions. Several varieties such as Ashirwad, Vardan, Navgold, RGN 145, NRCHB 101 CS 56, and Pusa mustard 26 of Indian mustard have been released for late sown conditions. Rapeseed mustard group of crops is substantially grown on salt affected areas. The yield of these crops is drastically reduced through reduced germination, yield components, hampered physiological functions. Amphi tetraploids (*B. napus, B. carinata* and *B. juncea*) species are better salt tolerant over the diploid species viz., *B. campestris, B. nigra, B. tournifortii* and *B. oleracea* in terms of growth and yield. Evaluation of crop plants for tolerance to salinity becomes very difficult. Tolerance level is characterized by screening in pot filled with soil of 12-15 ds/m on the basis of percent seedling emergence and dry weight. Under AICRP RM, BPR-540-6, BPR 541-4, RH 88816 and RH 8814 were identified for salinity tolerance. Three varieties CS-52, CS-54 and Narendra Rai-1 have been developed for saline areas. Frost is a problem of regular occurrence in north-western India, from mid December to late January. Some time it causes considerable yield losses up to 75%. Some genotypes such as Prakash, RH 7868 developed by CCS Haryana Agricultural University showed fairly a high tolerance to frost. Tolerance to frost is determined by number of killed / undeveloped seeds on exposure to low temperature. Some varieties RH 781 RGN 13, RGN 48, RH 819 have good tolerance to frost. The present paper reviews the status of research progress and also suggests future strategies.

Genetic transformation in oilseed *Brassicas*

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Brassica is the most economically important genus in the cruciferae family, remarkable for containing agricultural and horticultural crops than any other genus. It includes over 30 wild species, their cultivars and hybrids including six most important species of *Brassicas, Brassica campestris, B. juncea, B. carinata* & *B. napus* which are oil yielding species. Due to their agricultural importance, *Brassicas* have been the subject of much scientific interest and considerable progress has been made in *Brassica* biotechnology. The molecular breeding and transformation technology for the introduction of desirable traits are two main strategies for its improvement. Several genes of agronomic importance have been identified in *Brassica* species and other identified genes have been transferred in *Brassica* species. Plant regeneration, transformation methods and gene of interest are the main requirements for gene transfer in any crop. Regeneration has been optimized via organogenesis and somatic embryogenesis using various explants. Transformation systems have been developed in almost all the economically important species of *Brassica* such as *B. juncea*, *B. napus*, *B. rapa*, *B. oleracea*, *B. nigra*, and *B. carinata*. Transformation has improved *Brassica* species for many traits, such as herbicide resistance, insect resistance, salt tolerance, oil quality improvement, for the production of pharmacological and industrial products, development of male-sterile lines and restoration system. Among different methods of transformation, *Agrobacterium* mediated genetic transformation is most widely used for *Brassica* and it is generally quite efficient and practical for most species in the genus. However, there is still a need for development of efficient transformation methods to overcome genotype dependency. In the present paper, the work on genetic transformation in the *Brassica* species will be reviewed.

Broadening genetic diversity for breeding high value oilseed *Brassica* cultivars using conventional and molecular approaches

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Quality improvement is the second most important objective, after yield, for any crop breeding programme. Oleiferous Brassicas have two bi-products viz. oil and seed meal cake. The oil is predominantly consumed as edible oil and the defatted seed meal cake is utilized as animal/ poultry feed. When compared to other edible oils, the *Brassica* oil has the lowest amount of harmful saturated fatty acids. It contains nutritionally desirable oleic acid along with two essential fatty acids viz. linoleic and linolenic, not present in many other edible oils. However, the presence of higher concentration of undesirable long chain fatty acids like erucic acid (~40-50%) and eicosenoic acid (~10%) makes the oil inferior to other vegetable oils as it has a few adverse effects on human health. Deoiled seed meal cake is a rich source of proteins and minerals to the animals and poultry with a well balanced amino acids and vitamin E. It has been considered necessary by many countries to put a statutory limit on the intake of erucic acid and glucosinolates. Thus, the presence of high amounts of erucic acid in seed oil (40-50%) and high glucosinolates (80-160 micromoles/g defatted cake) in seed meal cake restricts the global utilization of Indian mustard oil and cake. The aim in case of rapeseed mustard should be to have low erucic acid and glucosinolate contents in the genotypes. Lowering erucic acid in turn increases oleic acid, nutritionally desirable fatty acid and a pre-requisite for longer shelf life of the oil. Genetic variability for the desirable oil quality traits, which is the prerequisite for its successful introgression in any suitable genetic background, was discovered in Polish summer rape (*B. napus*) cultivar, Bronowski, having a very low level of glucosinolates (12ì mol/g defatted dry matter). This provided the impetus to the attempts for the genetic elimination of potentially toxic glucosinolates from rapeseed meal. Further selection in this cultivar led to breeding lines containing only traces of glucosinolates. The zero erucic/ low eicosenoic acid components of two genotypes designated as ZEM-1 and ZEM-2 and were used widely by mustard breeders around the world, including those in Canada, China, India, USSR and UK. The Genetic variability was available for erucic acid and glucosinolate content in oilseed *Brassicas*, but present in agronomically inadaptable or unsuitable indigenous and exotic material.

Since high erucic acid and glucosinolate contents are governed by dominant genes, the dominant alleles need to be knocked out from the otherwise desirable genetic background to develop '0'(<1.5% erucic acid or <30 micromol/g glucosinolate in defatted dry matter) and '00'(<2% erucic acid and <30 micromol/g glucosinolate in defatted dry matter) varieties. The rapeseed mustard varieties fulfilling both the requirements of low erucic (<1.5 %) and low glucosinolate (<30 micro moles of defatted cake) are called as double zero ("00") and **Canola** is a registered name given to "00" varieties by the Western Canadian Oilseed Crushers' Association. Seed glucosinolate content is a complex quantitative trait, meaning thereby that the introgression of novel germplasm from the gene pool requires recurrent backcrossing to avoid linkage drag for high glucosinolate content. Glucosinolates are controlled by maternal genotypes and are governed by at least four recessive genes. Since both erucic acid and glucosinolates are inherited independently, a large segregating population needs to be screened. A lack of precise and efficient screening techniques is a strong bottleneck in selection towards double zero seed quality. Molecular markers for low glucosinolate alleles could potentially improve the selection process. Marker assisted screening against a range of canola and mustard quality *B. juncea* was found to be widely applicable. Earlier report of fine mapping of six glucosinolate QTLs involved with glucosinolate biosynthesis in oilseed mustard using candidate gene approach has shown three '**A'** genome QTLs as the most important loci for breeding for low glucosinolate *B. juncea*. Likewise markers linked to the target erucic acid genes are already available. Marker Assisted Backcross Breeding (MABB) using gene based molecular markers holds promise to precisely transfer these traits by identifying the gene(s) without looking at its expression in the individuals of segregating population.

Genetic improvement of Indian mustard *Brassica juncea* for seed yield and oilseed quality through conventional and biotechnological approaches

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Centre for Genetic manipulation of Crop Plants of University of Delhi is actively involved in genetic improvement of oilseed mustard *B. juncea* through the use of conventional and biotechnological approaches. The lab is mainly concentrating on two major objectives: (1) Enhancement of productivity through development of hybrids and (2) improvement of oil and meal quality through development of canola quality mustard. For large scale production of hybrid seeds in mustard a novel CMS/restorer system has been developed in the lab which could be used for large scale production of hybrid seeds. The most unique and agronomically interesting feature of this CMS is that any line of mustard can be used either to maintain the sterility (after certain number of backcrossing) or restore fertility (in the F1) and provides a wide choice of combiners and restorers for hybrid seed production. The CMS based mustard hybrid DMH-1 has been released and notified for cultivation in mustard growing zones II and III. The lab has also developed barnase-barstar male sterility and restorer system through transgenic approaches. Currently biosafety trials are in progress for the transgenic mustard hybrid DMH-11 to confirm the suitability and safety of the transgenic hybrids. A high-density linkage map has been constructed using different DNA marker systems namely; AFLP, RFLP and SSR markers. The map has been used to tag two loci of erucic acid genes by candidate gene approach and two loci of seed coat colour by microsatellite markers. These markers have been used in the marker assisted backcross transfer of Canola quality and yellow seed coat color traits from east European lines to Indian variety Varuna. Recently work on mapping of QTL for phytosterol contents in *B. juncea* has been initiated in the lab. Phytosterols are important for plant growth and development, structurally related to cholesterol are instrumental in lowering the blood cholesterol level in humans.

Prospects of bio-control of mustard aphid

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The mustard aphid, (*Lipaphis erysimi* Kaltenbach) is considered to be the key pest of rapeseed - mustard crops in every cultivated parts of India. This dreaded pest infests the mustard crop during its growth phase and cause losses ranging from 19-96 per cent and adversely affects the oil production. Several bio-control agents have been explored but their potential is yet to be evaluated in the field. The predatory potential of some bio-agents were found to be excellent and may prove very effective also in the field condition. The mass production of some of the very effective bio-agents is the major hindrance in supply at the time of pest infestation in field. The integration of bio-control agents for the management of mustard aphid Viz., chemical insecticide followed by *Coccinella septempunctata* @ 5000 beetles/ha and *Verticillium lecanii* @10^8 CS/ml followed *Coccinella septempunctata* @ 5000 beetles/ha proved very effective. Such other combinations having the bio-control agents as the major component may be effective in the management of mustard aphid and may help in reduction of the use of hazardous chemical pesticides. The inclusion of bio -agents needs to be developed for different agro-ecological regions as per their availability and effectiveness. Future strategies for the management of the mustard aphid with bio-control on their behavioral and economic interrelationship are also suggested.

Towards restructuring *Brassica rapa* genotypes using native genetic variability

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Among rapeseed-mustard, three ecotypes of *Brassica rapa* namely toria, yellow sarson and brown sarson, and *B. juncea* (mustard) are mainly grown as oilseed crop in India during winter season. Indian mustard accounts for about 80% of the acreage under these crops. Of the two forms of brown sarson, lotni type is predominantly grown in Kashmir and Himachal Pradesh. Tora type brown sarson is almost out of cultivation. Cultivation of yellow sarson is confined to Assam, Bihar, West Bengal, North Eastern states, Orissa, parts of Uttar Pradesh and Uttarakhand. Toria is grown as winter crop is Assam, Bihar, Orissa, and West Bengal. By virtue of its short duration and inherent high temperature tolerance during germination and seedling stages, toria is grown as catch crop in parts of Haryana, Himachal Pradesh, Madhya Pradesh, Chhattishgarh, Punjab, Uttarakhand and Uttar Pradesh. Genetic improvement of these crops in India following conventional breeding approaches depended heavily on naturally occurring variability, has paid rich dividends in all these crops. Northern India, especially Himalayan region presents rich diversity of oilseed Brassicas. At Pantnagar, germplasm collection of *B. rapa* (toria, brown sarson, yellow sarson), *B. juncea* (oleiferous as well as leafy types) and *B. nigra* from Uttarakhand hills exhibited considerable variability for different traits including a few unique features like extra earliness, dwarf stature and basal branching. This paper presents some features of unique genotypes identified/developed and their possible implications in restructuring improved types as future varieties of *B. rapa*.

Management of Sclerotinia rot of rapeseed-mustard through IPM interventions

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Sclerotinia rot is a significant agricultural problem of worldwide occurrence in major rapeseed-mustard growing areas of world. In severe infection it causes seed yield losses up to 74% in India. The explosive Pathogenicity of the fungus [*Sclerotinia sclerotiorum (Lib.*) de Bary] under favourable conditions and capacity of its sclerotia to survive for several years made it very difficult to guard the rapeseed-mustard from its infection. The sclerotia survive with seed as a contaminant as well as soil-borne pathogen and provide primary inoculums in the following years. Fungicides are frequently recommended for disease management that may negatively affect the environment and non-target organisms. Identification of improved source of host plant resistance is an important prerequisite for the management of disease. A detailed survey was made by Pathologists team in Rajasthan and Haryana to identify the factors predisposing these crops to Sclerotinia rot. Field experiments were conducted at IARI, New Delhi for virulence assessment of 50 notified varieties and refinement of integrated management (IDM) technology from Rabi 2009-10 to 2010-11 under artificial Sclerotinia rot development conditions. Similarly, Multilocational testing of IDM technology was conducted against disease at 24 locations in Haryana and Rajasthan on 18 ha, which were identified for assured incidence of Sclerotinia on farmers' field in Alwar, Sriganganagar and Hanumangarh in Rajasthan and Gurgaon in Haryana. IPM interventions (cultural practices as well as biointensive Trichoderma) were followed at different stages of crop. The survey revealed that Sclerotinia rot has set its foot in Rajasthan and now it has been emerging as serious threat to rapeseed-mustard in Haryana. It was clearly observed that heavy texture soil, monocropping, high seed rate, high nitrogenous fertilizer, excess irrigations and unhygienic field conditions are prime factors responsible for explosive incidence and severity of disease.

In virulence assessment studies, four varieties viz., Pusa Aditya, Kiran, RLM 619 and Pusa Karishma having < 5% incidence and low severity (0-1 grade) were rated as tolerant, whereas RH 30, CS 54, Pusa Vijay, Pusa Mustard 21, Pusa Jagannath and Pusa Swarnim having 5-10% incidence and moderate severity (grade 2) were rated moderately tolerant to Sclerotinia rot. *Trichoderma* based module i.e., Seed treatment @10g/kg, soil application @ 2.5kg/ha pre-incubated in FYM and two foliar spray @ 0.2% at 50 and 70 days after sowing, which reduced the disease incidence to minimum and increased the seed yield to maximum in research trials. In Multilocational testing, IDM technology of Sclerotinia rot resulted in lowering the incidence / severity and considerably increased the seed yield over control, its use was very much appreciated by farmers. This eco-friendly and biointensive Trichoderma based management module will probably reduce the excessive use of chemical pesticides and side by side will save the other beneficial microbes.

Developing a web-based database of rapeseed-mustard germplasm using LAMP technology

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Rapeseed-mustard crops are maily used for edible oil and grown in nearly 6 million hectares in India. Germplasm collection is valuable gene pool providing diverse genetic material that may be applied for the improvement of cultivars. More information is available about the germplasm, the wider selection and diversity of materials can be utilized for varietal improvement. The large number of germplasm collected and evaluated is being maintained without computer databases. There is therefore a great need to develop Web-based germplasm database for accessing the large amounts of rapeseed-mustard plant genetic resource data. We describe the design and implementation of a web-enable database of rapeseed-mustard varieties using open source technology LAMP.

Web-enabled germplasm database allow users to interactively search and locate information in real time and can also be configured to permit designated users to remotely add, delete, or update information. It can assist in decision-making activities that are related to germplasm documentation, conservation and management. The system facilitates to store and edit data on different characteristics as per the DUS descriptors and passport data for rapeseed-mustard. Presently, the database contains data for more than 100 released varieties on 40 characters which include 24 DUS characters that have been evaluated under Indian agro climatic conditions and others are relevant passport data. The system can be used on any machine having the browser and internet connectivity. Online evaluation of the system is in process and initial user response has been very positive due to effective and easy-user interface.

Status and opportunities in Taramira *(Eruca sativa)* research in India

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Taramira is an important winter season oilseed crop of the family Brassicaceae. It is an introduced crop in India. South Europe and North Africa are believed to be its centre of origin. The oil of this is not directly eaten, although it is mixed with mustard oil to increase the pungency and used for manufacture of grease, soap, plastics, lubricants, paints and chemicals etc. It has 2n-22 chromosomes which are very small. It is a very versatile crop and reasonably good yield can be obtained even when sown late and or with low inputs. Under reasonably good management, the yield as high as 18-20 quintals can be harvested, which is indicative of good yield potential. However, this crop has remained neglected so far as scientific research is concerned. Genetic improvement is limited in this crop, although some varieties are available. Very recently a variety RTM-2002 has been released for the general cultivation. Taramira has desirable traits, particularly, conferring disease resistance which can be transferred to *Brassica rapa* and *B. juncea* both are important crops. Present paper through the light on some efforts being underway for the development of taramira with limited success.

Induced mutagenesis for genetic improvement of Indian mustard

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Mutation breeding techniques have been extensively used for crop improvement. However, it is underutilised for the genetic improvement of Indian mustard (*Brassica juncea* L.). In the recent past,

extensive work on mutation breeding has been carried out in BARC. Results on some of the novel mutations have been reported here in brief. Gamma rays were widely used for mutation induction in the national check varieties 'Varuna' and 'Pusa bold'. Large spectrum of variability for leaf chlorophyll content, leaf morphology, flower colour, siliqua characters, seed shape, and seed coat colour has been isolated. Light green leaf mutation is under the control of incomplete dominance. It always segregates into yellow, light green, and dark green progeny in the ratio of 1:2:1. It has intermediate chlorophyll content than yellow and dark green leaf plants. However, it is vigorous and produced more fresh biomass and seed yield than dark green leaf plants and parent 'Pusa Bold'. It suggested that reduced chlorophyll content than parent 'Pusa Bold' could result to efficient photosynthesis and source-sink relationship.

Similar mutation has also been isolated in parent 'Varuna'. Variegated leaf mutation is characterized by white, yellow and green sectors on the leaf. It always segregates into green and variegated leaf progeny without any fixed Mendelian or epistatic ratios implying unstability for plastid inheritance. Reciprocal crosses with true breeding green and yellow leaf genotypes indicated that it is under control of maternal effect. It has inert capacity to induce variation for various characters. Stable mutation for yellow seed coat colour, small siliqua with higher seed density, and vigorous plants showing drought tolerance have been isolated from the progeny of this mutation. It suggested that unstability in the cytoplasmic organelle probably have influence on nuclear genome leading to mutations for various characters. Another chimeric leaf mutation is characterized by pigmented and green spots on the dorsal side of leaf. It also segregates into green and pigmented leaf progeny. The inheritance is similar to variegated leaf mutation.

A wide range of mutation for seed coat colour consisting of bright yellow to dirty yellow has been isolated. Yellow seed coat which was previously thought to be control by single recessive gene could be under the control of multiple alleles. It is being characterized. A novel mutation for seed coat colour is variegated seed which has yellow and brown stripes on seed coat. It always segregates into brown and variegated seed coat colour progeny. Rarely yellow seed coat progeny has also been observed along with brown and variegated seed. This could be due to transposable elements. Shrivelled seed mutation is deprived from seed filling and control by single recessive gene. Variegated leaf and variegated seed which were explained above individually have been found in one plant which was isolated as one mutant. It segregates into brown seed and variegated seed combined with green leaf or variegated leaf indicating genes for these mutations are located on different chromosome but segregation do not fit to Mendelian ratios.

Mutations for drought tolerance have been isolated in the variety Varuna which were isolated under drought simulated plots. It has long main root compared to parent. Two novel recombinants (mutations) namely fasciation and non-locular siliqua were isolated from segregating generations of two different crosses. Fasciation is the manifestation of fusion of 3-4 plants and non-locular siliqua has no defined locules. It has single tube like structure but number of seeds packed in this tube is more. This is very good character for increasing number of seeds in bi or tetralocular varieties.

Mutations showing better seed yield potential were evaluated in ICAR and SAU yield trials. TM50 has excelled over Varuna in two zones. TPM1 a yellow seed coat mutation has shown consistent performance over check varieties Seeta, Varuna, and Pusa Bold and released as a variety in state of Maharashtra. Mutations have been extensively used in crossing programme and large number of high yielding recombinants has been isolated. They are being tested in ICAR and SAU yield trials. Mutation breeding work has not been projected in mustard compared to cereal, pulse and other oilseed crops; however, it has immense potential for *Brassica* crop improvements. The results of the BARC's work, mutations for morphological characters, biochemical compositions of oil, varieties released using mutation technique, and related work in India and other countries shall be highlighted in this presentation.

An effort towards understanding of pathogenesis of *Alterenaria* species at physiological, biochemical and molecular level

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The fungal genus *Alternaria* is comprised of many saprophytic and endophytic species and ranked 10th among nearly 2,000 fungal genera based on the total number of host records. *Alternaria* species appear to have a sexual stage to their life cycles, but the majority lack sexuality altogether. Diseases caused by fungal pathogens of *Alternaria* genus are the most common diseases of many cultivated, wide plants and weeds throughout the world. Alternaria blight disease caused by a fungus *Alternaria brassicae* (Berk.) Sacc. has been reported from all the continents of the world affects most cruciferous crops and is one among the important diseases of rapeseed mustard causing severe yield losses with no proven source of transferable resistance in any of the hosts. Many species of *Alternaria* produce toxins with rather broad host ranges; a closely related group of agronomically important *Alternaria* species produce selective toxins with a very narrow range often to the cultivar level which play a major role in plant infection. The chlorotic toxin, a cyclodepsipeptide has been characterized as destruxin B which appears to interact with some extracellular or intracellular receptor molecule to activate a signal transduction pathway leading to cell death. Our lab demonstrated that destruxin B inhibits almost all-macromolecular biosynthesis, promotes ion leaching and cause aberrations in mitochondria and chloroplast of *Brassica juncea*. Differential expression of cell cycle proteins in toxin treated leaves and calli and overexpression of p53 suggested that the toxin-mediated perturbations in cell cycle eventually cause p53 induced programmed cell death (PCD). Here an attempt has been made to study the recent advances at physiological, biochemical, anatomical and molecular level in the pathogenesis of the disease and also try to understand the mode of action of host selective toxin (s) of *Alternaria* spp.

Induction of *myb* gene under drought stress in *Brassica juncea, B. carinata* and *B. tournefortii*

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Drought plays a major role in destabilizing the productivity in crop plants. In this regard, conscious efforts are required to improve production in areas commonly exposed to abiotic stress especially drought. Drought stress negatively influences survival, biomass production and crop yield. Being multigenic as well as a quantitative trait, it is a challenge to understand the molecular basis of drought stress tolerance. *Brassica* being third most cultivated oil seed crop needs to be improved for stress tolerance. MYB proteins are key factors in regulatory networks controlling development, metabolism and responses to biotic and abiotic stresses. It is a transcription factor (regulatory gene) gene having role in regulating stress induced genes. The investigation was carried out to study *myb* expression in *B. juncea* cv. RH-0116 (drought tolerant), *B. tournefortii* and *B. carinata* under drought stress. Fourteen days old in vitro grown seedlings were exposed to air-drying treatments for different intervals of time (1 and 2 hours) for studying *myb* gene expression through semi-quantitative RT-PCR. The primers were designed using *AtMyb2* gene sequence of *Arabidopsis thaliana* based on conserved DNA binding domain. A 250 bp amplified product was obtained in RT- PCR under drought stress for 1 hour. It was found that *myb* gene is not expressed in control seedlings while myb transcripts were induced within one hour of drought stress in all the three species. The myb transcripts disappeared when re-hydration treatments were given. The cloned and sequenced *myb* cDNAs showed similarity to *AtMyb2* and other *myb* genes known for their role in stress tolerance.

Non destructive method using near infrared reflectance spectroscopy for estimation of fatty acid profile in rapeseed-mustard germplasm

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A key element of successful development of new rapeseed-mustard cultivars is availability of inexpensive and rapid methods for measurement of fatty acid (FA) in seeds. A non destructive analytical method using intact seed is desirable as the seeds can be used for sowing after measurement. The objectives of this study were to investigate the applicability of NIR spectroscopy and to characterize the large number of germplasm of rapeseed-mustard received from various source for measurement of FA in whole rapeseed-mustard. Multiple linear-regression analysis of NIR spectral data of 624 seed samples and chemical data for whole seeds were carried out to develop calibration equations for predicting the proportion of each of the seven major fatty acid (FA) in rapeseed-mustard seeds from the total FA composition. The best predicted equations for each fatty acid were selected on the basis of minimizing the Standard error of cross validation and increasing the coefficient of determination R^2. The equation had low SECV (Standard error of cross validation) and high R^2 (coefficient of determination in calibration >0.8) except for stearic acid which is having 0.68 values. The range for palmitic, stearic, oleic, linoleic, linolenic, eicosenoic and erucic acids varied from 1.40-3.63, 1.1-3.34, 6.32-21.95, 9.01-20.64, 4.46-12.56, 0.90-10.51 and 44.11-55.36 percent with mean values 2.55, 1.99, 13.55, 16.14, 9.08, 5.94 and 51.56 percent, respectively. One of the accession IC313380 (*B.rapa* ssp. chinensis) was found promising for high oleic acid (21.95%) content. The results indicated that the whole-seed NIR spectroscopy equations for fatty acid estimation would be useful for improving efficiency of breeding programs aimed at altering fatty acid composition in rapeseed-mustard germplasm. Thus, the use of NIRS in estimating and characterizing a large germplasm collection has permitted the identification of accessions with varied fatty acid concentrations at low cost and in reduced time compared to GLC. This can be applied to documentation of potentially valuable characteristics of genebank materials, the evaluation of the oil quality of present varieties, and the selection of parents in a breeding program oriented to nutritional or industrial enhancement of rapeseed-mustard.

Broomrape: A threat to Indian mustard cultivation in Haryana and its control measures

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Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is the major oilseed crop of Haryana being grown in an area of 0.6 m ha on light textured loamy to sandy loam soils characterized by poor fertility, light in texture with low moisture holding capacity. Mustard crop in Bhiwani, Mahender Garh, Rewari, Jhajjar and Sirsa adjoining Rajasthan is severely infested with holoparasitic weed broom rape (*Orobanche aegyptiaca* L.) commonly known as 'Margoja', 'rukhri' or 'sarson ka mamma' which has threatened mustard cultivation in these areas. This pararsitic weed grows on the roots of mustard plant in response to germination stimulants secreted by its roots and looks like a beautiful plant with purple coloured scales, 15-30 cms in height and occasionally growing in clusters .Broomrape lacks chlorophyll and upsurp all their nutritional and water requirements from host plant. *Orobanche* plants are without leaves and upper 2/3 part of stem bears inflorescence which is rather sparse .Each flower bears a small capsule which contains 40,000 to

50,000 or even more minute seeds. The seeds remain in soil for up to 20 years. As infestation of this weed starts after 7-10 days of sowing, so control measures in the early stages of crop growth should be applied. Application of any control measure after panicle initiation of *Orobanche* is of no use as damage starts from 30 days after sowing while growing underneath for its initial growth stage. This paper discusses results of experiments conducted on *Orobanche* management at farmers' fields during last 12 years. Pre-emergence application or pre plant incorporation of different herbicides such as pendimethalin or trifluralin along with hoeing, use of organic sources of manure viz. FYM poultry manure, sugarcane slurry, castor cake and neem cake proved ineffective in minimizing density of this weed. All mustard genotypes recommended for cultivation and even popular hybrids being grown in Haryana, Punjab, Rajasthan and Delhi, were tested for their tolerance against *Orobanche* in fields showing high infestation of this weed during the previous years. None of the variety/hybrid showed tolerance against this weed. Even Var. Durgamani reported tolerant to this weed by NRC, Bharatpur (Rajasthan) showed severe infestation. Nitrogenous and potassic fertilizers, soybean oil, CAN and Calcium Nitrate did not prove effective in inhibiting germination of *Orobanche aegyptiaca* in mustard. Post mergence application of kerosene oil and paraquat causes toxicity to mustard crop (Punia *et al*., 2010). Seed coating of mustard with triasulfuron and chlorsulfuron at 1.0 ppm has been found effective to delay its infestation but *Orobanche* panicles emerge in later stages. Only post emergence application of glyphosate at 25 and 50 g/ha at 30 and 50-55 DAS not only in experimental fields but tested on large scale at farmers fields holds some promise with 60-80% control of this weed. Glyphosate dose range is very limited. Over dosing may result toxicity to mustard in terms of marginal leaf chlorosis, slow leaf growth and bending of apical stems and even stunting which recovers with irrigation 3-4 days of its application. Bleaching of few leaf tissues of mustard may also occur with 50 g/ha dose which also recover with in 20 days resulting with out significant loss in yield.