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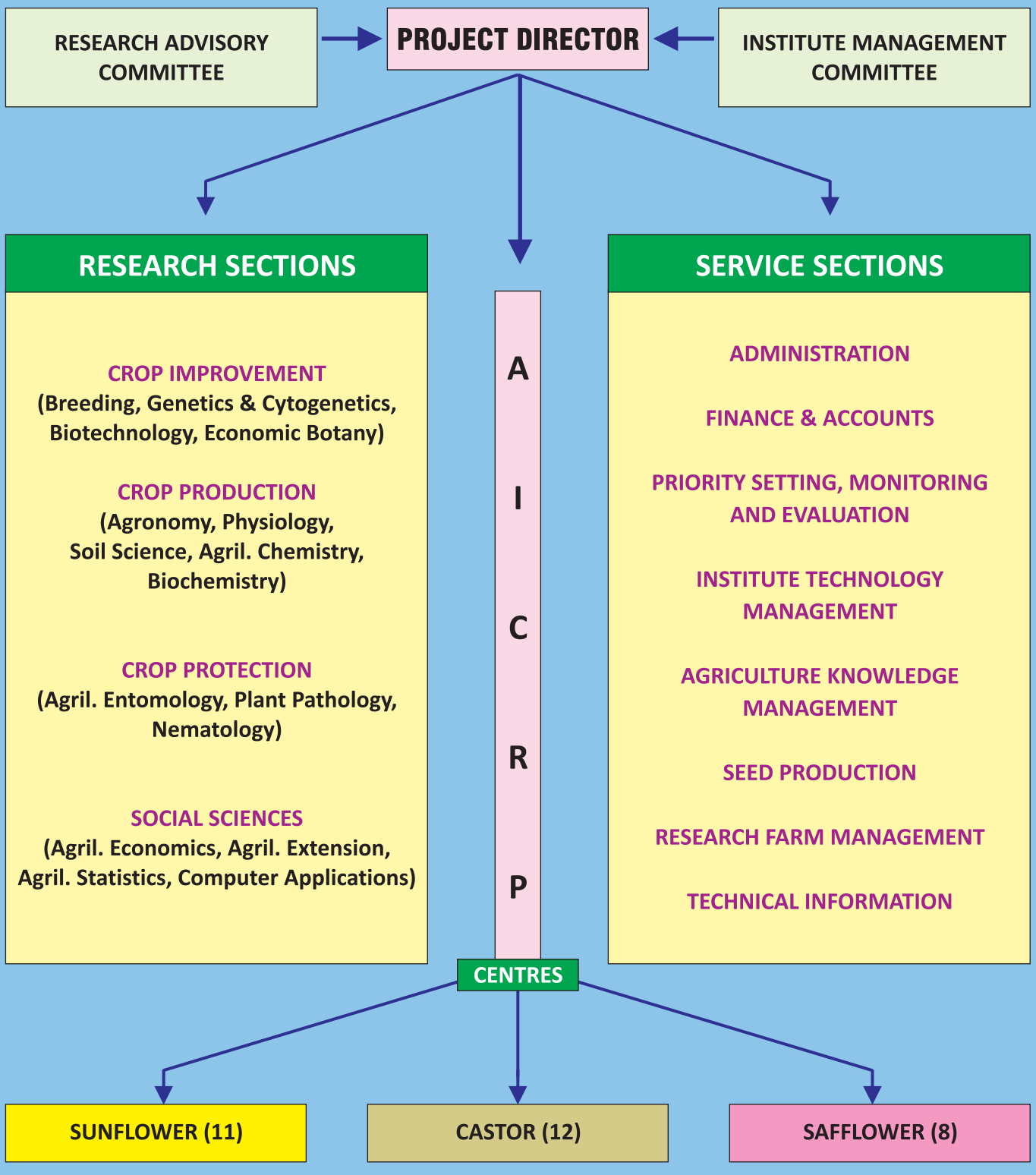
वार्षिक प्रतिवेदन
ANNUAL REPORT
2013-14

भाकृअनुप
ICAR

तिलहन अनुसंधान निदेशालय
DIRECTORATE OF OILSEEDS RESEARCH
(Indian Council of Agricultural Research)
राजेंद्रनगर, हैदराबाद-५०० ०३०
Rajendranagar, Hyderabad-500 030

Organogram

DIRECTORATE OF OILSEEDS RESEARCH



DOR Annual Report

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2013-14

तिलहन अनुसंधान निदेशालय
(भारतीय कृषि अनुसंधान परिषद)
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Directorate of Oilseeds Research
(Indian Council of Agricultural Research)
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PREFACE

It gives me immense pleasure in presenting the Annual Report 2013-14, highlighting the significant research achievements and activities of the Directorate of Oilseeds Research. Salient achievements in All India Coordinated Research Project on Sunflower, Castor and Safflower are also documented in this Annual Report. The research on sesame is added to the mandate of Directorate, since 2013 .

During the period under report, new initiatives have been taken up which include, formulation of bio-pesticide consortium; contract research project with M/s Marico Ltd.; collaborative projects with PDFSR, IICT and CSIR-CIMMACS; hybrid sesame development programme in a network mode and a new pre-breeding programme utilizing wild annual *Helianthus* species aiming diversification of inbred base with specific emphasis on desired agronomic and quality traits.

Some of the research highlights for the year 2013-14 include: identification of high oleic sunflower genotypes (TSG-17 and DOP-80); high phosphorus acquisition sunflower line (CMS 42B); critical vegetative stage of safflower for aphid attack; high ricinoleic acid castor germplasm accession, (RG-357); characterization of SND resistant sunflower transgenic events carrying TSV-CP gene; development of pedigree information system for sunflower inbreds/parental lines; mobile phone based knowledge modules and digitisation of annual reports of DOR and AICRPs.

I place on record my sincere gratitude to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR; Dr. S.K. Datta, Deputy Director General (CS) and Dr. B.B. Singh, Assistant Director General (OP), ICAR for their unstinted guidance and support in executing the mandate of the Directorate. I also express my gratefulness to the Chairmen and all the members of the Research Advisory Committee and Quinquennial Review Team for the critical assessment in improving the research programmes. My sincere appreciation goes to Dr. I.Y.L.N. Murthy and team of editors of the Annual Report and other staff members of the Directorate for their efforts and in bringing out the report highlighting the achievements and activities of the Directorate. Services of Mr. G. Raghunath, Technical Officer (T-6), for compiling information from all sections is appreciated. The contribution of Sri P. Srinivasa Rao, PA for editorial assistance, proof reading and final page setting is acknowledged.

DOR, Hyderabad
May 26, 2014

(K.S. VARAPRASAD)
Project Director

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EXECUTIVE SUMMARY

The salient findings of the research activities conducted during 2013-14 at the Directorate of Oilseeds Research are presented crop wise.

SUNFLOWER

About 39 trait specific germplasm accessions including (high seed yield (>40 g/plant) and high oil (>40%) were identified. From newly procured 62 accessions from USDA, USA, accessions with 46 days for 50% flowering and with 100 seed weight of more than 12 g were identified. Molecular marker derived from *fad2* gene associated with high oleic trait in sunflower detected high oleic genotypes, TSG-17 (EC699735) and CMS DOP-80 in the exotic germplasm accessions. One hundred and nine accessions of wild *Helianthus* species were obtained and established. Six wild annual diploid species (*H. annuus*, *H. debilis*, *H. praecox*, *H. niveus*, *H. argophyllus*, *H. petiolaris*) were shared with AICRP centres to initiate pre-breeding activity by crossing with promising B lines for genetic enhancement of yield traits. *H. niveus* (NIV1452) that showed resistance to powdery mildew has been crossed with susceptible line, 2023B for genetic analysis of resistance.

As part of the programme on development of inbreds, gene pools and identification of heterotic combinations, ten common restorers and six common maintainers were identified for two diverse CMS sources *viz., PET* and *lenticularis* (I). Promising inbreds for high autogamy (CSFI-5134 and AKSFI-49-3), early maturity (RHAGKVK-2), high oil content (GPR-102 and GPR-58) were identified. Construction of maintainer (6 lines) and restorer gene (5 lines) pools has been initiated. Seven hybrids among 160 new hybrids evaluated during *kharif* 2013 were promising for seed yield per plant (47.7 g: CMS-852A x CSFI-5075), oil content (44.3%: CMS-234A x CSFI-5133) and early maturity (81 days: CMS-852A x CSFI-5133). Expression of *TSV-CP* gene was confirmed in the homozygous transgenic event 481-10-11-2. Seeds of five events (237, 247, 481, 648 and 753) were multiplied for biosafety and viral bioassays. Recombinant inbred line (RIL) population from the cross, PS2023A x PI642072 was developed and characterized for powdery mildew resistance, which showed quantitative inheritance of the trait. Interspecific crosses between resistant accessions of *H. praecox*, *H. debilis* and *H. niveus* with susceptible genotypes, Morden and PS2013B were effected for mapping of powdery mildew resistance from wild sources. A pedigree information system has been developed for sunflower breeders for retrieving information on pedigree, selection method, year of development, centre involved in development and maintenance, quantitative traits, etc.

Seed yield of DRSH-1 was higher (1603 kg/ha) with long term fertilizer management of NPK + FYM 5 t/ha (sorghum) – NPK (sunflower) than application of NPK @ 150% (1338 kg/ha) to both the crops. Sunflower genotypes CSFH-8712 and CSFI-5075 produced higher root volume under P stress situation. In P x Zn nutrient interaction studies response to P was recorded up to 60 kg/ha (822 kg/ha) and for Zn up to 5 kg/ha (725 kg/ha). Moisture stress from thinning to star bud stage with or without N top dressing after relieving moisture stress, is critical to trigger leaf axil branch formation (up to 64% plants recorded leaf axil branches) at field level.

Sunflower leaf blight severity was more in 30th July and 16thAugust sown crops. Spore load, dew point, relative humidity, minimum temperature were the most influencing weather parameters for the disease severity. Three pathogenic groups were identified in *Alternariaster helianthi* isolates based on disease reaction to *H. occidentalis*. *H. maximiliani* was resistant to most of the isolates. Sunflower leaf curl virus is common on cotton, tomato, cowpea, mungbean and parthenium in Andhra Pradesh and Karnataka. The occurrence of SuLCV was more in *kharif* grown sunflower crop compared to *rabi*. The seed yields reduced by 21 to 53% at disease

severity levels of 30% and 64%, respectively of sunflower powdery mildew.

Suspension concentrate formulation of DOR *Bt*-1 developed with the synergist boric acid was found to be highly effective against *Achaea janata* and *Helicoverpa armigera*. Two local isolates 127 and 172 belonging to *B. thuringiensis* var. *kurstaki* were found to be highly promising against *Spodoptera litura*. Combination formulation of *Bt*-127 and conidia of *B. bassiana* ITCC-4513 gave effective control of *H. armigera* on sunflower and *S. litura* on castor. Novel *cry1Aa* gene identified from local isolate 52 belonging to *B. thuringiensis* var. *kurstaki*, toxin was designated as *cry1Aa24* by NCBI. Sunflower germplasm lines GMU-1, 126, 843 and advanced line GP 6-208 were found resistant to leafhopper with less than 10% hopper burn.

Improvised software platform for disseminating text based SMS in regional language (Telugu) was developed jointly by National Informatics Centre and DOR. The platform is being used for dissemination of text messages and vKVK platform for broadcasting of voice messages to sunflower and castor farmers.

CASTOR

Conducted a castor germplasm exploration in Rajasthan in collaboration with NBPGR, Regional Station, Jodhpur and collected 118 accessions. Identified one germplasm accession for long primary spike covered with capsules (49 cm) and one for high 100 seed weight (59 g). A farmer's variety with long compact spike (130 cm) has been identified from Dhandej village of Vadodara district, Gujarat. DPC-16, a pistillate line of unique morphotype with a hermaphrodite flower at the tip of the spike, red stem colour and zero bloom was registered by PGRC, NBPGR, New Delhi with national identity, IC0598621. Trait specific germplasm was characterized. Extra-early maturity trait was confirmed in three accessions *viz*., RG-22/EC168754, RG-26/EC169671 and RG-181/EC168759. The wilt and leafhopper resistant germplasm accession, RG-43, flowered 12 days early as compared to the check, DCS-9. For seed yield, the highest yield was realized from RG-155 (3317 g/net plot) while seed yield in the best check, DCS-107 was 2227 g/net plot. Twenty nine parental lines were identified as promising sources for improvement of physiological traits *viz.,* early vigour, high TDM and harvest index. Confirmed wilt resistance (0-10% wilt incidence) in RG-386 (IC-432910), RG-1624 (IC-373981) and RG-2787 (IC374338/IC346591) using root dip inoculation technique. Registered the wilt resistant germplasm selection, RG-2818 (IC346622; INGR14004) with PGRC, NBPGR, New Delhi. Confirmed leafhopper resistance in RG-2661 (IC374272) (hopper burn grade 0 on 0-4 scale), RG-43/IC0584671 and 2498/IC374208 (hopper burn grade 0.1-1.0) while the susceptible checks, DPC-9 and DCH-177 had hopper burn grade 4.0 on 0-4 scale. The accession, RG-2774 (IC346578/IC374330) recorded lower capsule borer damage of 25.8% as compared to 85.5% in susceptible check, DCS-9. Ward's minimum variance method of cluster analysis grouped the 39 biotic stress resistant accessions into eight diverse groups.

As part of the programme on widening the genetic base of the pistillate and male lines, construction of new gene pools, one each for monoecious and pistillate lines has been initiated. Two promising male lines (12-2 and 12-76) for high seed yield increase (103%, 87%, respectively) over the best check, DCS-107 were identified from PVT-I. Five promising male lines (11-2, 11-19, 11-34, 11-60 and 11-70) with higher yield increase (58-102%) over the best check DCS-107 were identified for early/medium maturity and monoecious trait. Wide hybridization programme using *Jatropha integerrima* and tapioca has been initiated for CMS development in castor. For understanding the sex mechanism in castor, the floral differentiation stages were identified in two parental lines by histological sections. No significant effect of epimutagen 2-deoxy 5-azacytidine was noticed on the sex

expression of two castor parental lines but two plants showed higher proportion of male flowers compared to control. Seven promising hybrids (CEH-40, CEH-73, CEH-99, CEH-68, CEH-134, CEH-108 and CEH-133) were identified with high seed yield increase (21-57%) over the best check, GCH-7 in a common hybrid evaluation trial at DOR (rainfed) and Anand (irrigated). Hybrids CEH-68 and CEH-73 were also resistant to wilt.

As a prelude for molecular mapping and linkage analysis, work on development of mapping populations and genomic resources has been intensified. An association-mapping panel consisting of 300 accessions was assembled for mapping wilt resistance and other agronomic traits in castor. Whole genome sequences of 12 diverse castor genotypes were generated and over 1 million SNP loci were identified. Illumina Infinium® assays for 3072 SNPs were designed for large scale genotyping applications in castor. Molecular characterization of castor core subset was done using 39 SSR markers. Prediction of microRNA genes in castor genome sequences was done and 4,054 putative pre-miRNAs were extracted.

Laboratory bioassay of *Cry1Aa* transgenic events (AK1304 PB-1, 804-1) on toxicity to eri-silkworm showed no larval mortality but resulted in 40-50% reduction in larval weight. A modified *in planta* transformation method was attempted for different gene constructs (*GUS, ERF1+GUS, AtEBP1, BIK1, AtEBP1 + BIK1*) and T_1 seeds were obtained from more than 600 T_0 plants. The effectiveness of the gene constructs against *Alternaria* and *Phytophthora* diseases have been validated in tobacco as a model system. For Alternaria, tobacco transgenics with stacked gene cassettes (*AtEBP1+ BIK1*) showed better tolerance than those with single gene cassettes. For *Phytophthora*, transgenics with stacked gene cassettes (*BIK1+ ERF1 and AtEBP1+ ERF1*) showed highest level of tolerance.

The experiments on colonizing ability of different isolates of *Trichoderma* spp. at different time intervals indicated the effective association of *Trichoderma* with castor roots. DCS-107 genotype showed better colonization with *N13*, *Th4d*, *TV5* and *7316* strains. DCS-107 plants grown after seed treatment with *Th4d* strain showed 85.7% reduced disease severity after infection by *Phytophthora nicotianae* and the plants treated with *7316* and *N13* strains showed 50% and 42.9% reduced disease severity, respectively when compared with disease on untreated seedlings. Similarly, wilt incidence (on the check hybrid GCH-4) was lower when *Trichoderma* was included in the soil along with *Fusarium oxysporum* f. sp. *ricini* inoculum. *Th4d* treatment showed least wilt incidence (21%), followed by *N13* (36%), *TV5* (43%), and *7316* (31%).

Application of 5 t FYM along with 100% RDF (NPK) has recorded highest seed yield of sorghum (3582 kg/ha) and castor (846 kg/ha). RG-27 and DCH-519 showed less percent reduction in total drymatter (<30%) and high drymatter stress index (>70%) before relieving water stress. Genotypes with >75% survival of seedlings in induction temperature and >50% survival even at lethal temperature include RG-89, RG-211, RG-941 and RG-1618. Highest ricinoleic acid content was recorded in RG-357 (91%).

Six parental lines *viz.*, Kh 12-317-2, Kh 12-1498-1, DCS-81, DCS-89, DCS-108, and DCS 120 and seventeen advanced breeding lines *i.e.,* PHT-2013-11, 15, 23, 27, 32, 46, PHT-11-13-56, 60, 62, 72, 73, 77, 78, 79, 80, 81 and PHT 13-2 were totally free from wilt disease. Isolates *viz.*, 12-1, 3, 10, 13-19, 20 of *F. oxysporum* f. sp. *ricini* collected from Palem and S.K. Nagar were highly virulent. Oatmeal agar amended with ammonium nitrate (1 g), yeast (1.5 g), gallic acid (1 g) and 20% castor pericarp extract per litre supported good sporulation and mycelial growth of *Botryotinia ricini*. Spraying of Propiconazole (0.2%) and Carbendazim (0.1%) two times at 15 days interval were found effective in reducing castor gray rot severity and increasing the seed yield. Morphological characterization and ITS

sequencing revealed that the species associated with Phytophthora seedling blight of castor is *P. nicotianae* but not *P. parasitica, P. drechsleri* and *P. palmivora*. Agar bit inoculation technique was found effective for seedling blight screening. Phytophthora damping off in castor was significantly low in seed treatment with Captan (2 g/kg), Metalaxyl + Mancozeb (0.2%) and *Trichoderma harzianum Th4d* SC (1 ml/kg.) Advanced lines *viz*., PHT-2013-14, PHT-2013-30, PHT-2013-32, PHT-2013-41, PHT-2013-46 and PHT-2013-79 were found resistant to leafhopper. Seven mutant selections of DPC-9 were found resistant to leafhopper *viz*., Rb-2011-244, 217, 213, 216, 231, 228 and 214. A highly significant and negative correlation between leaf wax content and hopper burn was observed. Monitoring of *S. litura* by sex pheromone traps showed two peak catches during 34 to 35th MW and 41 to 43rd MW. Significant positive relation was found between egg-masses in castor and trap catches. Response of *S. litura* to light trap was lower than sex pheromone trap. Wheat bran with sugarcane or palm jaggery attracted more larvae as compared to rice bran based baits. Wheat bran + palm jaggery bait mixed with novaluron (10 EC) or chlorpyriphos (20 EC) resulted into more than 90% mortality of *S. litura*. Maximum calling of female moths of capsule borer occurred during second scotophase and extracts of pheromone gland assayed in electroantennogram elicited hypersensitive reaction in male moths. IICT pheromone Blend II was consistently found effective in attracting capsule borer moths. Penetration behaviour of reniform nematode on resistant (JC-12) and susceptible (48-1) genotypes of castor showed large number of nematodes entering the roots of 48-1 than JC 12. Reaction of nematode resistant genotype JC-12 to three different isolates of *F. oxysporum* f. sp. *ricini* showed that it was resistant to DOR and SK Nagar isolates but susceptible to Palem isolate. *T. asperellum* Tv-2 B76 effected hatching inhibition of reniform nematode with average nematode hatch of 29 per egg mass compared to control (65 per egg mass).

SAFFLOWER

Out of the 1260 exotic accessions evaluated, 15 accessions recording seed yield higher than checks Bhima (488 g/plot) and A-1 (437 g/plot) were identified with highest seed yield recorded in GMU 972/EC 181180 (907 g/plot). Ten high oil accessions with oil content >35% were identified with GMU 1437/EC 181737 and GMU 1731/EC 182117 recording high oil content of 38.8 and 38.1%, respectively compared to the checks, A-1 (28.7%) and Bhima (31.7%). Germplasm accession EC 523368-2 was found resistant to aphids for the third consecutive year under field conditions with artificial release of aphids. Germplasm line IC 13884 (NIC 7133(SD5-1278)/GMU 4983) identified for resistance to Fusarium wilt was approved for Registration by PGRC, NBPGR, New Delhi and has been allotted the registration number INGR14002. Mexican safflower varieties recorded high oil and oleic acid content and EC755675 recorded highest oil content of 41% in Alfisol (Rajendranagar) and highest oleic content of 80.36% in Vertisol.

Genetic diversity in the core sub-set and genetic distance between Mexican and Indian safflower genotypes was assessed using SSR markers. A set of 89 SSR markers were developed and the SSR motif containing sequences were submitted to NCBI database (KJ586129-KJ586228). Molecular characterization of 148 accessions of sub-core collection using 50 SSR markers and STRUCTURE analysis revealed that the sub-core consisted of four sub-populations and an admixture group (pair-wise *Fst* values ranged from 0.0840 to 0.486). Analysis of genetic relatedness revealed that Indian and Mexican safflower cultivars were genetically distinct (*Fst*=0.396) suggesting that Mexican varieties could be useful source for widening the genetic base. *In planta* transformation for *GPAT9* and *DAGAT* genes was attempted. Following GUS analysis, T_1 seeds from 300 plants with double gene cassette and 30 plants with concoction of single gene cassettes were obtained.

Varietal Identification Committee identified safflower hybrid DSH-185 for cultivation in all India. Two high yielding wilt resistant, hybrids DSH-250 and DSH-249 were promoted to AHT-I in AICRP (Safflower). In preliminary multilocation hybrid trial, DSH-253 recorded 17% higher mean seed yield (1734 kg/ha) than the hybrid check, NARI-H-15 (1510 kg/ha). Eight hybrids recorded 17-30% higher seed yields (2038-2266 kg/ha) than the check, NARI-H-15 (1746 kg/ha) at DOR, Hyderabad under rainfed conditions. Under male parental line improvement programme, one high oil (37%) parent (SFS-9943), five wilt resistant parents (0-10% wilt incidence in sick plot for three years) and three wilt and seedling blight resistant parental lines *viz.,* W-05-2028, W-2026 and W-2037-9 (20% disease severity in agar disc inoculation technique in green house) were developed. Four interspecific derivatives recorded only up to a maximum of 20% Alternaria severity under high disease pressure in the fourth consecutive year. Introgressed desirable traits such as high basal branching and high number of capsules from *C. oxyacantha* into cultivated background and developed six high yielding BC_1F_6 interspecific derivatives of (*C. oxyacantha* x *C. tinctorius*) *C. tinctorius* (6.16-7.2 kg/net plot) which recorded 32-54% higher yields than the best check, PBNS-12 (4.65 kg/net plot). Developed and stabilized two new interspecific recombinants with yellow leaf variegation and extremely dwarf plant type. Eighty one F_5 families recorded high oleic content of 72 to 82%.

Seed treatment with Captan @ 0.2% and *T. harzianum* Th4d SC @ 2 ml/kg were most effective in reducing *Fusarium* wilt and *Phytophthora* damping off, while Captan @ 0.2% and Cymoxanil + Mancozeb treatments showed low incidence of Macrophomina root rot in safflower. Seed treatment with *Trichoderma asperellum* TaDOR673WP (10 g/kg) and Carbendazim (2 g/kg) were most effective and recorded significantly low *Fusarium* wilt incidence and increased seed yield in safflower.

Stem elongation stage is the most vulnerable to aphids and the stage is appropriate for screening of safflower. Inheritance pattern of resistance in safflower against aphids was found to be quantitative in nature. Antixenosis is operating against aphids in the initial stages in safflower resistant accession EC523368-2. No antibiosis is observed in safflower against aphids.

SESAME

Augmented 27 selected accessions of wild species from different AICRP centres and NBPGR, New Delhi. Through an exploration, 15 accessions of wild species (*S. malabaricum*-11, *S. radiatum*-1, *S. laciniatum*-3) were collected from Kerala state. A multi-location experiment was undertaken to establish the extent of heterosis. A set of selected 24 common male lines which have been crossed with three female lines to produce 72 experimental hybrids were tested in Hyderabad and Dharwad in summer, 2014. The F_1s of the crosses DSS-9 x MT-10-81, DSS-9 x Prachi, DS-5 x JLS-9707-2 and DSS-9 x DS-30 showed earliness compared to three national checks.

Frontline and Tribal Sub-Plan Demonstrations

Four thousand six hundred and thirteen frontline demonstrations on oilseeds and oilseed based cropping systems castor (415), sunflower (500), safflower (400), sesame (361) niger (328), linseed (460), Rapeseed-mustard (537), groundnut (832), soybean (680), farming systems (50) and STCR technologies (50) were conducted under the Integrated Scheme on Oilseeds, Pulses, Oilpalm and Maize (ISOPOM).

Five frontline demonstrations (FLD) of sunflower each on soil test based nutrient management application of sulphur and foliar spray of boron at star bud stage and 25 demonstrations on whole package were conducted in Prakasam district, Andhra Pradesh. For soil test based nutrient management, farmers were selected based on the soil test values. In FLDs on sulphur, elemental sulphur @ 25 kg/ha was applied in improved

technology as compared to no sulphur in farmers practice and in FLD on boron, borax @ 2 g/l was applied as directed spray to the capitulum at star bud stage in the form of borax @ 2 kg/ha as compared to no boron in FP. In whole package, the seed yield increased by 20.9% followed by soil test based nutrient management (16.6%), sulphur (10.2%) and boron (7.0%) as compared to farmers' practice. Farmers obtained additional net returns of ₹ 6900, 5680, 3750 and 810 with whole package, soil test based nutrient management, sulphur and boron, respectively.

Castor FLDs were conducted for impact assessment at Bawal revealed that castor (2635 kg/ha) with mung (500 kg/ha) as intercrop has yield advantage over farmers' practice of mung (750 kg/ha) - mustard (2125 kg/ha) and mung (750 kg/ha) - wheat (4438 kg/ha) systems. The additional net returns were also higher in the castor-mung system as compared to other systems. The FLDs on castor conducted at Anantapur revealed the superiority of DCH-177, (1090 kg/ha) and DCH-519 (916 kg/ha) as compared to farmers' practice (760 and 713 kg/ha), respectively. The major constraints experienced by farmers were non-availability of quality seeds, high cost of labour and their shortages at critical periods, poor marketing facilities and low price, high cost of inputs, yield losses due to incidence of wilt, aberrant weather such as frost during crop growth and low awareness on improved production technologies. Haryana farmers feedback indicated that there is a need to develop frost tolerant varieties and their management, good remunerative price, training and exposure visit to research stations to learn newly developed technologies. Castor has good scope for its spread in districts like Mewat, Rewari, Mahendragarh, Fatiabad, Jhajjar, Hisar and Gurgaon. Castor information portal was developed with eight modules, which includes the information pertaining to cultivars, suitable areas for cultivation, management practices, average yield, oil content, etc. Information on prices and arrivals of major markets in various states are being displayed in DOR website.

Tribal sub-plan programme was implemented in 23 villages of Andhra Pradesh, one village of Rajasthan, one village of Karnataka and 12 villages of Tamil Nadu for castor; four villages of Andhra Pradesh, two villages of Karnataka and 24 villages of West Bengal for Sunflower and five villages of Andhra Pradesh for safflower with the objective of alleviating poverty among the schedule tribe population and creation of productive assets for them. Under this programme, 1238 demonstrations of improved varieties/hybrids of DOR mandate crops (Castor- 778, Sunflower- 310 and Safflower-150) were conducted in association with NGOs.

कार्यकारी सारांश

तिलहन अनुसंधान निदेशालय में 2013-14 के दौरान हुई अनुसंधान गतिविधियों से प्रमुख शोध, फसल के अनुसार प्रस्तुत है -

सूरजमुखी

लगभग 39 विशिष्ट लक्षणों के जीवद्रव्य जीवाश्म जिनमें अधिक बीज फसल >40 ग्रा/पौधा और अधिक तेल >40% की पहचान की गई है । यूएसडीए, युएसए से प्राप्त नए जीवाश्मों जिनसे 46 दिन में फूल और 100 बीजों का वजन 12 ग्राम. से अधिक की पहचान की गई है । fad2 जीन से प्राप्त मॉलिक्युलर मार्कर सूरजमुखी में अधिक ऑलिक विशिष्टता से संबंधित है, अधिक ऑलिक जीनोटाइप टीएसजी-17 (इसी 699735) और डीओपी-80 जीवद्रव्य जीवाश्म में पाए गए । जंगली हेलिएंथस के एक सौ नौ जीवाश्म प्राप्त कर स्थापित किए गए । छः वार्षिक जंगली डिप्लोइड जातियाँ (H anuus, H. debilis, H. praecox, H.niveus, H. agrophyllus, H. petiolaris) को एआईसीआरपी केंद्रों से बाँटा गया ताकि बी लाइंस से आनुवंशिक फसल गुणों में वृद्धि हेतु क्रास कर पूर्व प्रजनन गतिविधि प्रारंभ की जा सके । चुर्णिल मिल्ड्यु प्रतिरोधक H.niveus(NIV1452) को ग्रहणशील लाइन 2032 बी से क्रास किया गया ताकि प्रतिरोधकता का आनुवंशिक विश्लेषण किया जा सके ।

कार्यक्रम के अंश के तौर पर इनब्रेड, जीन पुल और दस सामान्य पुनर्स्थापक और छः सामान्य देखभालक की पहचान दो भिन्न सीएमएस स्रोत पीइटी और लेंटिक्युकिंस के लिए की गई. अधिक स्वयुगमन के लिए (एकेएसएफआई-49-3) शीघ्र परिपक्वता के लिए (आरएचएजीकेवीके-2) अधिक तेल की मात्रा (जीपीआर-102 और जीपीआर-58) इनब्रेड की पहचान की गई । देखभालक (6 लाईंस) तथा पुनर्स्थापक जीन (5 लाईंस) एकत्र कर निर्माण रचना प्रारंभ की गई । खरीफ 2013 के दौरान 160 नए संकरों का मूल्यांकन किया गया जिनमे से सात संकरों को बीज पैदावार प्रति पौधा (47.7 ग्रा, सीएमएस-852 ए X सीएसएफआई - 5075), तेल की मात्रा (44.3% सीएमएस - 234 ए X सीएसएफआई 5133) और शीघ्र परिपक्वता (81 दिन, सीएमएस-852 ए X सीएसएफआई 5133) को आशाजनक पाया गया । टीएसवी-सीपी जीन के एक्सप्रेशन को समयुग्मज ट्रान्सजेनिक 481-10-11-2 से पुष्ट की गई । पाँच इवेंटस के बीजों (237,247,481, 648 और 753) को जैव सुरक्षा और वैयरल बॉयोएसेज हेतु बढाया गया । आईआईएल के संकर से पीएस 2023 X पी 1642072 विकसित किए गए तथा चुर्णिल मिल्डयु प्रतिरोधक रहे जो उसके गुण की गुणात्मक वंशक्रम को दर्शाता है । प्रतिरोधक जीवाश्मों के संकर H. debilis, H. praecox और H.niveus के संभावित जीनोटाइप मार्डेन और पीएस 2013 बी चुर्णिल मिल्ड्यु प्रतिरोधकता वाइल्ड स्रोतों से मैपिंग को प्रभावित करती है । सूरजमुखी प्रजनकों हेतु इसके वंशक्रम की सूचना पद्धति विकसित की गई है ताकि वंशक्रम से संबंधित सूचना, चयन पद्धति, विकसित करने का वर्ष, विकास अनुरक्षण और गुणात्मक विशेषताओं इत्यादि में शामिल केंद्र की जानकारी प्राप्त की जा सकती है ।

एनपीके 150% (1338 कि.ग्रा/है.) की तुलना में एनपीके + एफवाईएम 5 टन/है.(जवार) - एनपीके (सूरजमुखी) डीआरएसएच-1 की बीज फसल (1603 कि.ग्रा/है.) अधिक रही । एनपीके-एनपीके + बी 1 कि.ग्रा. और एनपीके+एस 20 कि.ग्रा./है. + बी1कि.ग्रा./है. + जिंक5कि.ग्रा./है. को समानांतर पाया । सूरजमुखी का जीनोटाइप सीएसएफएच 8712 और सीएसएफआई-5075 ने पी स्ट्रेस स्थिति में बेहतरीन जड वैल्युम पैदा किया । पोटाशियम X जिंक पौष्टिकता प्रतिक्रिया अध्ययन से ज्ञात हुआ कि पोटाशियम से 60 कि.ग्रा.\है.) (822 कि.ग्रा / है.) और जिंक 05 कि.ग्रा. है. (725कि.ग्रा./है.)। आर्द्रता का दबाव थिनिंग से स्टार बड स्टेज तक नाइट्रोजन के साथ या बिना अक्षवर्ती शाखाओं (लगभग 64 पौधों में अक्षवर्ती शाखाएँ रिकार्ड की गई) की रचना खेत स्तर पर होती है ।

सूरजमुखी में 30 जुलाई और 16 अगस्त के मध्य वाली फसलों में लीफ ब्लाइट की संक्रमणता अधिक होती है । बीजाणु, ओस, आर्द्रता, न्युनतम तापमान आदि रोग की संक्रमणता को प्रभावित करने वाले कारक है । तीन पैथोजेनिक समूहों की Alternariaster helaianthi आइसोलेट की H. occidntalis के प्रति रोग प्रतिक्रिया के आधार पर पहचान की जा चुकी है. H. maximiliani बहुत सारे आइसोलेट प्रतिरोधक है । आन्ध्रप्रदेश और कर्नाटक में सूरजमुखी का कर्ल लीफ वायरस कपास, टमाटर, लोबिया और गाजरघास में सामान्यतः पाया जाता है । रबि की तुलना में खरीफ में SulCv का प्रकोप सूरजमुखी पर अधिक होता है । बीज फसल की पैदावार क्रमशः 21% से 53% तक चुर्णिल मिल्ड्यु रोग की संक्रमणता 30%, 60% के अनुरुप कम हो जाती है । डीओआर बीटी 1 के फार्मूला सेनरजेटिक बोरिक एसिड का घोल Achaea Janata और Helicoverpa armigera के खिलाफ काफी प्रभावी है । B. thuringiensis var. kurstaki के दो स्थानीय आइसोलेटस 127 और 172 एस. लिटुरा के प्रति काफी प्रभावी है । B. bassiana ITCC-4513 के बीटी 127 और कोनिडिया का मिश्रण सूरजमुखी के H. armigera और अरंड के एस लिटुरा पर काफी प्रभावी है । Bacillus thuringiensis var. kurstaki के Novel cry1Aa जीन की पहचान स्थानीय आइसोलेट 52 से की गई है, जिसे एनसीबीआई ने cry1Aa24 का नाम दिया है । सूरजमुखी के जीवद्रव्य लाईंस जीएमयु -1, 126, 843 तथा उन्नत लाइन जीपी 6-208 को टिड्डा प्रतिरोधी पाया गया, 10% से भी कम हानी देखी गई।

नेशनल इन्फोर्मेटिक्स सेंटर और डीओआर द्वारा संयुक्त रुप से विकसित एसएमएस सेवा क्षेत्रीय भाषा (तेलुगु) में आरंभ की गई है । इसके द्वारा सूरजमुखी और अरंड के किसानों को टेक्सट और वाइस मैसेज द्वारा जानकारी प्रदान की जाती है ।

अरंड

एनबीपीजीआर रिजनल स्टेशन, जोधपुर के सहयोग से एक अरंड जीवद्रव्य खोज कार्य आयोजित किया गया तथा 118 जीवाश्म एकत्रित किए गए । एक जीवद्रव्य जीवाश्म को लंबे प्रारंभिक स्पाइक के लिए कैप्सुल से भरा हुआ (49 से.मी) और एक अधिक को बीज वजन 100

बीजों का वजन (59 ग्रा.) हेतु पहचान की गई । धनदेज गांव, वडोदरा जिला, गुजरात के किसान के पास लंबी सघन स्पाइक (130 से.मी) की पहचान की गई । पीजीआरसी, एनबीपीजीआर, नई दिल्ली ने नेशनल आइडेन्टीटी नं. IC0598621 द्वारा डीपीसी -16 में केसर लाइन वाली अद्भूत मार्फोटाइप स्पाइक के शीर्ष पर फूल, लाल तना तथा शुन्य ब्लुम वाली किस्म को रजिस्टर किया है । अति शीघ्र परिपक्वता गुणवाले जीवद्रव्य को तीन जीवाश्मों आरजी 22 / ईसी 168754, आर जी 26/ ईसी 169761 और आरजी 181/ ईसी 168759 की पुष्टि की है । विल्ट और टिड्डा प्रतिरोधक जीवद्रव्य जीवाश्म आरजी 43 चेक डीसीएस-9 की तुलना में 12 दिन पहले फूल खिले । बीज फसल के लिए अधिकतम फसल चेक डीसीएस - 107 की तुलना में आरजी 155 में (3317 ग्रा. / प्रति प्लाट) प्राप्त हुई । उनतीस पेरेंटल लाईंस को पौधे की विशेषताएँ जैसे शीघ्र मजबूती, उच्च टीडीएम और फसल इंडेक्स के लिए पहचान की गई । आरजी 386 (आईसी 432910), आरजी -1624 (आईसी 373981 और आर जी 2787 (आई सी 374338 / आई सी 346591 में गहरी जड़ संचारण तकनीक द्वारा (0-10%) विल्ट प्रतिरोधकता की पुष्टि की गई । पीजीआरसी, एनबीपीजीआर, नई दिल्ली ने आरजी 2818 (आईसी 346622, आईएनजीआर 14004) का अरंड जीवद्रव्य प्रतिरोधक के रुप में चयन कर पंजीकरण किया है । चेक डीपीसी - 9 और डीसीएच - 177 में टिड्डे से 4.0 (0-4 के मापदंड पर) की तुलना में आरजी 2661 (आई सी 374272 (टिड्डे से हानि 0, 0-4 के मापदंड पर) आरजी 43 (आईसी 584671 और 2498 (आईसी 374208) थी, टिड्डा प्रतिरोधक की पुष्टि की गई । जीवाश्म आरजी 2774 (आईसी 346578/ आईसी 374330) में न्युनतम कैप्सुल भेदक हानि 25.8% देखी गई जबकि चेक डीसीएस 9 में यह 85.5% है । वार्डस के न्यूनतम वेरियन्स पद्धति ने कलस्टर विश्लेषण समूहों में 30 जैविक स्ट्रेस प्रतिरोधक जीवाश्म को आठ भिन्न समुह में रखा गया है ।

कार्यक्रम के भाग के तौर पर पिस्टीलेट और नर लाइन्स के अनुवंशिक आधार को विस्तृत करने के लिए, नए जीन पुल के निर्माण के लिए, एक monoecious और पिस्टीलेट लाइन का आरंभ किया गया । दो आशाजनक नर लाइन (12-2 और 12-76) चेक डीसीएस-107 से बीज फसल में वृद्धि (क्रमशः 103%, 87%) की पहचान पीवीटी - 1 से की गई । पाँच आशाजनक नर लाइन (11-2, 11-19, 11-34, 11-60, 11-70) जिनमें श्रेष्ठ चेक डीसीएस -107 के मुकाबले फसल वृद्धि (58-102%) की पहचान जल्दी / मध्यम परिपक्वता और monoecious गुण के लिए की गई. अरंड में jatropha integerrima और tapioca के उपयोग से सीएमएस विकसित करने हेतु विस्तृत संकरीकरण कार्यक्रम आरंभ किया गया । अरंड के लैंगिक क्रियाविधि को जानने के लिए, दो पेरेंटल लाइंस में हिस्टोलोजिकल सेक्शन द्वारा फूल की भिन्न अवस्थाओं की पहचान की गई है । कोई महत्वपूर्ण प्रभाव epimutagen 2-deoxy 5-azactidine का अरंड पेरेंटल लाइन पर नहीं देखा गया परन्तु दो पौधों में नियंत्रण की तुलना में नर फूलों को अधिक अनुपात में देखा गया । सात आशाजनक संकर (सीइएच-40, सीइएच-73, सीइएच-99, सीइएच-68, सीइएच-134, सीइएच-108, और सीइएच-133) की पहचान डीओआर (वर्षा आधारित) और आनंद (सिंचित) संकर मूल्यांकन में श्रेष्ठ चेक जीसीएच सीइएच-7 के मुकाबले अधिक फसल वृद्धि (21-57%) के लिए की गई । संकर सीइएच - 68 और सीइएच - 73 विल्ट प्रतिरोधी है ।

मॉलिक्युलर मैंपिग और लिंकेज विश्लेषण को आरंभ करने हेतु मैपिंग पाप्युलेशन्स और जेनोमिक संसाधन को विकसित करने के कार्य में तेजी लाई गई है । अरंड के लिए एक एसोसिएशन मैपिंग पैनल जिसमें विल्ट प्रतिरोधक और अन्य एग्रोनोमिक गुणों की मैपिंग कर 300 जीवाश्म को एकत्र किया गया । 12 भिन्न अरंड जीनटाइप के संपूर्ण जीनोमी स्किवेंस निर्मित किए गए और 1 मिलियन एसएनपी loci की पहचान की गई । अरंड के बड़े पैमाने पर जीनोटाइप एप्लीकेशन हेतु illumina Infinum के 3072 एसएनपी अभिकल्प तैयार किए गए । अरंड के जमात उपसंकलन के लिए 39 एसएसआर मार्कर्स का मॉलिक्युलर कैरेक्टराइजेशन किया गया । अरंड जीनोमी स्किवेंस में माइक्रोआरएनए प्रिडिक्शन किया गया और 4.054 putative pre-miRNA को निकाल गया । प्रयोगशाला में Cry1Aa transgenic events का (एके 1304 पीबी -1, 804-1) इरी रेशम के कीडे की टाक्सीसिटी बायोऐसे करने पर लार्वे की नश्वरता में फर्क नहीं हुआ परन्तु लार्वे के वजन में 40-50% की कमी आई । एक संशोधित in planta रुपांतरण पद्धति का प्रयास भिन्न जीन संरचना (GUS, ERF1+GUS, AtEBP1, BIK1, AtEBP1+BIK1) और टी$_1$ बीज 600 से अधिक टी$_0$ पौधो से प्राप्त हुए । इस जीन संरचना की Alternaria और Phytophthora रोगों के प्रति प्रभावात्मकता को तंबाकु में मॉडल पद्धति के तौर पर मान्यता मिली । तंबाकु जीन कैसेट (AtEBP1+BIK1) ने एकल जीन कैसेट के मुकाबले Alternaria के प्रति बेहतर प्रतिरोधक क्षमता दिखाई । जीन कैसेट (BIK1+ERF1 और AtEBP1 + ERF1) ने Phytophthora के प्रति अधिकतम प्रतिरोधकता दिखाई है।

Trichoderma spp. के भिन्न समय अंतरालों पर किए गए विभिन्न एकलों की समूह में रहने की क्षमता के परीक्षणों ने अरंड की जड़ों पर प्रभावी रूप से संगठित होने की क्षमता का संकेत दिया है । डीसीएस -107 जीनोटाइप ने N13, Th4d, TV5 और 7316 स्ट्रेन्स से बेहतर कॉलोनाईजेशन दर्शाया है । बिना उपचारित पौधों की तुलना में डीसीएस-107 पौधों ने Th4d से बीज उपचार के बाद Phytophthora nicotianae रोग की संक्रमणता में 85.7% कमी दिखाई है तथा 7316 और N13 से उपचारित बीजों ने 50% से 42.9% की कमी दर्शाई । इसी प्रकार विल्ट (चेक संकर जीसीएच-4) का संक्रमण कम रहा जब मिट्टी में Trichoderma को Fusarium oxysporum f.sp.ricini inoculum के साथ मिलाया गया । Th4d से उपचार से विल्ट का प्रभाव सबसे कम (21%) इसके बाद N13 से (36%) TV5(43%) और 7316(31%) पाया गया ।

पाँच टन एफवाईएम के साथ (100%) आरडीएफ (एनपीके) का उपयोग करने से अधिकतम पैदावार जवार (3852 कि.ग्रा./है.) और अरंड (846 कि.ग्रा./है.) हुई । आर जी 27 और डीसीएच 519 ने TDM (<30%) अरंड अधिकतम ड्राईमैटर स्ट्रेस इंडेक्स (DMSI)(>70%) वॉटर स्ट्रेस के पूर्व दिखाया है । आरजी 89 आरजी 211, आर जी 941 और

आरजी 1618 के जीनोटाइप का आरंभिक तापमान में >75% बीजांकुर जीवित रहते है और भीषण तापमान में >50% जीवित रहते है । आर जी 357 में अधिकतम रिसिनोलिक अम्ल (91%) रिकार्ड किया गया ।

छः पेरेंटल लाइंस जिनमें केएच 12-317-2 केएच 12-1498-1, डीसीएस 81, डीसीएस -89, डीसीएस 108 और डीसीएस 120 तथा सत्रह उन्नत प्रजनन लाइंस जैसे पीएचटी 2013-11, 15, 23, 27, 32, 46 पीचएटी 11-13-56, 60, 72, 73, 77, 78, 79, 80, 81 और पीएचटी 13-2 विल्ट रोग से पूर्णतया मुक्त थे । पालेम और एस. के. नगर से एकत्रित आइसोलेटस 12-1,3-10, 13-19, 20 Fusarium oxysporum f.sp. ricini काफी विषाक्त थे । Oatmeal agar को अमोनियम नाइट्रेट से संशोधित कर, खमीर (1.5 ग्रा.) गैलिक अम्ल (1 ग्रा) और 20%अरंड के फलावरण के अर्क, बीजाणु जनन Botryotinaia ricini के mycelial विकास में सहयोग करता है । Propiconzable0.2% और कार्बेनडेजियम 01.% के घोल का 15 दिन के अंतराल से छिडकाव अरंड में ग्रे रॉट की संक्रमणकता को कम करने तथा फसल की पैदावर बढ़ाने में प्रभावी है । Morphological characterization और ITS sequencing से पता चला है कि अरंड के Phytophothora seed-ling blight से जुडी जाति Phytophora nicotianae है ना कि P. parasitica, P. drechsleri , P palmivora. Agar bit संचारण तकनीक सीडिलिंग ब्लाइट स्क्रिनिंग में प्रभावी है । यदि बीज उपचार कैप्टन 2 ग्रा. /कि.ग्रा., मेटालैक्सिल +मैनकोजेब 0.2% और ट्राइकोडरमा हर्जिएनम Th4dSc 1 ml./ कि.ग्रा से बीज उपचार करने पर Phytophothora की सीलन काफी हद तक कम हो जाती है । उन्नत लाइंस जैसे पीएचटी 2013-14, पीएचटी 2013-30, पीएचटी 2013-32, पीएचटी 2013-41, पीएचटी 2013-46 ,और पीएचटी 2013-79, टिड्डे प्रतिरोधक पाए गए । डीपीसी - 9 के सात म्युटंट सलेक्शंस जैसे आरबी 2011-244, 217, 213, 216, 231, 228 और 214 टिड्डे प्रतिरोधक पाए गए । पत्तों में वैक्स की मात्रा और टिट्डों से हानि में एक बड़ा महत्वपूर्ण एवं नकारात्मक संबंध देखा गया । गेहूँ की कनकी के साथ गन्ने और गुड के मिश्रण ने चावल की कनकी के मिश्रण की तुलना में अधिक लावों का आकर्षित किया । एस. लिटुरा ने प्रकाश जाल के बजाय सेक्स फेरमोन जाल पर अधिक प्रतिक्रिया दिखाई । गेहूँ की कनकी + गुड के साथ 10 ECnovaluron या chlorpyriphos 20 EC के मिश्रण ने 90% से अधिक घातकता दिखाई । कैप्सुल बोरर मादा पतंगों का आक्रमण दूसरे scotophase में देखा गया और फार्मेन ग्रंथी के निचोड से नर पतंगों के अतिसंवेदनशील प्रतिक्रिया का पता चलता है । आईआईसीटी Phero-mone Blend II निरंतर कैप्सुल बोरर पतंगों को आकर्षित करता है । एरंड के जेनोटाइप प्रतिरक्षक (जेसी 12) और संभावित (48-1) में गुदेदार गोलकृमि के छेदक आचरण को देखने से पता चलता है कि बडी संख्या में गोलकृमि जेसी 12 के बजाए 48-1 की जड़ों में प्रवेश कर रहे थे । गोलकृमि प्रतिरोधक जेसी 12 का तीन विभिन्न Fusarium oxysporum f.sp. ricini से प्रतिक्रिया ने दिखाया की यह डीओआर और एस.के. नगर आईसलेट प्रतिरोधक है परन्तु पालेम आइसोलेट के प्रति संभावित है । t. asperellum Tv-2 B76 ने गोलकृमि के अंडज उत्पत्ति को प्रभावित किया है (65 प्रति अंडज समूह) की तुलना में 29 प्रति अंडज समूह ।

कुसुम

1260 जीवाश्मों के मूल्यांकन में से 15 जीवाश्मों ने भीमा के मुकाबले उच्च बीज दर रिकार्ड की (488 ग्र./प्लाट) और ए - 1 (437 ग्र/ प्लाट) तथा जीएमयु 972/ईसी 181180 (907 ग्र./प्लाट) दस उच्च तेल जीवाश्मों जीएमयु 1437/ ईसी 181737 और जीएमयु 1731/ईसी 182117 की पहचान की गई जिनमें तेल की मात्रा 35% से अधिक क्रमश 38.8% और 38.1% थी जो चैक ए - (28.7%) और भीमा (31.7%) से अधिक है । जीवद्रव्य जीवाश्मों ईसी 523368-2 को लगातार तीसरे वर्ष खेत में बनावटी माहु जारी कर माहु प्रतिरोधी पाया गया । जीवद्रव्य लाइन आईसी 13884 (एनआईसी 7133 (एसडी 5-1278)/ जीएमयु 4983 को फ्युजेरियम प्रतिरोधीक्षमता के लिए पहचान की गई तथा पीजीआरसी, एनबीपीजीआर, नई दिल्ली द्वारा पंजीकरण हेतु अनुमोदित की गई एवं पंजीकरण सं. आईएनजीआर 14002 आंबटित की गई । मैक्सिको की कुसुम किस्मों ने अधिकतम तेल मात्रा और ऑलिक अम्ल की मात्रा तथा ईसी 755675 ने अधिकतम तेल की मात्रा 41%अल्फिसोल (राजेंद्रनगर) तथा अधिकतम ऑलिक अम्ल की मात्रा 80.36% काली मिट्टी में रिकार्ड की गई ।

एसएसआर मार्कस के द्वारा मैक्सिको तथा भारतीय कुसुम जमात के उप संकलन की आनुवांशिक भिन्नता तथा अंतर के जेनटाईप का मूल्यांकन किया गया । 89 एसएसआर मार्कस का सेट विकसित किया गया और एसएसआर के नमूना क्रम को एनसीबीआई डेटाबेस (केजे 586129 - केजे 586228 को प्रस्तुत किया गया। 148 जीवाश्मों के आणविक चित्रण जमात के उप संकलन का 50 एसएसआर मार्कस और स्ट्रक्चर विश्लेषण से पता चला कि सब-कोर चार सब-पाप्युलेशन से युक्त होता है तथा एडमिक्सचर समुह (एफ एस टी की रेंज 0.0840 से 0.486) । भारतीय और मैक्सिको के अनुवांशिक सम्बद्धता का विश्लेषण करने पर पता चला कि (एफएसटी =0.396)) दोनों में काफी अंतर है तथा मैक्सिको किस्मे अनुवंशिक आधार को विस्तृत करने में बहुत उपयोगी स्त्रोत होगा । जीपीएटी 9 और डीएजीएटी जीन के इनप्लांटा रूपांतरण का प्रयास किया गया । जीयूएस विश्लेषण के आधार पर टी- 300 प्लांट में दूगने जीन कैसेट और 30 प्लांटो के सिंगल जीन कैसेट प्राप्त हुए ।

वैरिएटल जीन समिति ने कुसुम संकर डीएसएच 185 की संपूर्ण भारत में खेती के लिए पहचान की है । दो अधिक फसल देने वाली विल्ट प्रतिरोधी डीसीएच - 250 और डीसीएच 249 आगे बढ़कर एआईसीआरपी में एएचटी-1 पर पहुँच गए । कई स्थानों पर किए प्रारंभिक परिक्षणों में डीसीएच - 253 ने संकर चैक एनएआरआई -एच 15(1510 कि.ग्रा. /है) के मुकाबले 17% अधिक (1734 कि.ग्रा./है.) फसल प्राप्त हुई । आठ हाईब्रीडों ने चेक एनएआरआई-एच 15 (1746 कि.ग्रा./है) के मुकाबले 17-30% अधिक बीज फसल (2038-2266 कि. ग्रा./है)बारिश वाली स्थिति में डीओआर, हैदराबाद में प्राप्त हुई है । नर पैतृक लाइन सुधार कार्यक्रम में एक उच्च तेल (37%) पेरेंट (एसएफएस 9943) पाँच विल्ट प्रतिरोधी पेरेंट (0-10% तीन वर्षों से विल्ट संक्रमित खेत में) और तीन विल्ट सीडलिंग ब्लाइट प्रतिरोधी पेरेंटल लाइनसे जैसे डब्ल्यु 0502028

डब्ल्यु - 2026 और डब्ल्यु 2037-9 (20% रोग की तीव्रता ग्रीन हाऊस में एगर डिस्क एनओक्युलेशन तकनीक) विकसित की गयी । चार अंतरविशिष्ट कृत्रिम अधिकतम 20% रिकार्ड किए गए अल्टरनेरियाक की संक्रमणता का दबाव लगातार चौथे वर्ष भी रहा । इन्ट्रोग्रेसड विशिष्टताएँ जैसे अधिक आधार शाखाएं और C. Oxyacantha से अधिक कैप्सुल से छः अधिक फसल वाली बीसी1 एफ 6 अंतरविशिष्ट कृत्रिम जिनसे पीबीएनएस- 12 (4.65 कि.ग्रा./प्रति खेत) के मुकाबले 32-54% अधिक फसल प्राप्त हुई । दो नए अंतरविशिष्ट सम्मिश्रण पीले पत्तों के रूपांतरण और बौने किस्म के विकसित और स्थापित किए गए । इक्कासी एफ 5 में अधिकतम ऑलिक की मात्रा 72 से 82% दर्ज की गई ।

कैप्टन 0.2% और टी. हर्जीएनम टीएच 4 डी 2 मी.ली. / कि.ग्रा. से बीज उपचार करने पर फ्युजेरियम और फाइटोपथोरा के प्रभाव को कम करने में प्रभावी रहा । जबकि कैप्टन 0.2% और सैमोक्सिनिल मैनकोजेब के उपचार से मैक्रोफोमिना रूट रॉट का प्रभाव कुसुम में कम रहा । trichoderma asperellum TaDOR673WP (10g/kg) carbendazim (2g/kg)अत्याधिक प्रभावी रहे तथा fusarium wilt का प्रभाव काफी कम रहा तथा कुसुम की फसल में वृद्धि हुई ।

तने के बढ़ने के समय माहू का खतरा बना रहता है तथा यह स्थिति कुसुम के छाटने के लिए उपयुक्त होती है । कुसुम में माहू की प्रतिरोधकता वंशगत होता है । जीवाश्म इसी 523368 की प्रारंभिक व्यवस्था में Antixenosis माहु के विरुद्ध कार्य करता है । कुसुम में माहु के विरुद्ध कोई antibiosis नहीं देखा गया ।

तिल

विभिन्न एआईसीआरपी केंद्रों तथा एनबीपीजीआर नई दिल्ली से 27 चुनिंदा जीवाश्म एकत्र किए गए । 15 जंगली किस्म के जीवाश्म (S. malabarcium 11, S-Radiatum -1, S. Laciniatum -3) केरल से एकत्रित किए गए। कई केंद्रों पर परिक्षण की योजना heterosis को स्थापित करने के लिए बनाई गई। 24 सामान्य नर लाइनों को तीन मादा लाइनों से क्रास कर 72 प्रायोगिक संकर बनाए गए जिनका ग्रीष्मकाल 2014 में हैदराबाद और धारवाड़ तथा खरीफ 2014 में अमरेली, मंडोर और जलगाँव के केंद्रों पर परीक्षण किया गया। डीएसएस-9x एम टी 10-81, डीएसएस 9 x प्राची, डीएस-35 x जेएलएस 9707और डीएसएस. 9x डीएस 30 तीन नेशनुल चैक के मुकाबले तेजी दिखाई है ।

फ्रंटलाइन और जनजाति उप-योजना प्रदर्शन

तिलहन और तिलहन आधारित फसल पद्धति पर चार हजार छःसौ तेरह फ्रंटलाइन प्रदर्शन (अरंड 415), सूरजमुखी (500), कुसुम (400), तिल (361), रामतिल (328), अलसी (460), सरसो (537),मुंगफली (832), सोयाबीन (680), खेती की पद्धति (50) और एसटीसीआर प्रौद्योगिकी (50)वर्ष 2013-14 में आईएसओपीओएम तिलहन, दलहन, तेलताड और मक्का के समन्वित कार्यक्रम के अंतर्गत किए गए।

सूरजमुखी के पाँच फ्रंटलाइन प्रदर्शन (एफएलडी) मिट्टी के परीक्षण के आधार पर प्रारंभिक अवस्था में पौष्टिकता प्रबंधन, सल्फर का उपयोग तथा बोरॉन का छिड़काव तथा पूरे पैकेज के 25 प्रदर्शन आंध्र प्रदेश के प्रकाशम जिले में आयोजित किए गए । मिट्टी परीक्षण पर आधारित पौष्टिकता प्रबंधन के लिए मिट्टी परीक्षण के आधार पर ही किसानों का चुनाव किया गया । सल्फर के एफएलडी के लिए जहाँ किसान सल्फर का कोई उपयोग नहीं करता था उसकी तुलना में वहाँ सल्फर 25 कि.ग्रा. /है. का विकसित प्रौद्योगिकी में उपयोग किया गया । बोरॉन के एफएलडी में जहाँ किसान बोरोंन का कोई उपयोग नहीं करता था उसकी तुलना में वहाँ बोरोक्स 2 ग्रा./ लि. का फूल के शीर्ष पर छिड़काव किया गया । पुरे पैकेज में बीज फसल में 20.9% की वृद्धि हुई । इसके साथ ही किसानों द्वारा मिट्टी परीक्षण आधारित पौष्टिकता प्रबंधन में (16.6%) सल्फर (10.2%), और बोरॉन में (7%) वृद्धि हुई । किसानों को पूरे पैकेज, मिट्टी परीक्षण आधारित पौष्टिकता प्रबंधन, सल्फर और बोरॉन पर अतिरिक्त आय 6900, 5680, 3750 और 810 की हुई ।

बावल में आयोजित एफएलडी के प्रभाव निर्धारण से ज्ञात हुआ है कि अरंड (2365 कि.ग्रा. /है) के साथ मुँग (500 कि.ग्रा. /है) बोने से किसान को मुंग (750 कि.ग्रा. /है) - सरसों (2125 कि.ग्रा. /है) और मुंग (750 कि.ग्रा. /है) - गेहुँ (4438 कि.ग्रा. /है) से अधिक लाभ होता है । अन्य उपजों के मुकाबले अरंड - मुंग से अतिरिक्त आय प्राप्त होती है । अरंड पर अनंतपुर में आयोजित एफएलडी से किसान द्वारा (760 और 713 कि.ग्रा. /है) के मुकाबले डीसीएच 177 (1090 कि.ग्रा. /है) और डीसीएच (519 कि.ग्रा. /है) की श्रेष्ठता का पता चला । किसान की मुख्य समस्या अच्छी गुणवत्ता के बीज का अभाव, मजदूरों का अधिक परिश्रामिक और जरूरत के समय उनकी कमी, विपणन सुविधा का अभाव तथा फसल की कम कीमत, खेती की जरूरतों की ऊंची कीमते, विल्ट के कारण फसल हानि, अनियमित मौसम जैसे फसल ऊगने के समय पाला पडना और विकसित उत्पादन प्रौद्योगिकी की कम जागरूकता है । हरियाणा के किसानों ने अपने फीड़बैक में बताया कि पाला प्रतिरोधी किस्म विकसित करने तथा उसका प्रबंधन, अच्छी लाभदायक कीमत, प्रशिक्षण तथा अनुसंधान स्टेशनों की यात्रा द्वारा नव विकसित प्रौद्योगिकी को सीखने की आवश्यकता है । अरंड की खेती को मेवट, रेवाडी, महेन्द्रगढ, फतियाबाद, झाझर, हिस्सार और गुडगांव में विस्तारित करने की काफी संभावना है । अरंड का सूचना पोर्टल आठ माड्युल के साथ विकसित किया गया जिसमें किसानों से संबंधित सूचना, खेती के लिए उपयोगी क्षेत्र, प्रबंधन अभ्यास, औसत फसल, तेल की मात्रा इत्यादि से संबंधित जानकारी है । कीमतों की जानकारी तथा विभिन्न राज्यों की प्रमुख मंडियों से संबंधित सूचना डीओआर की वेबसाईट पर उपलब्ध है ।

जनजाति उपयोजना हेतु अरंड के लिए आंध्र प्रदेश के 23 गाँवों, राजस्थान के 1 गाँव, कर्नाटक के 1 गाँव और तमिलनाडु के 12 गाँवों, सूरजमुखी के लिए आंध्र प्रदेश के 4 गाँवों, कर्नाटक के 2 गाँवों और पं. बंगाल के 24 गाँवों। कुसुम के लिए आंध्र प्रदेश के 5 गाँवों जनजाति से निर्धनता को दूर करने के उद्देश्य से चलाए गए । कार्यक्रम के अंतर्गत 1238 डीओआर के मैनडेट फसलों (अरंड 778, सूरजमुखी -310 और कुसुम -150) का प्रदर्शन एनजीओ के सहयोग से किया गया ।

DOR

वार्षिक प्रतिवेदन

Annual Report

2013-14

The Directorate

* Mandate
* Staff Position
* Financial Statement
* Resource Generation


DOR

THE DIRECTORATE

The establishment of All India Coordinated Research Project on Oilseeds (AICORPO) started 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 a Project Director as its administrative head and seven Project Coordinators for these oilseed crops. 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. 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 have been 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, castor and safflower crops in the country through All India Coordinated Research Project (AICRP) operating at 31 locations spanning over 14 states. In 2013, the research activities of sesame crop have been entrusted to DOR by the Council.

Mandate

- Augmentation, maintenance and characterization of genetic resources
- Basic, strategic and applied research to increase productivity, oil content and quality
- Socio-economic research for assessing sustainability of technologies and transfer of technology
- Coordination of multi-location research to develop varieties and technologies of national and regional importance through All India Coordinated Research Project on sunflower, castor and safflower.

Staff position as on March 31, 2014

Category	Sanctioned	Filled	Vacant
Scientific	43*	39	4
Technical	51	44	7
Administration	29	24	5
Skilled supporting	33**	23	10
Total	**156**	**130**	**26**

* including one RMP

** including 8 additional posts sanctioned by the Council for which administrative approval is yet to be received.

Financial Statement (2013-14)

Head of Account	Allocation (₹ in lakhs)				Expenditure (₹ in lakhs)			
	DOR Plan	AICRP (OS + S&N + LIN)	Non Plan	Total	DOR Plan	AICRP (OS + S&N + LIN)	Non Plan	Total
A. GRANT IN AID - CAPITAL								
1. Equipment	23.95	0.00	8.00	31.95	23.95	0.00	7.81	31.76
2. Library	15.05	0.00	0.00	15.05	15.05	0.00	0.00	15.05
3. Furniture	1.00	0.00	2.00	3.00	1.00	0.00	2.00	3.00
B. GRANT IN AID - SALARIES								
Establishment Charges	0.00	1809.69	1080.00	2889.69	0.00	1809.69	1050.00	2859.69
Overtime Allowance	0.00	0.00	0.25	0.25	0.00	0.00	0.17	0.17
Pension	0.00	0.00	68.28	68.28	0.00	0.00	68.28	68.28
Wages	0.00	0.00	250.00	250.00	0.00	0.00	234.44	234.44
C. GRANT IN AID - GENERAL								
TA	25.00	43.65	6.00	74.65	25.00	43.65	6.00	74.65
Res. & Operational Expenses	262.29	181.51	45.00	488.80	262.29	181.51	44.85	488.65
Administrative Expenses	40.01	0.00	150.25	190.26	40.01	0.00	150.25	190.26
Miscellaneous Expenses	2.70	0.00	8.00	10.70	2.70	0.00	8.00	10.70
Need Based Research	0.00	54.15	0.00	54.15	0.00	54.15	0.00	54.15
Tribal Sub-Plan	40.00	88.00	0.00	128.00	40.00	88.00	0.00	128.00
Total	**410.00**	**2177.00**	**1617.78**	**4204.78**	**410.00**	**2177.00**	**1571.80**	**4158.80**

AICRP on Sunflower, Castor & Safflower

	Allocation (₹ in lakhs)	Expenditure (₹ in lakhs)
Grants for Capital (₹)	0	0
Grants for Salaries (₹)	7,72,65,000	7,72,65,000
Grants for General incl. TSP (₹)	1,84,35,000	1,84,35,000
Total	**9,57,00,000**	**9,57,00,000**

AICRP on Sesame & Niger

Grants for Capital (₹)	0	0
Grants for Salaries (₹)	5,72,04,000	5,72,04,000
Grants for General incl. TSP (₹)	97,96,000	97,96,000
Total	**6,70,00,000**	**6,70,00,000**

AICRP on Linseed

	Allocation (₹ in lakhs)	Expenditure (₹ in lakhs)
Grants for Capital (₹)	0	0
Grants for Salaries (₹)	4,65,00,000	4,65,00,000
Grants for General incl. TSP (₹)	90,00,000	90,00,000
Total	**5,55,00,000**	**5,55,00,000**

Resource Generation (2013-14)

Particulars	Amount (₹ in lakhs)
Sale of Farm Produce	5.08
Sale of DOR Publications & Tender Forms	0.07
Rent	9.50
License Fee	1.64
Interest earned on Loans & Advances	7.59
Analytical Testing Charges	1.18
Interest earned on STDR	38.94
Training	2.55
Miscellaneous Receipts	14.73
Total	**81.28**

Funds Received for Externally Funded Projects (2013-14)

Particulars	Amount (₹ in lakhs)
DST Projects	19.86
Deposit Schemes	153.9
Total	**173.76**

DOR

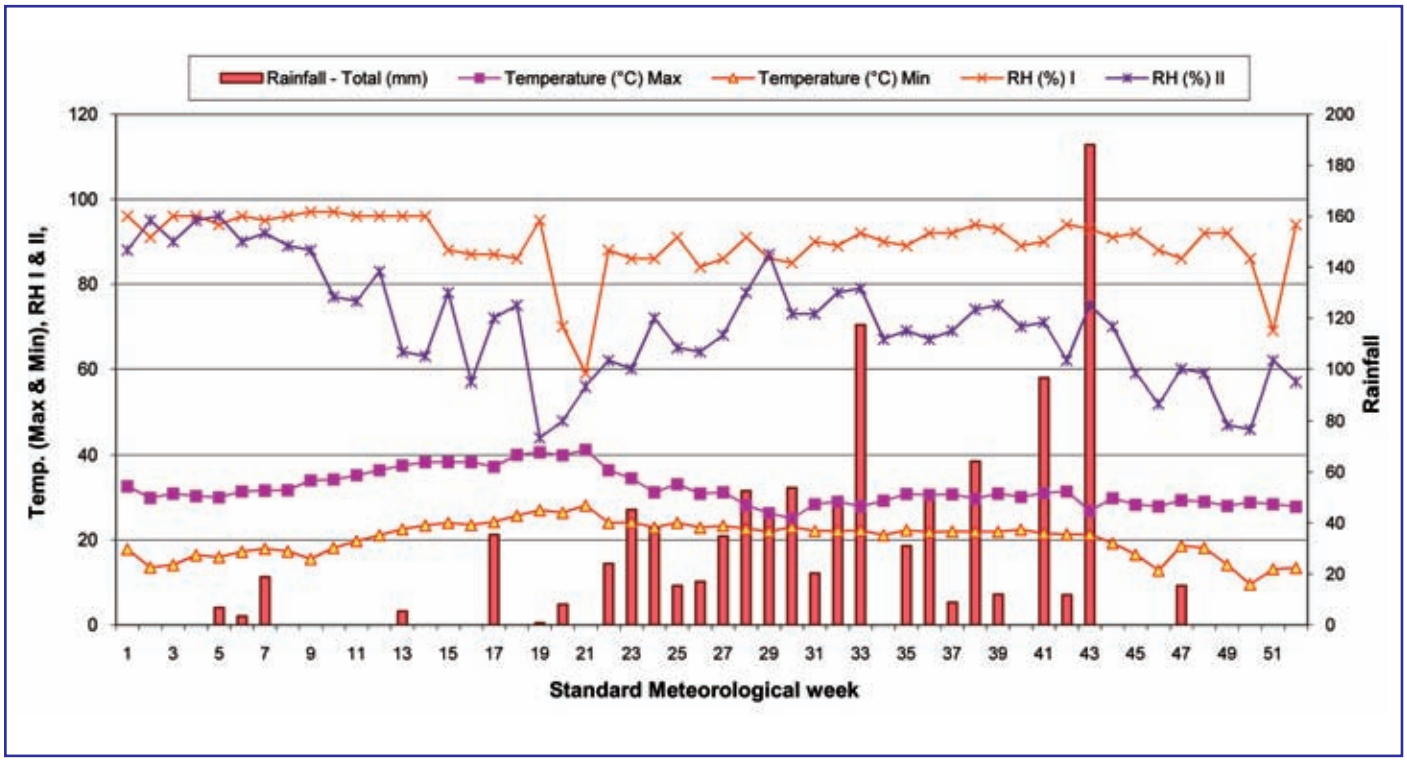
वार्षिक प्रतिवेदन

Annual Report

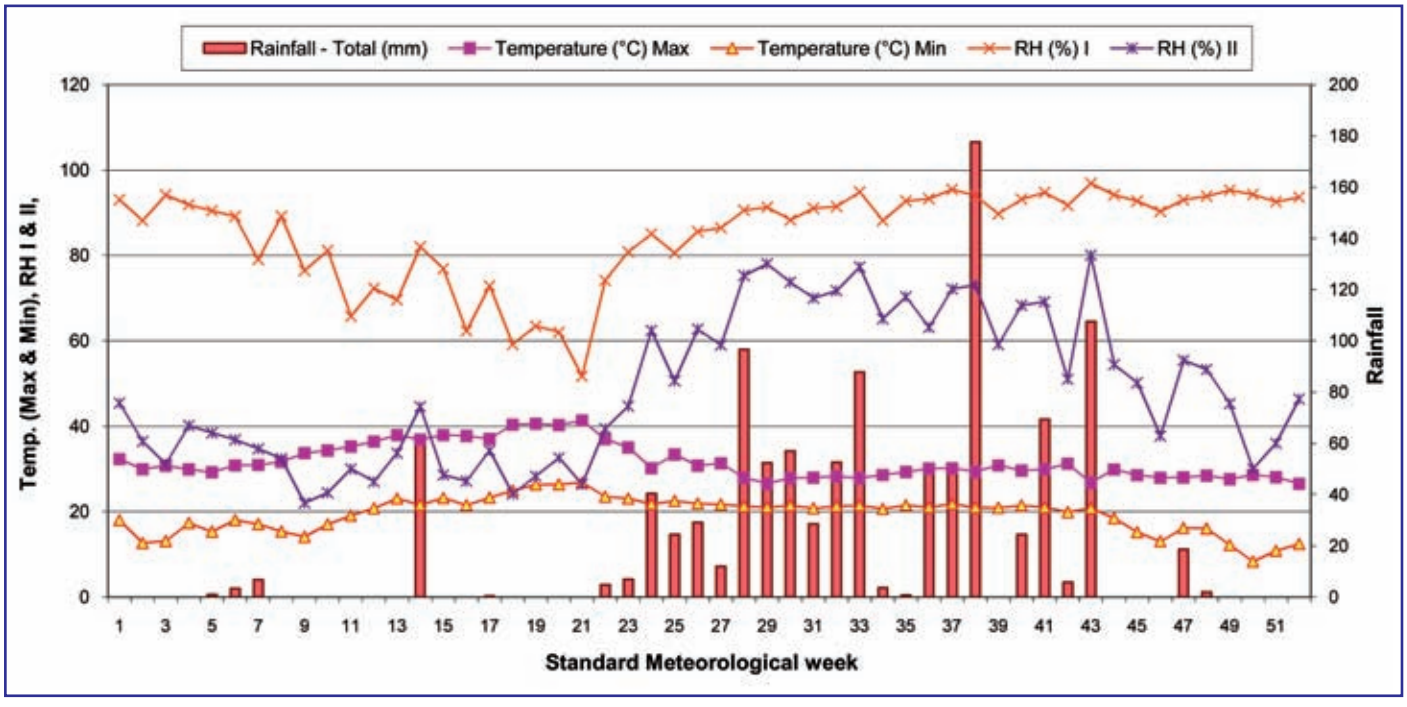
2013-14

Research Achievements

* Sunflower
* Castor
* Safflower
* Sesame
* Other Scientific Activities
* AICRP



Weekly Weather Data at DOR-Narkoda Farm: 2013



Weekly Weather Data at DOR-ICRISAT Farm: 2013

SUNFLOWER

CROP IMPROVEMENT

Management of genetic resources

The Germplasm Management Unit is maintaining 1750 of 2140 accessions under medium term storage in the central cold storage facility available at DOR followed by multiplication and rejuvenation at regular intervals. Major emphasis was given on confirmation of the data through characterization and evaluation of 2000 accessions. These accessions were characterised and documented based on 34 descriptors used for DUS testing while 1750 accessions were evaluated based on eight agronomic characteristics *viz.,* days to 50 per cent flowering, days to maturity, head diameter, plant height, number of leaves per plant, 100 seed weight, seed yield per plant and oil content.

Identification of trait specific germplasm

Two germplasm accessions i.e., DOR O-P33 (oleic acid content >70%) and high phosphorus acquisition genotype 42B were added to the existing 37 trait specific germplasm accessions.

Trait specific germplasm accessions identified

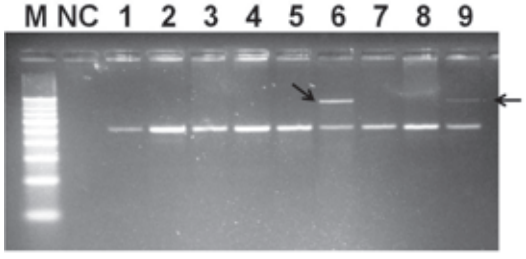
Trait	Germplasm accessions
High yield (≥40 g/plant)	GMU 1032, GMU 503, GP2 1217, GP6 1475
High to medium yield coupled with medium to high oil (yield >30 g/plant and oil >30%)	GMU 1075, GMU 1108, GP6 211
High oil (>35%)	GMU 1132, GMU 56
Early maturity (75 days)	GP 41244, GMU 104
Dwarfness (<65 cm)	GMU 62, PSCMM-185
Late maturity (>110 days)	Selection DRSF 109, GMU 1020
Powdery mildew tolerance	GMU 520, GP6-79
White pollen	GMU 933, DRSI P48
High phosphorus acquisition	42B
Oleic acid content (<70%)	DOR O-P33
Ornamental type	GMU 668

A mutant with three stems from base observed during k*harif* 2012 in the germplasm bred true for the character in progeny rows raised during *kharif* and *rabi* 2013 with normal seed setting. The seed yield (2 g/pl) and oil content (34%) of stem fasciated mutant were also on par with the non-mutated sunflower plants.

Sunflower mutant with 3 stems

Evaluation of trait specific germplasm and establishment of wild sunflower

Sixty two newly procured germplasm accessions were evaluated for dwarfness, oil content, earliness, oleic acid content and test weight. Accessions with plant height of 23.2 cm, oil content of 39%, 46 days for 50% flowering and with 100-seed weight of more than 12 g were identified. Confirmation of high oleic acid in trait specific germplasm and high oleic CMS lines from Serbia using microsatellite markers was done. The *fad2* primers, based on earlier reports, were used to detect the high oleic specific amplicon in the high oleic lines. Nine genotypes with low and high oleic acid content were used to constitute the panel (KBSH-44, DRSH-1, CMS 17 A, 6D-1, TSG-12, TSG-17, TSG-38, UK-90, DOP-80). Among nine genotypes, the high oleic genotypes (TSG-17 and DOP-80) showed the expected specific band of 900 bp size while the low oleic genotypes (KBSH-44, DRSH-1, CMS 17 A, 6D-1, TSG-12, TSG-38, UK-90) did not show this band.



PCR analysis of high and low oleic genotypes with *fad2* primers
Expected size band (900 bp) is indicated by arrow

Augmenting germplasm

Twenty nine annual and four perennial wild *Helianthus* species obtained during the year under report were successfully established. From these, *H. niveus* (Niv 1452) that exhibited resistance to powdery mildew has been crossed with the susceptible line 2023B for studying the genetics of inheritance.

Development of sunflower hybrids suitable to different agro-climatic conditions

Identification of maintainer/restorer lines for different CMS sources

Two diverse cytoplasmic sources *viz.,* PET (COSF-7A, COSF-1A, CMS-234A, CMS-10A, CMS-2A, CMS-7-1A, CMS-852A) and I (IMS-852A) were crossed with 20 inbreds in a line x tester design to assess the fertility reaction of inbred lines. Evaluation of F_1s for pollen fertility reaction identified the following common restorers and maintainers for majority of the CMS lines while some of the restorers for PET source were maintainers for I source CMS (IMS-852A) *viz.,* RHAGKVK-1, AKSFI-49-3, AKSFI-49-4, AKSFI-42-1, AKSFI-46-2, HOHAL-37, CSFI-5055, CSFI-5261, CSFI-5133, CSFI-5185, CSFI-5033, CSFI-5075, RHAGKVK-2, Selection-I, IB-60, IB-61. The restorer lines identified would help in development of hybrids with diverse cytoplasm.

List of common restorers and maintainers

Restorers	Maintainers
AKSFI-49-3, AKSFI-49-4, AKSFI-46-2, RHAGKVK-1, RHAGKVK-2, CSFI-5134, CSFI-5133, CSFI-5185, CSFI-5075, HOHAL-37	CSFI-5033, IB-50, IB-60, IB-61, IB-67, IB-101

Evaluation of inbreds

Six inbreds of 60 genotypes received from AICRP centres *viz.,* Akola, Bengaluru, Coimbatore, DOR, Ludhiana and Raichur for the National Crossing Programme confirmed for second year for their yield superiority and early maturity during *rabi* 2013. Some of these inbreds were also found promising for specific traits.

Promising inbreds for seed yield and early maturity

Inbred	Seed yield (g/plant)	Days to maturity
AKSFI-49-4	31.6	81
HOHAL-23	48.5	87
HOHAL-34	35.2	92
CSFI-5033	35.2	86
CSFI-5056	39.4	89
CSFI-5134	49.8	94

Promising sunflower inbreds for specific traits

Trait	Promising inbreds
High autogamy	CSFI-5134 AKSFI-49-3
Thin hull	AKSFI-51-6-1
Early maturity	RHAGKVK-2
Dwarf plant height	CSFI-5090
High oil content (38-42%)	RHA-288, RHA-6D-1, RHAGKVK-1 HOHAL-23, R-630, CSFI-5133, AKSF-52-2, GPR-102, GPR-58
Stearic acid (10%)	AKSFI-52-2, CSFI-5033

Construction of gene pool

Gene pools for maintainer and restorer lines were initiated by allowing random mating in *rabi* 2013 among high yielding maintainer (B) and multi or mono-headed restorer lines with good combining ability.

Lines used for construction of gene pool

Maintainers	Restorers
CMS-378B, CMS-17B, CMS-234B, ARM-243B, CMS-7-1B, CMS-335B	RHA-6D-1 (multi-headed), RHA-95C-1 (multi-headed), GPR-58 (multi-headed), P-62R (mono-headed), CSFI-5075 (mono-headed)

Evaluation of experimental hybrids

Seven hybrids among 160 new hybrids evaluated during *kharif* 2013 were promising for seed yield per plant (40.1-47.7 g), oil content (30.7-44.3%) and early maturity (81-88 days) compared to two checks. Two hybrids *viz*., CMS-234A x CSFI-5133 and CMS-234A x RHAGKVK-2 were promising for high oil content compared to DRSH-1.

Promising early maturing sunflower hybrids for high seed yield and oil content

Promising crosses	Days to maturity	Seed yield/plant (g)	Oil content (%)	Oil yield (g/plant)	% superior over DRSH-1 (Oil%)
CMS-234A x RHAGKVK-2	83	41.7	42.10	17.55	4.83
CMS-852A x AKSFI-46-2	83	40.9	39.56	16.18	-1.49
CMS-852A x CSFI-5133	81	41.1	39.23	16.12	-2.31
CMS-852A x CSFI-5075	85	47.7	40.27	19.20	0.27
CMS-7-1A x RHAGKVK-2	88	40.1	38.58	15.47	-3.93
CMS-234A x CSFI-5133	82	39.2	44.32	17.37	10.36
IMS-852A x CSFI-5134	87	41.2	30.72	12.65	-24.87
DRSH-1 (Check)	95	35.2	40.16	14.13	-
KBSH-44 (Check)	98	42.6	36.82	15.68	-8.32

Prebreeding

Pre-breeding for genetic enhancement of yield traits in sunflower was initiated through interspecific hybridization involving parental lines of hybrids and wild diploid annual species. Seventy-six accessions of six wild diploid annual species were imported from USDA. Twenty-nine accessions were shared with different AICRP centres to initiate crossing programme with promising B lines. A wild garden has been established at DOR farm.

***Helianthus* species imported from USDA**

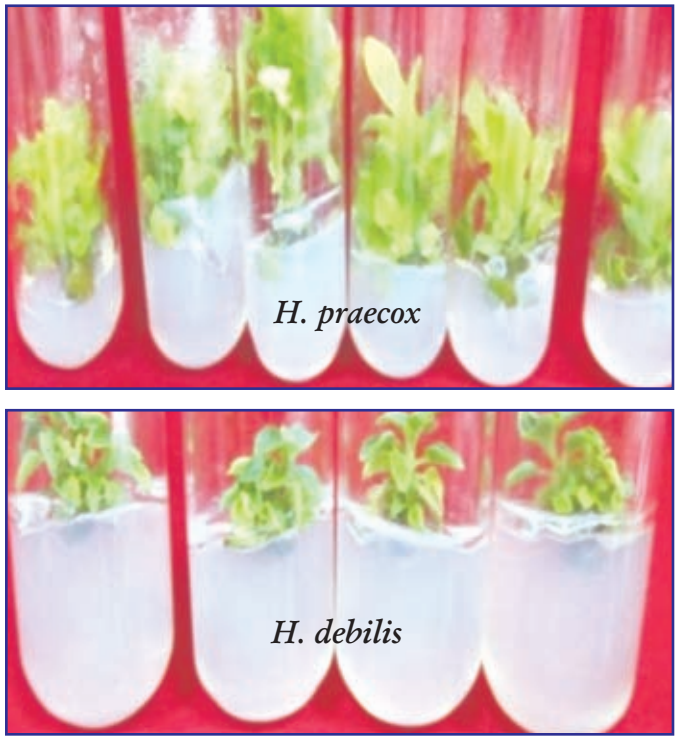
Species	Sub-species	Number of accessions
H. annuus (wild)	-	28
H. debilis	*debilis*	5
	cucumerifolius	4
	silvestris	5
	vestitus	2
	tardiflorus	3
H. praecox	*praecox*	5
	hirtus	5
	runyonii	5
H. niveus	*canescens*	4
H. argophyllus	-	1
H. petiolaris	*petiolaris*	4
	fallax	5

Interspecific hybridization has been initiated using selected B lines from the AICRP centres (LSF08-B, CMS67-B, CMS335-B and COSF6-B) and DOR (ARM-243B). Interspecific crosses were made with wild *Helianthus annuus, H. argophyllus* and *H. petiolaris* species in both directions by hand emasculation. Crosses involving cultivated sunflower (ARM-243B) and *H. annuus* (wild) (ANN-1270, ANN-1272, ANN-232, ANN-243, ANN-1624, ANN-1790, ANN-1529 and ANN-1483), *H. petiolaris* (PET-2126) and *H. argophyllus* (ARG-1317 and ARG-1807) were successful.

To identify highly autogamous individuals from the ARM-243B population, over 1000 plants were raised from the breeder seed and seed yield under selfing was measured. Single plant yield under selfing ranged from 0.1 to 30.0 g. Over 40 plants were selected based on high seed set (20-30 g/plant) under selfing. The oil content in the selected plants ranged from 29.6 to 39.9%. Ten plants having high selfed seed set (>20 g/plant) and high oil content (>37%) were selected for further testing and advancement to improve the autogamy in ARM-243A/B pair.

Molecular tagging and mapping of powdery mildew resistance

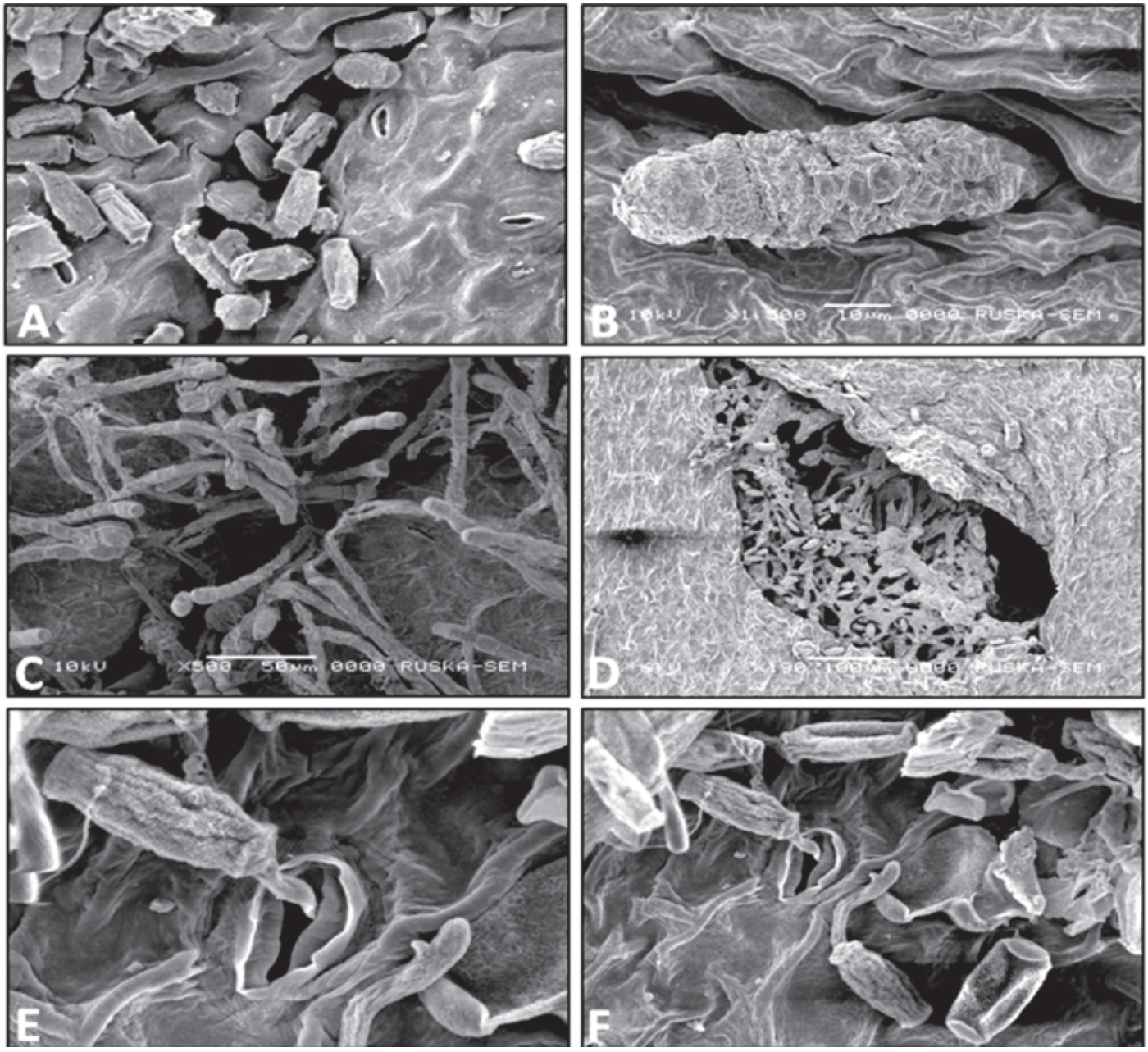
Wild sunflowers are a valuable source of resistance for powdery mildew but their multiplication, seed increase and purity maintenance is a problem particularly, in diploid annuals, which are propagated through seeds. Hence, mass propagation of wild annual *Helianthus* species (*H. praecox* 1823, *H. debilis*-T-689, *H. debito*-841 and *H. niveus*1452) through tissue culture was done to ensure continuous availability of the plants for interspecific hybridization and transcriptome analysis. Axillary buds were cultured on Murashige and Skoog medium with 0.5 mg/l benzyladenine (BA) followed by transfer to the multiplication medium which consisted of either 0.2 mg/l of BA or 0.5 mg/l of kinetin. Rooting was successful on medium supplemented with 0.5 mg/l NAA.



Propagation of wild diploid annual sunflowers

Plant pathogen-interaction studies in powdery mildew infection process

The infection process of *Golovinomyces cichoracearum* was studied in sunflower which included resistant (PI642072- TX16R) and susceptible (PS 2023A) genotypes. Inoculation was done by dusting the conidia on leaf lamina using camel hairbrush. Leaves were sampled, at 6 h, 24 h, and 2 to 10 days following inoculation cleared and stained (Lacto phenol cotton blue). Microscopic analysis of the development of powdery mildew showed infection within 6 h of inoculation with dense hyphal growth and penetration in susceptible genotype when compared with the resistant genotype in which hyphal growth was sparse and observed only after 3 dpi. SEM analysis showed that penetration of conidia into host occurred most frequently through the junction of the epidermal cells (anticlinal wall) while penetration through stomata was rarely observed.



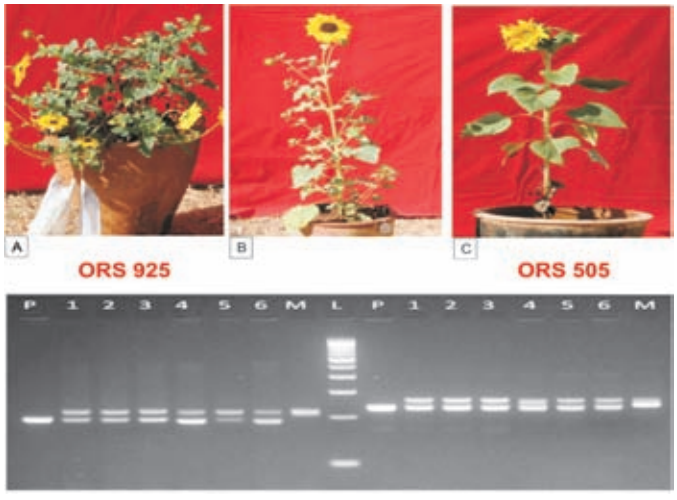
Scanning electron microscopic observation of penetration process of *G. cichoracearum* conidia in sunflower
Penetration through the junction of the epidermal cells (A, B, C), through mechanical damage (D) and stomata (E, F)

Biochemical estimation of defense related enzymes particularly ROIs induced enzymes during powdery mildew infection

The accumulation of reactive oxygen intermediates (ROIs) such as superoxide anion radicals (O_2^-) and hydrogen peroxide (H_2O_2) was studied using nitro blue tetrazolium (NBT) and 3,3-diaminobenzidine (DAB). Quantitative estimation of H_2O_2 levels and important oxidative stress related enzymes like peroxidase, ascorbate peroxidase, superoxide dismutase, glutathione reductase was also done. Results suggest that the resistance in sunflower to *G. cichoracearum* is associated with a hypersensitive response (HR) which fails to halt the pathogen. This HR may be triggering systemic acquired resistance (SAR) which takes place in the upper part of resistant plant and eventually leads to the arrest of the pathogen.

Interspecific hybridization with powdery milduw resistant donor species

Interspecific crosses of cultivated sunflower (Morden, 2023B) were effected with three diploid annual species *viz., H. praecox, H. debilis* and *H. niveus*. The F_1s of crosses involving *H. praecox* were confirmed through morphological characters (leaf size and serration, branching, disc colour, capitulum size), pollen sterility/fertility and molecular markers.



Confirmation of interspecific hybrid of *H. praecox* 1823 and Morden

A. H. praecox 1823; B. Hybrid; C. Morden;
and hybrid confirmation using SSR markers
P- *H. praecox* 1823, M- Morden, l-6 denote number for the hybrids and
L- Molecular size marker, 100 bp ladder

A set of 92 SSR primers were tested for hybridity confirmation of which ORS 925 and ORS 505 were used. All the F_1 hybrids with *H. praecox* as female parent were found resistant to powdery mildew.

Characterization of the mapping population for powdery mildew resistance in PS2023A x TX-16R (PI 642072)

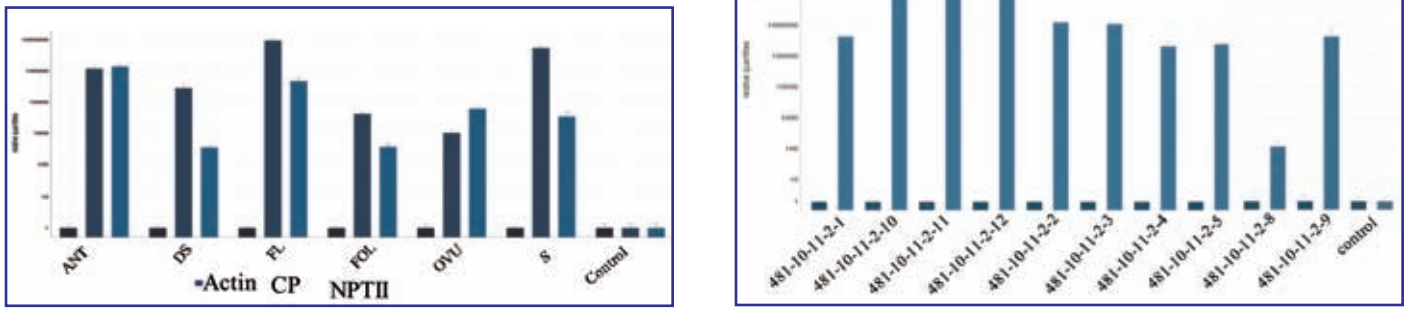
Among the identified sources of resistance to powdery mildew, PI 642072 (TX-16R) was selected as resistance source for mapping gene(s) that conferred resistance to powdery mildew in sunflower. The segregation of resistance to powdery mildew in F_2 population showed that resistance to powdery mildew was quantitative and the material was advanced for RIL development through single seed descent method. The populations involving cultivated sunflower with USDA-25 and TX-16R were advanced to the F_6 stage. Crosses involving the resistant accessions (TX-16R x ID-25; TX-16R x USDA-25; USDA-25 x ID25) for combining the powdery mildew resistance traits were advanced to the F_4 generation.

RILs of PS2023A x TX-16R showing contrasting reaction to powdery mildew

Multiplication and characterization of transgenics conferring resistance to necrosis disease

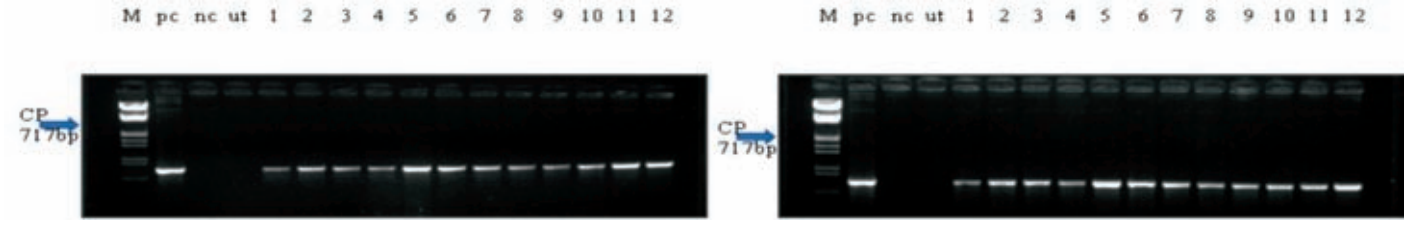
Expression analysis was carried out for homozygous line of the event 481-10-11-2 and

heterozygous line of the event 753-7-3 with actin gene as internal control. qRT-PCR analysis was done to check the expression of TSV-CP gene in different organs (i.e., fully opened leaf, flag leaf, anthers, ovules, seed) for event 481 for CP, *npt*II and actin genes. Expression was high in flag leaf followed by mature seed, anthers, developing seed, fully opened leaf and ovules. Gene expression was high in the homozygous lines of event 481 and the CT values for CP gene ranged from 16.0 to 22.0 and 12.0 to 15.0 for *npt*II gene. For the heterozygous line, CT values ranged from 24.0 to 27.0 while in control it was more than 32.0.

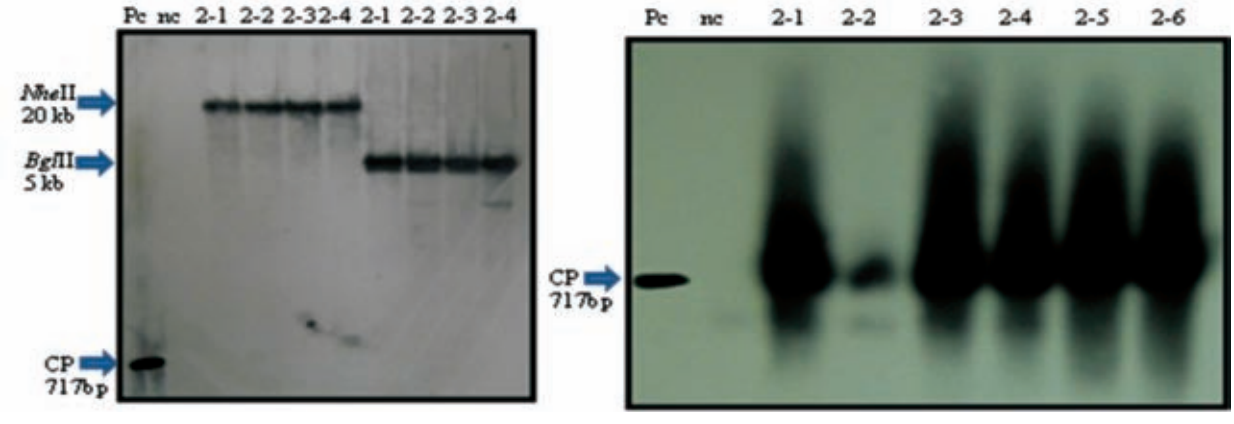


Expression analysis of CP gene using Real-time PCR in different plant parts and different plants of event No 481
ANT- Anther, DS- Developing seed, FL-Flag leaf, FOL- Fully opened leaf, OVU- Ovule, S-Mature seed

Seed multiplication and molecular analysis (PCR, Southern and Northern analysis) of the event 481 and four other events (237, 247, 648 and 753) was done along with their null segregants for carrying out bio-safety and viral bioassays. All the events were subjected to virus challenging using 15 to 20-day-old seedlings and the events showed resistance to necrosis disease under artificial sap inoculation conditions.



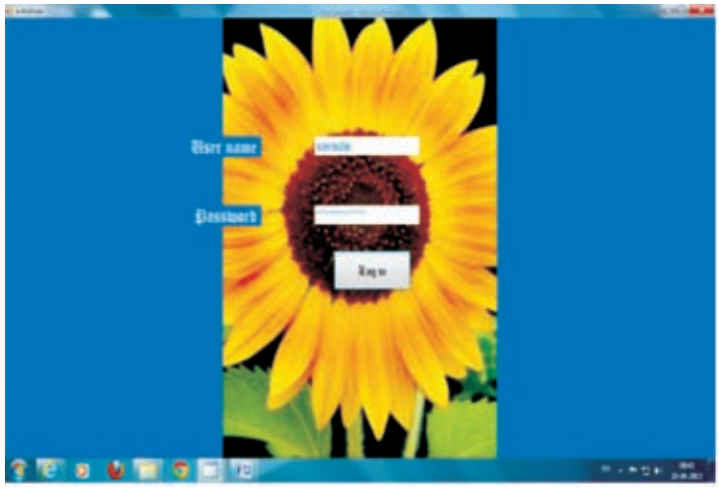
PCR and RT-PCR analysis of event no 481



Southern and Northern blots of a line derived from event no 481

Development of pedigree information system

Pedigree information system is invaluable for any plant breeder for selection of diverse parents in heterosis breeding and further enhancement of diverse breeding material. A sunflower pedigree information system was developed using visual basic for retrieving information on pedigree, selection method, year of development, centre involved in developing and maintaining, quantitative characters like seed yield (g/plant), oil content (%), plant height (cm), head diameter (cm), stem pigmentation, days to maturity and seed colour. The information on breeding lines like B lines, CMS lines, germplasm, hybrids, inbreds, R lines and varieties across different sunflower AICRP centres namely Akola, Bengaluru, Coimbatore, DOR, Latur, Ludhiana, Nandyal and Raichur is being documented and will be available for all AICRP sunflower breeders. The snap shots of sunflower pedigree information system is presented.



Screenshots of Pedigree Information System

CROP PRODUCTION

Sustainability of sunflower based cropping System with reference to input management in Alfisols

Under long-term fertilizer studies for sustainable sunflower production in Alfisols a fixed plot field experiment was initiated during *kharif* 1999 to assess the need and response of major, secondary and micronutrients on a long-term basis for sustainable sunflower production in sorghum (*kharif*) - sunflower (*rabi*) cropping system in Alfisols. Sorghum yield showed significant variation from the second cropping cycle onwards and application of 150% RDF recorded the highest yield. Response to K was negative for sorghum seed yield up to 2007-08 and from 2009-10 onwards, application of K increased the yield over application of NP. The response to boron (B) was significant in sunflower from 4th crop cycle onwards, over 100% NPK. Supplementation of 5 t FYM/ha along with RDF to *kharif* sorghum followed by growing sunflower with its recommended NPK gave higher sunflower seed yield compared to 150% NPK to both the crops in the system. No-manure control or nutrient imbalance with application of N or NP alone or reducing the fertilizer dose by 50% resulted in lowest growth and seed yield of sorghum and sunflower, delayed flowering, lowest test weight and lower sustainable yield index. Soil fertility in general has declined over the years except for the increase noticed for organic carbon in treatment that received FYM or crop residue along with NPK. Phosphorus build up was significant over the years in all treatments receiving regular P application compared to only N or no manure applications. Sorghum yield showed declining trend due to application of Zn along with NPK to preceding

sunflower possibly due to antagonistic effect of P and Zn under the conditions of very high P build up in P applied treatments. Profile soil depth was 1.15 m and the fertility declined with depth from 30 cm downward.

Performance of sorghum

The general growth of sorghum (Hybrid CSH-16) in *kharif* 2013 was normal and significant differences were observed due to treatments. The highest seed yield (3270 kg/ha) of sorghum was recorded with RDF (60:60:30) + FYM (@ 5 t/ha) application that was at par with NPK+crop residue and NPK to *kharif* sorghum crop. This was significantly higher over 150% RDF (2558 kg/ha) to both the crops. The treatment recorded highest stover yield (3.3 t/ha) and green fodder yield (13.4 t/ha), test weight (32 g/100 seeds) and early flowering (62 days). Unmanured treatment or application of N alone or reducing the fertilizer dose by 50% resulted in the lowest growth and seed yield (373 and 789 kg/ha with no manure or N alone), yield parameters besides, delayed flowering (74 *vs.* 60-63 days). Application of Zn @ 5 kg/ha to preceding sunflower with NPK has recorded lower harvest index (40%) of sorghum. Highest sustainable yield index (0.42) of sorghum was recorded with NPK+CR followed by 150% RDF (0.41) to both the crops in the system compared to 0.18 and 0.22 in no manure and N alone treatments, respectively.

Performance of sunflower

Growth and yield of sunflower hybrid, DRSH-1 succeeding sorghum in *rabi* 2013 differed significantly due to nutrient management treatments. Plant height was significantly the highest with NPK (75:90:30) + FYM 5 t/ha (sorghum) – NPK (sunflower) (193 cm) compared to all other treatments. Significantly lowest plant height was recorded in no manure or N alone treatments (104 to 110 cm). Nutrient imbalance or inadequate nutrition resulted in significantly lower plant height compared to complete nutrition with NPK (170 to 193 cm). Seed yield was significantly highest (1603 kg/ha) with NPK + FYM 5 t/ha (sorghum) – NPK (sunflower) that was at par with NPK – NPK + B @ 1 kg or NPK + S @ 20 kg/ha + B @ 1 kg/ha + Zn @ 5 kg/ha application compared to 150% NPK application (1338 kg/ha). No manure applications to both the crops in the system or imbalanced fertilization with only N were at par with lowest growth and yield parameters compared to other nutrient management systems. NPK + S recorded highest sustainable yield index (0.73).

Soil fertility

There was a general decline in soil fertility in all the treatments compared to initial level except for increase in organic carbon in treatment receiving FYM @ 5 t/ha along with NPK compared to the rest. In addition to organic carbon, organic carbon fractions from <40 to >250 µ were estimated. Phosphorus status was significantly higher (30 to 43 kg/ha) in all treatments receiving regular P applications compared to only N or no manure applications.

P x Zn interaction studies

To understand the response of sunflower to interaction of P and Zn, a field trial was conducted in Alfisols during *kharif* 2013 with 6 levels of P (0, 20, 40, 60, 80 and 100 kg P_2O_5/ha through monocalcium phosphate source) and 4 levels of Zn (0, 5, 10 and 15 kg Zn/ha through ZnO source). The effects of P and Zn levels and their interaction were not significant on soil testing medium in P and Zn status. Owing to the incidence of *Alternariaster* leaf spot due to higher rainfall, the filling percentage was low (65 to 80%) with low harvest index (23 to 29%). Response to P was recorded up to 60 kg/ha (822 kg/ha) and response to Zn was up to 5 kg/ha (725 kg/ha). Interaction effect was not significant for all parameters studied. At higher levels of P and Zn, there was a decline in yield.

Studies on phosphorus acquisition in sunflower genotypes

Rapid screening of 52 sunflower genotypes in poly bags under net house condition was conducted to study the root traits for phosphorus acquisition under sufficient (30 mg P/kg soil) and deficient (4 mg P/kg soil) P levels. The results indicated that at 30-day growth period, genotypes CSFH-8712 and CSFI-5075 had produced superior root volume (10 and 12.67 cc/plant, respectively) under P stress (4 mg P/kg soil) situation.

Variation in root traits due to P acquisition

Understanding causes for branching in sunflower

Axillary branch formation in cultivated sunflower is considered to negatively affect the seed yield from main head and is known to be influenced both by genetic and environmental factors. Among several environmental factors studied, soil moisture stress during vegetative stage was known to cause leaf axil formation occurring at flowering stage. The confirmatory field trial conducted in Alfisols in summer of 2014 clearly established consecutively that moisture stress from thinning to star bud stage with or without N top dressing after relieving moisture stress, is critical to trigger leaf axil branch formation in sunflower (up to 64% plants recorded leaf axil branches) at field level for hybrid, DRSH-1.

Studies on drought tolerance and water use efficiency in sunflower

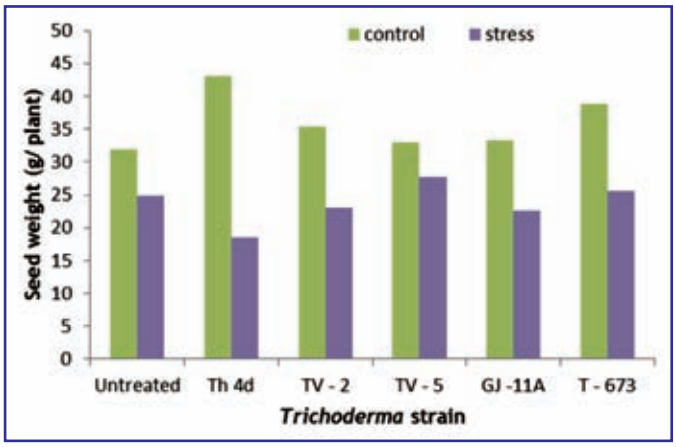
Twelve genotypes (9 with good and 3 with poor root traits) were evaluated in January 2014 sown crop for their drought tolerance in field by subjecting them to drought by withholding irrigation from 40 to 75 DAS. Drought affected different parameters (seedling vigour, before imposing stress, during stress, before relieving stress) significantly except for days to flowering and leaf number. SPAD chlorophyll meter readings showed increased stress in younger leaves. Genotypes KBSH-44, 856-R and 189-R accumulated proline under stress. Promissing genotypes with good growth at different stages of stress were identified.

Promising sunflower inbreds at specific stages

Stage	Inbreds
Seedling vigour	KBSH-44, DRSH-1, GKVK-1, 298 R
Before imposing stress	KBSH-44, DRSH-1, 856R, 298 R
During stress	AKSFI-51-6-1, 856 R, 298 R
Before relieving stress	M -1026, AKSFI-42-1, 298 R

Effect of *Trichoderma* seed treatment on drought tolerance

Seed treatment with five isolates of *Trichoderma* resulted in increased plant growth before relieving stress with Th-4d and Tv-5 in both control and stress. Th-4D (35%) and T-673 (22%) recorded higher seed weight than untreated (control) where as TV-5 proved promising under stress with 12% increase in seed weight compared to the untreated. Harvest index improved by 4% cent with *Trichoderma* seed treatment compared to control.



Quality

Sixty sunflower inbreds were screened for oleic acid content, oil content, total antioxidative power, reducing power and total phenol content. Oleic acid content varied from 29.0 to 43.0%. Total antioxidant capacity of sunflower inbreds ranged from 21.8 to 34.2 DPPH (TEAC mm/g), reducing power varied from 8.5 to 23.9 (GAE mg/g), while total phenol content ranged from 46.8 to 71.8 mg/100 g dry weight.

CROP PROTECTION

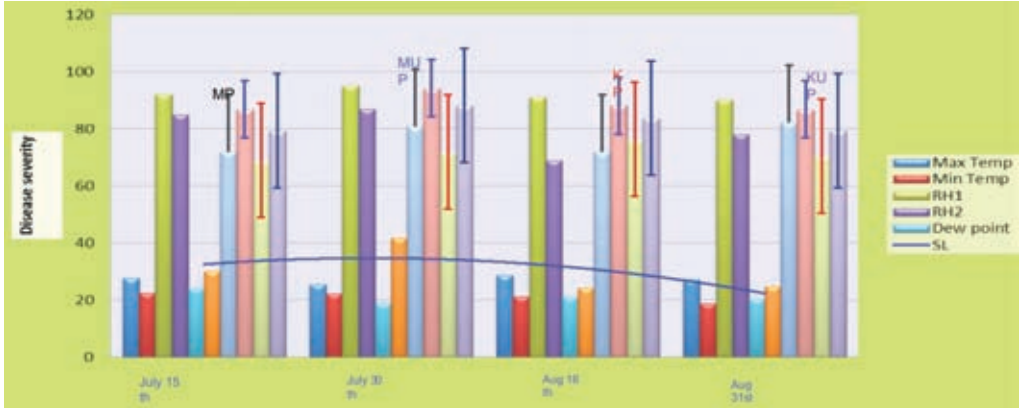
Alternariaster leaf blight

Three pathogenic groups among 130 *Alternariaster helianthi* isolates were identified based on their reaction to wild *Helianthus* species *H. occidentalis* and *H. maximiliani*. Leaf blight disease severity varied from 0 to 90% on *H. occidentalis* while *H. maximiliani* was resistant to most of the isolates.

Reaction of *Helianthus occidentalis* to *A. helianthi* isolates

Epidemiology of *Alternariaster* leaf blight

Leaf blight severity was high in 30th July and 16th August sown crops. In 30th July sown crop, the disease severity was 94.1% and 88.1% in Morden and KBSH-44, respectively with spore load of 42. Spore load, relative humidity and dew were the contributing factors for 16th July, 30th July, 31st August sown crops while minimum temperature, wind speed were the contributing factors for 16th August sown crop. In step-wise regression analysis, spore load, dew point were significant contributors for increasing the disease severity in the form of equation of PDI = + 1.90034 Spl + 0.39736* dew



Date of sowing

***Alternariaster* leaf blight severity on sunflower crop sown at different dates**

period. These results indicated that spore load, dew point, relative humidity, min. temperature were the most influencing weather parameters for the disease severity.

Mechanisms of resistance (MR) of *Alternariaster* leaf blight (ALB)

In studies on mechanism of disease resistance, the activity of peroxidases, polyphenol oxidases and PAL increased in DRSH-1, EC 595332, KBSH-1, KBSH-44, PI 535890, INGR No. 04102, EC 537925 and Morden cultivars while activity of catalases was minimum in DRSH-1 and Morden. In contrast with other biochemical constituents, total sugars reduced slightly in DRSH-1, KBSH-1, KBSH-44 and EC 537925. The reduction of total sugars was high in Morden, PI 535890, EC 595332 and INGR No. 04102.

Management of Alternariaster leaf blight

Two sprays of propiconazole 0.1% at 15 days interval recorded low disease severity with a disease reduction of 37.4% and high yield. Foliar spray of garlic 0.5% followed by propiconazole 0.1% at 15 days interval was also effective with 42.7% disease reduction. *Alternariaster* leaf blight disease severity was 69.9 % in control.

Propiconazole 0.1% **Control**

Effect of propiconazole on leaf blight of sunflower

Studies on host range of Sunflower leaf curl virus (SuLCV)

Under the experimental host range studies of SuLCV (Gemini virus of ToLCV), 12 plant species comprising vegetables, legumes and weeds were tested. The results indicated that among the tested, the susceptible hosts are 85.7% (6 out of 7) in vegetable crops, 42.9% (3 out of 7) in oilseed crops and 100% (2/2) in weeds. The virus was recorded naturally on cotton, tomato, cowpea, mungbean, parthenium and azeratum.

Occurrence of SuLCV on different cropping pattern systems

The disease incidence of SuLCV in the range of 0-2% was recorded in 22.5% (9 out of 40) fields surveyed in AP during *kharif* as compared to 7.7% (2/26) in *rabi* season. The occurrence of SuLCV in the range of 0-2.5% was recorded up to 25% (5 out of 20) fields surveyed under the vegetable cropping system area compared to only 4.8% (1/21) in the rainfed sunflower growing areas.

Yield loss assessment of powdery mildew disease

The yield loss estimation for powdery mildew was carried through field experiments. The results revealed, at 30% and 64% of disease severity levels the seed yields were reduced by 20.5% and 52.6%, respectively.

Characterization of *Cry1Aa* gene from isolate 52 of DOR Bt collection

Full length *Cry1Aa* gene was separated from PGEM-T Easy vector by digesting with restriction enzymes *xho-1* and *Nde-1*, cloned into expression vector pET29a (+) and finally transformed into expression system (*E. coli* BL21 (DE3). SDS-PAGE of the expressed cry1Aa protein resulted in a band of 105 KDa. Quantification of the purified protein through ELISA resulted in a concentration of 7.78 mg/ml. The toxin was found effective against one-day-old *Helicoverpa armigera* larvae.

Development of microencapsulated formulations of *Beauveria bassiana* conidia

Spray drying of the conidia along with sodium humate-0.2% at 175 ^{0}C resulted in complete retention of conidial viability (21.18 *L*CFU) with 21.11 *L*CFU after 6 months of storage at room temperature. Wettable powder formulation of the encapsulated conidia @ 225 mg/l resulted in complete mortality of 6 days old *H. armigera* larvae by 5 days after treatment (DAT). Scanning electron microscopy of the cuticles of treated larvae (2 DAT) revealed normal germination of the encapsulated conidia on the cuticular surface.

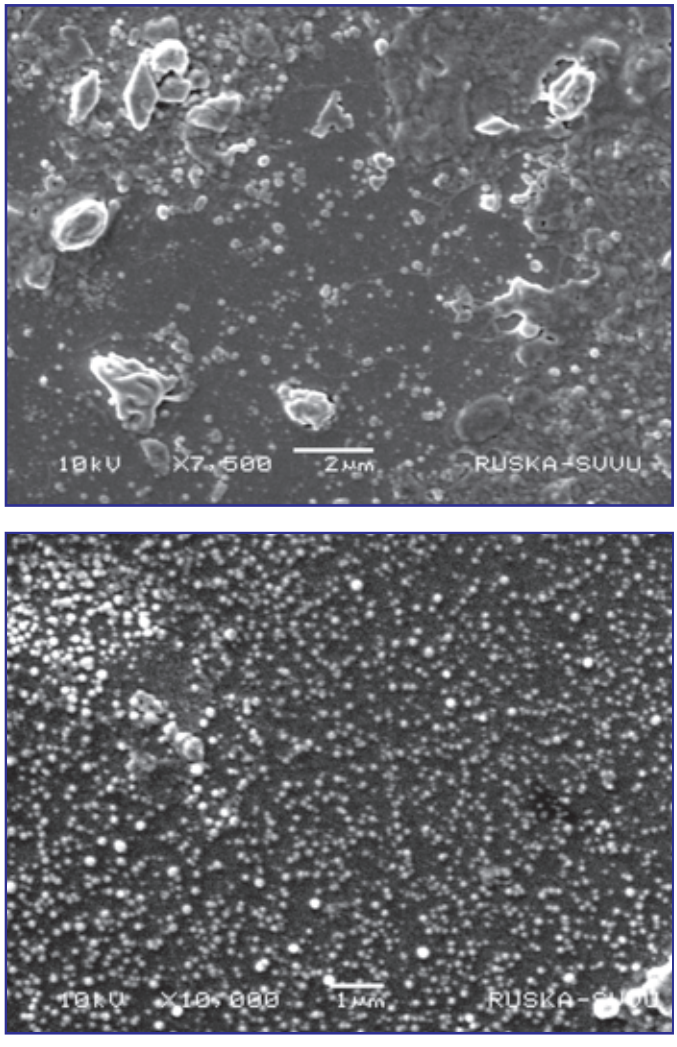
Field-testing of DOR *Bt*-1 SC formulation @ 1.0, 1.5, 2.0, 2.5 and 3.0 ml/l against *H. armigera* on sunflower resulted in 87-100% reduction of larvae within 5 DAT caused by larval mortality due to Bt at all the five doses and efficacy was on par with profenophos.

Identification of *Bt* isolates effective against of *S. litura* and *H. armigera* through larval bioassays with 50 new isolates

Larval bioassays with 50 new Bt isolates resulted in identification of 6 promising isolates effective against 3rd instar larvae of *S. litura* and *H. armigera*.

Development of micro-particles of *Bt*

Two promising local isolates DOR *Bt*-127 and 172 belonging to *Bt* var. *kurstaki* were multiplied through solid-state fermentation (SSF) and the resultant powders were milled to get 105 µ particles. These powders were then subjected to high pressure homogenization (HPH) at 15,000 psi (at CIRCOT, Mumbai) resulting in particle size reduction to 165 and 68 nm, respectively as determined by dynamic light scattering and scanning electron microscopy. Heat viable spore count values showed only a slight reduction after HPH with retention of efficacy in bioassays against *S. litura* larvae.



Scanning electron micrographs of micro-particles of *Bt* obtained through high-pressure homogenization at 15,000 psi

Multiplication of promising isolates on solid substrate and determination of LC_{50} through larval bioassays

Six promising *Bt* isolates *viz*., 127, 145, 151, 154, 171 and 172 were multiplied through SSF and bio-assayed against *S. litura* and *H. armigera* larvae. Isolates 172 and 127 were highly promising resulting in 73 and 77% mortality of seven days old *S. litura* larvae respectively at 5 DAT with 77 and 97% mortality of 6 days old *H. armigera* larvae respectively 2 DAT. Isolate 127 was found effective against *A. janata*, *H. armigera* and *S. litura* with LC_{50} values of 0.24, 0.36 and 1.8 mg/ml, respectively.

Deposition of the promising *Bt* isolates at NAIMCC, NBAIM

Two promising *Bt* isolates 127 and 172 were deposited at NAIMCC, NBAIM, Mau, with accession nos. B-01463 and B-01464, respectively.

Formulation of the technical powder of *Bt*-127 in combination with *B. bassiana* conidia and evaluation of efficacy through larval bioassays

A suspension concentrate formulation using technical powder of *Bt*-127 was developed in combination with conidia of *B. bassiana* isolate ITCC-4513 and evaluated in laboratory bioassays. LC_{50} was found to be 4.15 µl/ml at 3 DAT against five days old *S. litura* larvae and 1.3 µl/ml at 2 DAT against six days old *H. armigera* larvae.

Field testing of the combination formulation during *rabi* against *S. litura* on castor and *H. armigera* on sunflower through inundative releases

Field testing of the combination formulation (CF) against *S. litura* larvae on castor @ 2.5, 3.0 and 3.5 ml/l against natural incidence of the pest ranging egg masses to the gregarious stages of larvae resulted in complete larval mortality within 5 DAS with foliar damage of 15% recorded 10 DAS in 3.0 and 3.5 ml/l doses over 50% damage in control. Efficacy of these two concentrations was on par with insecticidal check, profenophos.

Field testing of the CF against *H. armigera* larvae on sunflower @ 2.0, 2.5 and 3.0 ml/l (through inundative releases @ 2.0 larvae/capitulum) resulted in 95-100% reduction of the larval population within 3-5 DAS caused by larval mortality while larvae were observed to be feeding and boring into the capitulum in the control plots. All the three CF doses were on par with the insecticidal check, profenophos in efficacy.

Validation of promising germplasm against leafhopper

Among 20 promising sunflower germplasm lines screened under high pest pressure, GMU-1, 126 and 843 were found resistant to leafhopper with less than 10% hopper burn (injury grade-1). GMU-4, 34, 340, 595, 696, 701, 914 and 1058 were found moderately resistant with less than 20% hopper

Field testing of combination formulation against *H. armigera* on sunflower

burn (injury grade-2) compared to the susceptible check Morden with more than 70% hopper burn (injury grade-5).

Evaluation of advanced breeding lines and wild species against leafhopper

Out of 150 sunflower advanced lines screened under high pest pressure, GP 6-208 was found resistant to leafhopper (injury grade-1). GP 6-564, GP 9-279-7-4 were found moderately resistant (injury grade-2) compared to the susceptible check, Morden (injury grade-5). All the ten perennial sunflower wild species (OCC-522, MOL-1629, HIR-1536, GIG-184, DEC-1887, MAX-30, DIV-1881, TUB-15, STR-15 and NUT-23) screened under high pest pressure were found resistant to leafhopper without any hopper burn injury compared to the susceptible check, Morden.

Determination of damage potential of leafhopper

Damage potential of leafhopper in sunflower was determined by conducting an experiment involving moderately resistant sunflower hybrid (KBSH-53) and susceptible variety (Morden) by maintaining unprotected crop, crop with full protection and crop with need-based protection. Leafhopper caused 25.2 and 41.0% seed yield reduction in KBSH-53 and Morden, respectively in the unprotected crop than the crop fully protected with insecticide. There was 11.5 and 23% seed yield reduction in KBSH-53 and Morden, respectively in the need based protection crop (2 times) than fully protected crop. Apart from causing seed yield reduction there was 4.0, 2.3 and 3.6, 1.9% reduction in the oil content in the KBSH-53 and Morden, respectively in the unprotected and crop with need based protection than fully protected crop with insecticide.

Development and evaluation of four IPM modules against insect pests

Among four IPM modules evaluated against insect pests and diseases of sunflower in large plots of 10x10 m with 4 replications, IPM module-I [components (i) KBSH-53 (promising against powdery mildew), (ii) seed treatment with Imidacloprid 600FS (6 ml/kg) and metalaxyl 35% WS (6 g/kg), (iii) hand picking and destruction of early stage larvae of *Spodoptera,* (iv) one spray of novaluron (0.01%) and 2 sprays of mancozeb (0.3%)] was found effective against insect pests and diseases of sunflower with a seed yield of 1048 kg/ha and an incremental benefit cost ratio (IBC ratio) of 4.11. IPM module -II [components - i, ii, iii from module- I with one spray of spinosad (0.018%) and 2 sprays of Mancozeb (0.3%)] was found effective against insect pests and diseases of sunflower with a seed yield of 1050 kg/ha and an IBC ratio of 3.75. Natural enemy activity was more in both the IPM modules compared to profenophos (0.05%) treated crop.

Population dynamics of insect pests and natural enemies

Pest incidence was recorded on the hybrid DRSH-1 and variety DRSH-108 at weekly intervals throughout the crop season during *kharif* and *rabi* 2013. The leafhopper population ranged from 0.2 to 6.5 nymphs/6 leaf/plant during *kharif* compared to 3.2 to 28.0 nymphs/6 leaf/plant during *rabi*. Defoliators, *Spodoptera exigua* (Hubner) (0.1 to 0.6 larvae/plant), *Thysanoplusia orichalcea* Fab. (0.1 to 1.3 larvae/plant), *Spodoptera litura* Fab. (0.1 to 1.7 larvae/plant) caused 20-30% defoliation. Defoliators and head borer, *Helicoverpa armigera* Hubner (0.6 larvae/plant) were major lepidopteron insect pests recorded in sunflower during *kharif*. Major biocontrol agents like *Chilomenes sexmaculata* (F.), *Coccinella transversalis* (F.), *Harmonia octomaculata* (F.) and spiders were dominant predators of major insect pests of sunflower during *kharif* and *rabi* with peak activity during September and January. Pentatomid predatory bug, *Eocanthecona furcellata* (Wolff), *Menida* sp. and *Harpactor* sp. were actively predating on larvae of lepidopteron insect pests during *kharif*. The larval parasitoid *Parapanteles* sp. indet. was found parasitizing larvae of *T. orichalcea*. There was not much difference in the occurrence of pests on sunflower hybrid, DRSH-1 and variety DRSH-108 except sucking pests, which were relatively less on hybrid.

Predatory pentatomid bug predating on *Spodoptera litura* larva

Collection and identification of pollinators

In sunflower, major pollinators include honeybees. *Apis dorsata* was predominant with maximum activity followed by stingless bee, *Tetragonula laeviceps Smith*, *A. florea, A. cerana indica.* Bumble bee species *Xylocopa tenuiscopa* Westwood, *X. amethystina* (F.), *X aestuans* (L.) and leaf cutter bee, *Megachile bicolor* (F.) were frequently found visiting sunflower crop and pollinating. *T. laeviceps* also collected gummy substance from flower buds in addition to nectar and pollen from flower.

SOCIAL SCIENCES

Frontline demonstrations

Forty frontline demonstrations (FLDs) were conducted on sunflower during *rabi* 2013-14 at Bavapuram and Thamballapally villages of Prakasam district, Andhra Pradesh. Five demonstrations each on soil test based nutrient management, application of sulphur and foliar spray of boron at star bud stage and 25 demonstrations on whole package were conducted. In FLDs on sulphur, elemental sulphur @ 25 kg/ha was applied in improved technology as compared to no sulphur in farmers practice and in FLD on boron, borax @ 2 g/l was applied as directed spray to the capitulum at star bud stage in the form of borax @ 2 kg/ha as compared to no boron in FP. In whole package, the seed yield increased by 20.9% followed by soil test based nutrient management (16.6%), sulphur (10.2%) and boron (7.0%) as compared to farmers' practice. Farmers obtained additional net returns of Rs. 6900, 5680, 3750 and 810 with whole package, soil test based nutrient management, sulphur and boron, respectively.

Sunflower hybrid, DRSH-1 was compared with farmers' practice of growing private hybrids. Soil samples were collected from the selected 20 farmers' fields and analyzed for N, P, K, S and organic carbon. Based on the soil test values, STCR equations for the region (Nandyal) were fitted with target yield of 1800 kg/ha and fertilizer recommendations were worked out.

A farmers' field school (FFS) on integrated nutrient management was organized during *rabi* 2013-14 at Thamballapally in collaboration with a NGO, REEDS. Twenty farmers selected for FLDs participated in the FFS. A pre-sowing discussion was held with the selected farmers and awareness was created among the farmers on the integrated nutrient management in sunflower. The fertilizer recommendation consisted of application of Urea, SSP, MOP, elemental S, B and FYM. The recommendations were discussed with the selected farmers and five farmers were selected as master farmers, on whose fields the demonstrations on site-specific nutrient management (SSNM) were conducted. The FFS farmers were shown the fields of the master farmers at critical stages of the crop and focused discussions were held on the farmers' fields with scientists of DOR and REEDS.

A field day was organized on January 24, 2014 at peak flowering stage on one of the master farmers' field to show the benefits of integrated nutrient management in sunflower. Around 80 farmers participated in the field day. *Adarsha rythu* (model farmer), Shri Raghava Reddy from Thamballapalle participated in the FFS as one of the representative of State Agricultural Department.

FLD on whole package at Thamballapally in Prakasam Dt.

Frontline demonstrations on oilseeds funded by ISOPOM

The Integrated Scheme on Oilseeds, Pulses, Oilpalm and Maize (ISOPOM) sanctioned 4850 frontline demonstrations (FLDs) on oilseeds including oilseeds-based cropping systems (Project Directorate for Farming System Research, Modipuram) and Soil Test Crop Response Correlation (All India Coordinated Research Project on Soil Test Crop Response Correlation, Indian Institute of Soil Science, Bhopal) during 2013-14.

Four thousand six hundred and thirteen frontline demonstrations on oilseeds and oilseed based cropping systems [i.e. with castor (415), sunflower (500), safflower (400), sesame (361) niger (328), linseed (460), Rapeseed-mustard (537), groundnut (832) soybean (680), farming systems (50) and STCR technologies (50)] were conducted during 2013-14 under the Integrated Scheme on Oilseeds, Pulses, Oilpalm and Maize (ISOPOM).

CASTOR

CROP IMPROVEMENT

Management of genetic resources

The Germplasm Maintenance Unit at the Directorate added 118 fresh accessions from an exploration visit to Rajasthan in collaboration with NBPGR Regional Station, Jodhpur and four fresh accessions from Maharashtra to the castor repository. About 109 new accessions were characterized for 23 descriptors and evaluated for 19 quantitative traits. Great diversity was observed among the fresh accessions with respect to morphological traits.

Pinkish-yellow capsules

Simultaneous maturation of primary and secondary spikes

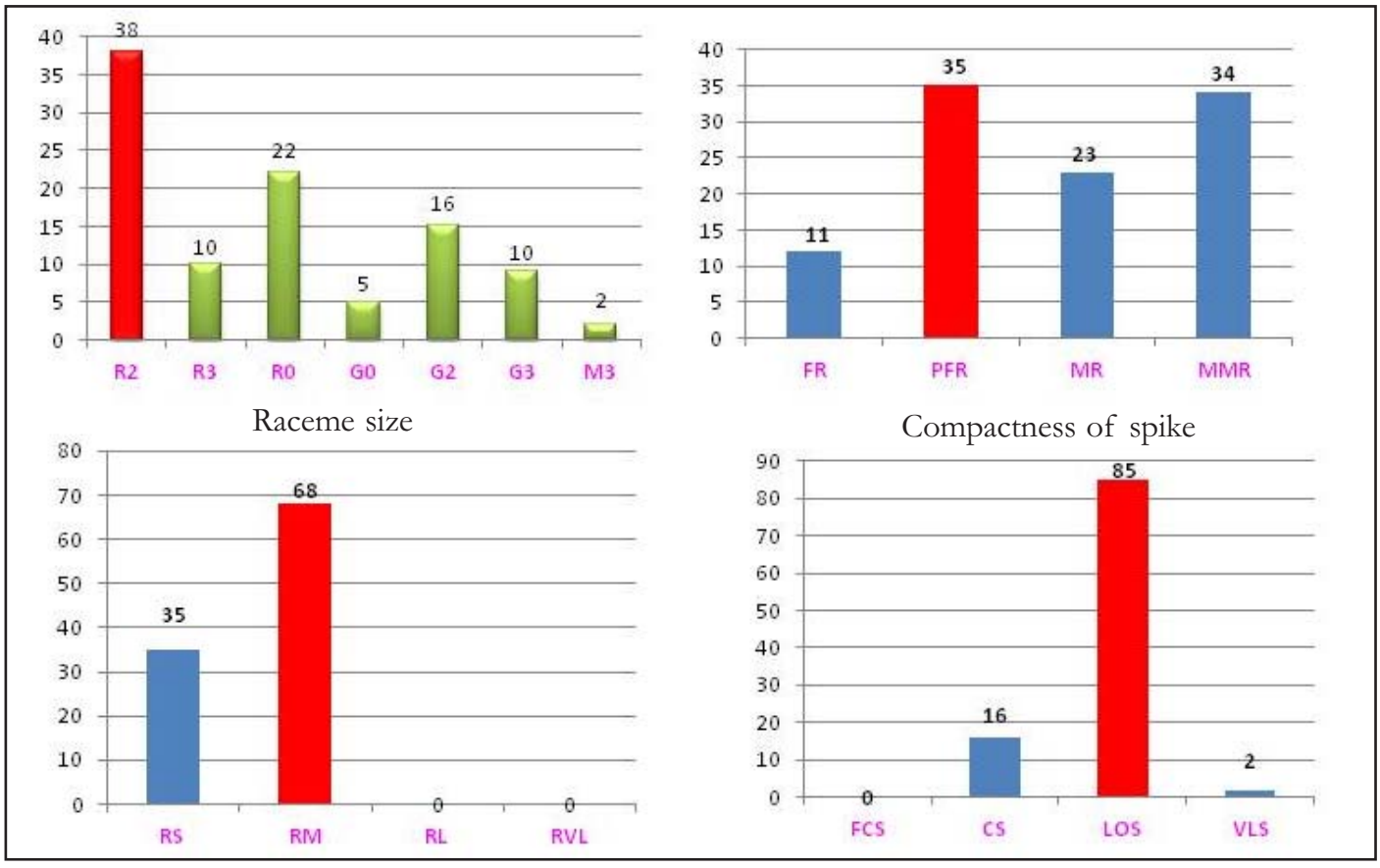
High number of spikes/plant

Long productive spikes

Diversity in germplasm collected from Rajasthan

Stem colour and bloom

Nature of raceme



Raceme size

Compactness of spike

R/G : Red/Green stem colour; 0-3: Bloom; FR: Female; PFR-Partially female; MR: Male; MMR: Mostely male raceme; RS: Small; RM: Medium; RL: Long; RVL: Very long raceme; FCS: Firmly compact; CS: Compact; LOS: Loose; VLS: Very loose spike

Diversity in new castor collections for different morphological traits

Forty two among 109 accessions characterized for 23 descriptors and evaluated for quantitative traits were promising for agronomic and yield traits. Four accessions, RG-3760, RG-3765, RG-3771, and RG-3784 had pistillate primary spike.

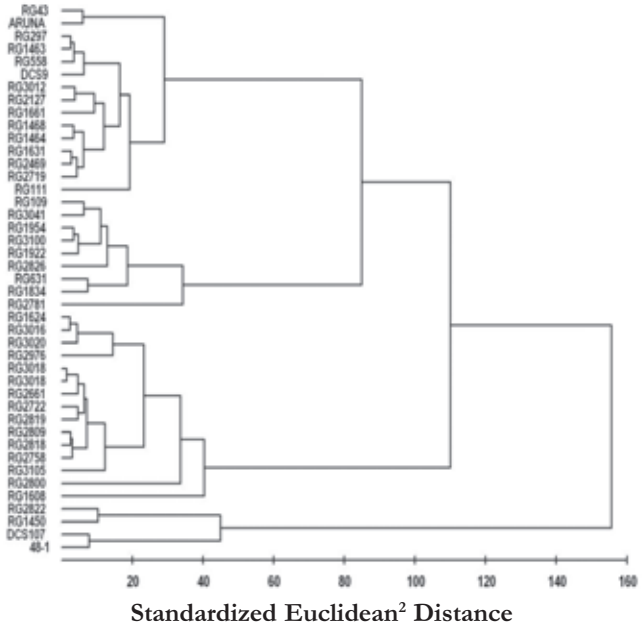
Trait	Promising accessions*	Checks
Total length of primary spike (cm)	RG-3798 (58)	48-1 (30) RG-3782 (49) DCH-519 (42)
Effective length of primary spike (cm)	RG-3798 (49)	DCH-519 (47)
Hundred seed weight (g)	RG-3794 (53.4), RG-3797 (59.4) RG-3798 (52.7)	DCH-519 (33)

*Figures in parentheses indicate value of the trait

Twenty seven accessions were identified for pick-wise high yielding ability from 120 days to 210 days after planting. Among them, two accessions *viz.,* RG-3799 and RG-3736 yielded consistently higher seed yield (g/plant) at 120 days (109 g, 107 g), 150 days (66.8 g), 210 days (162 g) after planting and

total seed yield per plant (372 g, 352 g) than the best check DCH-519 (94 g, 60 g, 118 g, 317 g) respectively.

Evaluation of 39 biotic and abiotic stress resistant accessions for seed yield and agronomic characters resulted in identification of several promising accessions for seed yield/plant *viz.,* RG-1450-a wilt and putative drought resistant accession (230 g) compared to best check, DCS-9 (111 g), five wilt resistant accessions *viz.,* RG-2822 (IC-346626), RG-1954, RG-3100, RG-1624 and RG-2800 (IC-346604) (152-182 g/plant). RG-43, an early, wilt and leafhopper resistant accession took 41 days to 50% flowering and 78 days to 50% maturity while the earliest check, DCS-9 flowered in 61 days and matured in 106 days. Another wilt resistant accession, RG-1608 had high test weight (100 seed weight: 78.7 g). Ward's minimum variance method of cluster analysis using 20 agro morphological traits grouped the 39 biotic and abiotic stress resistant accessions and four checks into eight distinct groups and the accessions - RG-2781 (IC346585/IC374333) and RG-1608 (IC373978) formed two distinct groups.



Dendrogram of cluster analysis of 43 castor genotypes

Evaluation of trait specific germplasm

Three extra-early accessions (RG-22/EC168754, RG-26/EC169671, RG-181/EC168759) reached to 50% flowering in 36 to 38 days and 50% maturity in 83 to 87 days compared to the earliest check, DCS-9 (50 and 112 days). Among the extra-early accessions, RG-22 and RG-26 yielded 1583 and 1588 g/net plot, respectively at par with the early variety check, DCS-9 (1580 g/plot). Four early maturing accessions *viz.,* RG-18, RG-155, RG-2375 and RG-1511 (IC373970) recorded significantly higher seed yield (49-40 g/plant) at 120 days after planting than DCS-9 (25 g/plant). Among all the 30 trait-specific accessions, the highest seed yield was realized from RG-155 (3317 g/net plot), followed by RG-3477 (2773 g/net plot), and RG-2375 (2382 g/net plot) while seed yield in the highest yielding check, DCS-107 was 2227 g/net plot.

Development of inbred lines from promising germplasm

Wilt resistance in RG-2787 (IC374338/IC346591) and RG-2818 (IC346622), wilt and leafhopper resistance in RG-2661 (IC374272) and leaf miner resistance in RG-1771 was confirmed prior to inbred development.

Development of heterotic groups

High heterosis over the best hybrid check, DCH-519 was observed for seed yield and yield traits as well as for phenological traits among the 50 hybrids developed using five non-TSP-10R pistillate lines and 29 diverse germplasm accessions.

Stabilization of non-TSP-10R pistillate lines

Four non-TSP-10R pistillate lines developed from wild germplasm accessions were stabilized for pistillateness. These were multiplied by using pollen from interspersed staminate flowers that developed on quaternary order spikes.

Range of heterosis (%) in 50 castor hybrids based on non-TSP-10R pistillate lines

Trait	Range of heterosis (%)
Plant height	-4 to 136
Number of nodes to primary spike	-8 to 44
Days to 50% flowering	-20 to 24
Days to 50 % maturity	-11 to 2
Length of primary spike covered by capsules	-52 to 37
Number of spikes/plant	-32 to 11
100-seed weight	-32 to 41
Seed yield/plant	-58 to 191
Seed yield/plot	-54 to 196

Multiplication, documentation, conservation and supply of germplasm

During this year, 356 accessions were multiplied through self-pollination. Passport information, morphological descriptors and data on quantitative traits of 109 fresh accessions were documented. A total of 2776 castor germplasm accessions were conserved in MTS module and 702 accessions were supplied to different castor researchers in India.

Registration of germplasm

Castor germplasm accession, RG-2818 (IC346622; INGR14004), proposed for resistance to wilt, was approved for registration by Plant Germplasm Registration Committee in its 13th meeting held on January 31, 2014.

Evaluation of farmers' varieties

Evaluation of 104 farmers' varieties of Tamilnadu indicated their susceptibility to *Botrytis* grey mold under severe incidence of the disease in *kharif* 2013. Stable expression of a farmer's variety with very long compact spike collected from Dhandej village of Vadodara district, Gujarat at DOR, Hyderabad indicated its potential use in both monoecious and pistillate line development.

Farmer's variety with long compact spikes

Construction of gene pools

Construction of new gene pools, one each for monoecious and pistillate lines has been initiated. During *rabi* 2013, six selected monoecious inbreds proven as good combiners as well as elite male parents with ideal sex expression have been allowed for random mating under controlled conditions. To ensure uniform random mating and sufficient seed for next cycle, hand pollination using mixed pollen from all the lines was attempted. The seeds thus obtained will be distributed to the selected centers to continue the second cycle of random mating and construct the gene pool-2 for monoecious trait during *kharif* 2014. Similarly, random mating as described above has been undertaken during summer 2014 using six selected pistillate lines for constructing pistillate gene pool-1 and the seeds of the random mated populations will be shared with the centers for further use during next summer season.

Development of genetic stocks

Several genetic stocks with distinct and unique stem and capsule colour combinations *viz*., yellow capsules on green stem and red capsules on red stem were isolated from the advance breeding lines of the crosses involving new yellow stem mutant and other stem color genotypes. About 46 genetic stocks constituted out of 100 possible combinations will help in understanding the evolution of capsule colour variation in castor. Ten stable homogenous genetic stocks were documented for specific capsule colour and stem colour combination.

Stable genetic stocks for stem and capsule colour combinations

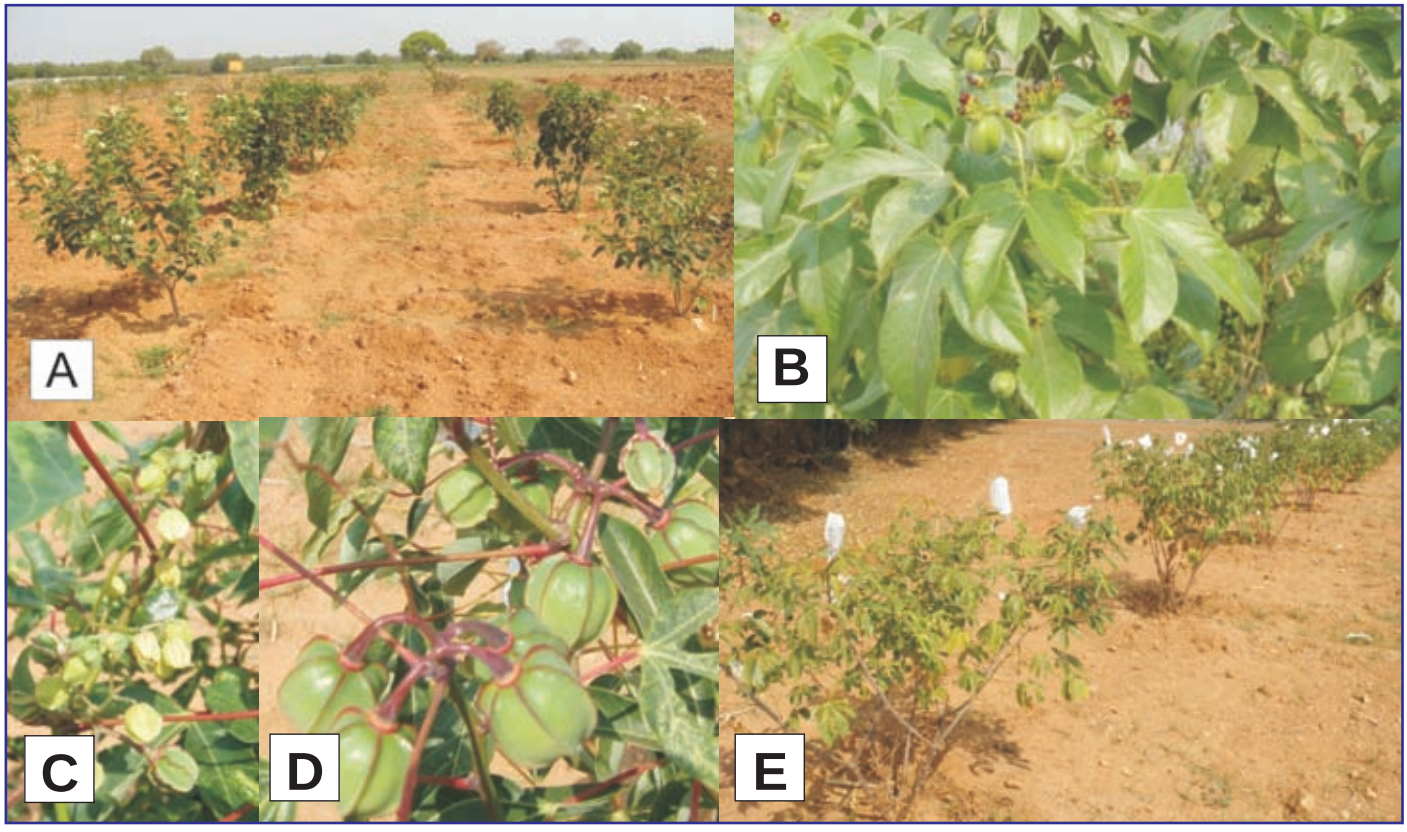
Stock No.	Pedigree No.	Morphological characters	Capsule colour	Other features
GSC 001	K13-1255	17N, G0,Sp,	Lemon yellow	Strong stem, compact spikes
GSC 002	K13-1277	16N, DR0,Sp	Dark red	Strong stem, long spikes
GSC 003	K13-1286	13N, G2,Sp	White yellow	Early, very strong stem
GSC 004	K13-1268	15N, P3,Sp	Yellowish pink	Very strong stem
GSC 005	K13-1280	17N, R2,Sp	Yellowish red	Strong stem
GSC 006	K13-988	18N, G3,Sp	White yellow	Strong stem, long spikes
GSC 007	K13-997	12N, G0,Sp	Lemon yellow	Early, bold capsules
GSC 008	K13-551	18N, DP0,Sp	Dark pink	Strong stem
GSC 009	K13-672	18N, P3,Sp	Light pink	Strong stem, good branching
GSC 010	K13-685	23N, DP0,Sp	Greenish pink	Very strong stem, long spikes

N-node number up to primary, G/R/P-green, red, purple stem colour, 0-3 bloom, Sp-spiny capsules

New stem colour developed using yellow stem mutant

Wide hybridization using *Jatropha* sp and Tapioca

The *Jatropha* species garden was established at Narkhoda farm with 7 known species (*J. curcas, J. multifida, J. podagrica, J. panduraefolia, J. gossypifolia, J. tanjorensis* and *J. glandulifera*) obtained from different sources and a new species collected from Kanpur. About 7 varieties of tapioca obtained from TCRS (TNAU), Yethapur were grown in the permanent garden. It was interesting to note that flowering in tapioca planted in August 2013 had started as early as in October 2013 and was continuing even in the month of April 2014 in spite of prevailing hot weather condition in Hyderabad. There were heavy capsule and seed set in tapioca by open pollination. Wide hybridization programme in castor has been initiated with *J. integerrima* and Tapioca for CMS development in castor.



Establishment of *Jatropha* (A, B) and tapioca (C, D, E) garden

Evaluation of prebred monoecious lines

Thirty-five monoecious inbreds, including 15 pre-bred and 20 breeding lines were used as male inbreds in heterosis breeding programme to test their combining ability for seed yield. Selected monoecious were also being screened for their wilt resistance in wilt sick plot. Since, the crop was with severely infested *Botrytis* in 2013-14, castor breeders from AICRP centres will be provided an opportunity in the coming years to exercise selection from these lines for use in their breeding programmes.

Selection No. kh-13-161 -167 with overlapping leaves

Diversification of pistillate base and development of high yielding varieties and hybrids

Development of diverse male combiners/ varietal lines

Male line development programme has continued by selecting 300 single plant selections in five double cross and two three-way cross F_2 s involving wilt resistant, high yielding male lines *viz.*, SKI-291, SKI-217, DCS-106, JI-226, JI-227 and a local selection from Narkhoda farm for its long spike with monoecious trait (60 cm with 30% maleness). Pedigree method of selection involving 245 single plant selections of F_5 and F_6 generation was followed. Selection criteria included less than 10% infected capsules in different spike orders after a severe natural incidence of *Botrytis* in two-three spells during October-November 2013. Among the 54 progenies from six cross combinations reported with low *Botrytis* incidence in *kharif* 2012, 21 progenies from a single cross combination *viz.*, DPC-17 x DCS-64 alone recorded low or delayed incidence of the disease.

Selection No. kh-13-148 – 151 short plant height with acute angle

Evaluation of advanced lines in Preliminary Varietal Trials (PVT-I and PVT-II)

Seventy five advanced lines were evaluated in PVT I and II in an augmented randomized block design in a four row plot along with three checks replicated after every 10 entries. Advanced lines were selected based on three criteria *viz.*, early (90-110 days) or medium (111-130 days) maturity, high seed yield (>300 g/plant) and monoecious trait (with 2-3 whorls of male flowers).

Promising male lines for seed yield and yield components

Male	Spike length (cm)		Number of effective spikes/ plant	100 seed weight (g)	Seed yield (g/plant)
	Total	Effective			
PVT-I-12-2	35	34	12.1	26.1	668
PVT-I-12-76	43	42	10.1	34.2	615
PVT-II-11-2	45	45	9.7	30.0	637
PVT-II-11-19	44	44	12.1	37.2	562
PVT-II-11-34	43	41	9.6	35.6	603
PVT-II-11-60	40	34	9.8	41.9	664
PVT-II-11-70	43	44	7.0	22.8	520
DCS-9 (C)	31	31	7.3	26.0	159
48-1 (C)	38	37	8.2	26.5	200
DCS-107	39	39	7.6	32.2	328
Mean	37.0	36.5	8.2	28.4	302.7
C.V (%)	9.9	10.4	11.5	9.2	12.0
CD (P=0.05)	9.8	10.1	2.5	7.0	97.8

Among 15 advanced lines evaluated for confirmation in PVT-II, 11-2, 11-19, 11-34, 11-60 and 11-70 with 58-102% higher yield than the best check, DCS-107 (328 g/plant) were promising for their early / medium maturity and monoecious trait. Two entries, PVT-I-12-2 and 12-76 in PVT-I with higher seed yield increase (103%, 87%, respectively) over the checks and good proportion of female: male whorls will be further tested for their combining ability. The line PVT-II-2012-2 was also found resistant to *Botrytis* under severe incidence of the disease. It was also moderately resistant to leafhopper (grade 1.1 to 2).

PVT-II-2012-2: Low *Botrytis* incidence

Development of new pistillate lines

A new source of pistilate trait was identified in the progenies of the cross NES-22 x CH-1 (kh-13-154) with distinct characteres like dwarf plant hight, condensed nodes, overlapping divergent leaves covering the main stem and semi compact spike. Single plant selections from 26 crosses in different segregating generations (F_7 to F_{14}) were under evaluation for pistillate trait. Pistillate selections from eight crosses were homozygous and homogenous for morphological traits and were selected for pistillate trait in late order spikes.

New pistillate lines identified for further evaluation

Selection no.	Pedigree	Significant character
DPC-27	(DCH-1218 x DCS-9) x DCS-9	Early maturity (7-11 nodes), green stem, triple bloom, spiny capsules
DPC-28	(163-1-10-2 x 48-1) x DCS-2 x DCS-2	Early maturity (7-10 nodes), red stem, double bloom, spiny capsules, medium primary spike (40-50 cm), short plant height and good branching ability
DPC-29	(163-1-10-2 x 48-1) x DCS-2 x DCS-2	Medium maturity (13-19 nodes), red stem, double bloom, spiny capsules, medium tall and long primary spike (60-70 cm)

Registration of pistillate line : DPC-16

DPC-16, a pistillate line of unique morphotype with a hermaphrodite flower at the tip of the spike, red stem colour and zero bloom was registered by the Plant Germplasm Registration Committee in its XXVIIIth meeting held on 31st January, 2014 with national identity, IC0598621 and registration number INGR14003. The genetic stock DPC-16 was initially identified in a segregating population of the cross NES-6 x TMV-5. It has other distinct morphological characters like medium long (45-50 cm), semi-compact spike with spiny capsules. The red stem colour of the plants is very distinct without any bloom (Ref. No. RHA 187A as per the RHS colour chart).

Development of new experimental hybrids

Fifty-seven new hybrids were generated using three pistillate lines *viz*., DPC-23, DPC-26 and M-571 with 19 male lines that were either resistant to wilt and leaf hopper or both. In addition, 77 new hybrids were produced during *rabi* 2013-14 by crossing 34 monoecious inbreds (31 inbreds and 3

farmer's varieties) developed from pre-breeding programme as male lines with four well-adapted and popular pistillate lines. These experimental hybrids will be tested in common evaluation trials and multilocation trial of DOR.

Evaluation of experimental hybrids for seed yield and wilt resistance

Two hybrids *viz*., PHT-12-17 (DPC-21 x DCS-107) with 37% increase in seed yield and PHT-12-12 (DPC-19 x DCS-107) with 15% increase over the best check GCH-7 (2330 kg/ha) and resistant to wilt in the National Screening Nursery on Wilt (NSNW) both at DOR and SK Nagar will be tested in the coordinated multi locational Initial Hybrid Trial (IHT).

Fifty hybrids were evaluated in a four-row plot in an augmented randomized block design (ARBD) along with two checks replicated after every 10 entries. Promising hybrids were identified based on seed yield (>400 g/plant) and resistance to wilt in sick plot.

Among 20 hybrids evaluated in PHT-I for the second year, two hybrids *viz*., PHT-12-15 (DPC-21 x DCS-81), PHT-12-17 (DPC-21 x DCS-107) reconfirmed their yield potential over the national check, DCH-519 (306 g/plant) and wilt resistance in sick plot. In PHT-II, among the 30 hybrids, the top five high yielding hybrids, PHT-12-3, PHT-12-9, PHT-12-21 involving JI-244 male parent were also resistant to wilt in sick plot.

In addition, 136 hybrids generated at DOR were evaluated in a common evaluation hybrid trial in two rows in an augmented randomized block design (ARBD) along with two checks replicated after every 10 entries. The trial was conducted at DOR under rainfed and at Anand under irrigated conditions in *kharif* 2013. The hybrids CEH-40, CEH-73, CEH-99 (21%), CEH-68, CEH-134 (47%), CEH-108 (57%) and CEH-133 (41%) with significant increase over the best check GCH-7 (4102 kg/ha) under irrigated conditions were found promising. They are also found promising under rainfed conditions despite severe incidence of *Botrytis* grey mold during the crop growth period. Two high yielding hybrids CEH-68 (M-574 x JI-315) and CEH-73 (DPC-23 x DCS-104) which were resistant to wilt will be further evaluated in multi location coordinated trials.

Wilt resistant hybrids

Wilt incidence (%) in wilt sick plot		
Nil	**1-10%**	**11-20%**
CEH-45, CEH-49,	CEH-44, CEH-47,	CEH-37, CEH-38, CEH-42, CEH-43,
CEH-55, CEH-58,	CEH-48, CEH-54,	CEH-44, CEH-59, CEH-60, CEH-65,
CEH-61, CEH-74	CEH-57, CEH-62,	CEH-69, CEH-71, CEH-72, CEH-73,
	CEH-63, CEH-67,	CEH-75, CEH-76, CEH-77
	CEH-68, CEH-70,	
	CEH-78, CEH-80	

In addition, several experimental hybrids were evaluated at Hiriyur (37), Raichur (45), Yethapur (24) and Bhavanipatna (24) (rainfed) and Bawal (57) and Anand (56) (irrigated) to identify promising hybrids.

Identification of parents with multiple traits

A common set of 25 parental lines were evaluated for wilt incidence in sick plot and also for insect pests like leafhopper and capsule borer.

Among the 25 male lines, DCS-110 and DCS-118 were reconfirmed for wilt resistance (<20% wilt incidence in sick plot) and leafhopper (grade 0 to 0.1). Three new pistillate lines *viz*., DPC-23, DPC-25 and DPC-26 resistant to wilt (<20% wilt in sick plot) and leafhopper (0-1 grade) were selected for generation of wilt and leaf hopper resistant hybrids.

A study on genetic variability for physiological parameters in 31 parents was undertaken to identify the parents with early vigour, high total drymater (TDM) production and harvest index (HI). Correlations among seed size, early vigour measured as TDM at 25, 35, 50 DAS with total seed yield, TDM and HI indicated that early vigour is highly correlated with seed size (0.59) and TDM at 25 DAS (0.45) and 35 DAS (0.49) while TDM is significantly correlated with total seed yield (0.79*) but not with HI at any stage.

Promising parents for physiological traits

	Genotypes
Early vigour	48-1, DCS-89, DCS-112, DCS-117, DCS-119, DCS-120, DPC-25, k12-86-2, k12-98-3, k12-1555-1
High TDM	48-1, DCS-112, DCS-113, DCS-119, Haritha, k12-86-2, k12-91-2, k12-98-3, k12-1555-1, DPC-24
Harvest index	48-1, DCS-89, DCS-109, DCS-119, k12-86-2, k12-91-2, k12-98-3, k12-1555-1, M-571

Correlation among seed size, TDM, seed yield and harvest index in 31 genotypes

Parameter	Vigour	TDM at 25 DAS	TDM at 35 DAS	TDM at 50 DAS	Seed yield of primary spikes	Total seed yield	TDM at harvest	HI
Seed size	0.591**	0.416*	0.327	0.352	0.265	0.345	0.175	0.319
Vigour		0.448*	0.487*	0.237	0.133	0.227	0.131	0.209
TDM at 25 DAS			0.626**	0.159	0.038	-0.132	-0.134	-0.053
TDM at 35 DAS				0.195	-0.198	-0.274	-0.195	-0.206
TDM at 50 DAS					-0.028	0.009	0.115	-0.135
Seed yield of primary spike					0.810**	0.686**	0.489**	
Total seed yield							0.785**	0.684**
TDM at harvest								0.544

*significant at 5% level ; **significant at 1% level

Seed production and Maintenance breeding

Nucleus seed of the released varieties and male lines *viz*., DCS-107 (2 kg), DCS-9 (0.5 kg), 48-1 (0.5 kg), DCS-78 (0.1 kg) and female lines *viz*., DPC-9 (0.4 kg), M-574 (0.2 kg) were produced by bulking selfed seed of individual plants. About 300 single plants each of DPC-9 and M-574, selected in *rabi* 2012 were raised in progeny rows in late *rabi* 2013 to maintain the genetic purity of the pistillate lines.

Permanent observation nursery

The permanent observation nursery developed at Narkhoda farm to study and maintain the pistillate lines of all the hybrids released through AICRP

(Castor) has been maintained with the parental lines of GCH-7, YRCH-1, DCH-177 and DCH-519 raised in the new permanent block. The pistillate lines include DPC-9, M-574, and SKP-84.

Generation of mapping populations

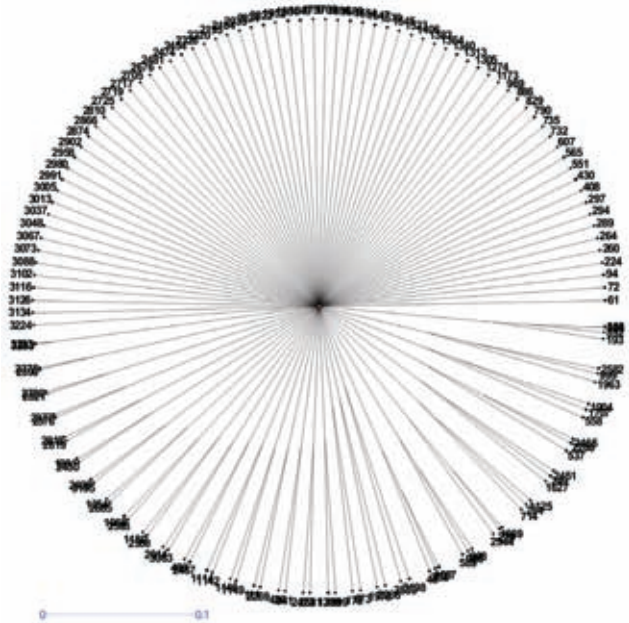
Four mapping populations (DCS-9 × RG-3216, DCS-9 × RG-1139, DCS-9 × RG-2787 and DCS-9 × RG-3309) consisting of circa 200 progenies were advanced from F_3 to F_5 during the reporting period in the process of generating recombinant inbred lines (RIL) for genetic analysis, mapping of gray mold resistance and constructing a high density linkage map. From these populations, over 50 near-inbreds could be identified as potential male lines for hybrid development. One population (JC-12 × 48-1) consisting of circa 300 progenies was advanced from F_1 to F_3 for developing RILs for genetic analysis and mapping of wilt and nematode resistance in castor. This could be an ideal genetic material to study the wilt-nematode complex.

Assembling of association mapping panel

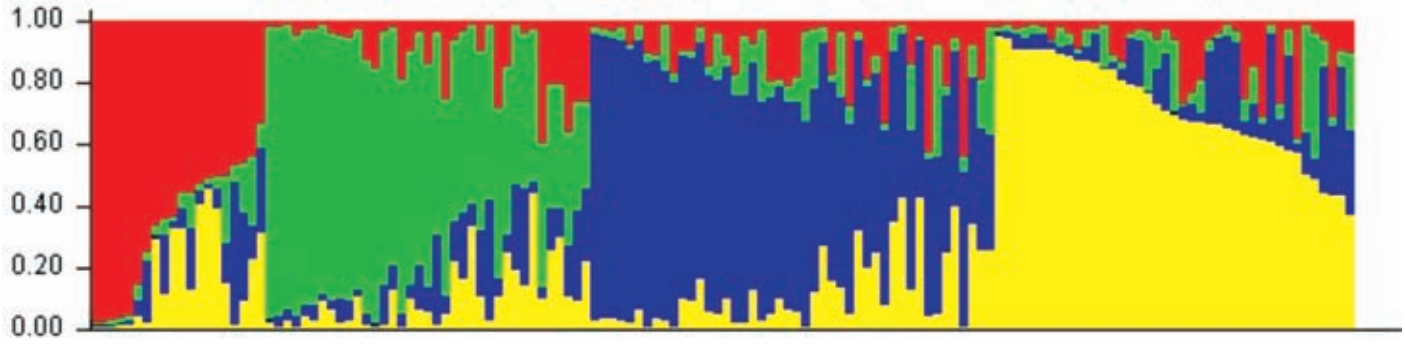
A set of 302 castor genotypes consisting of the castor core sub-set, trait specific germplasm, elite inbreds, released varieties and parental lines of hybrids was stabilized by individual plant selfing for two generations during the reporting period. All these accessions were characterized using 20 morphological descriptors and seeds were multiplied by selfing. Most of the morphological diversity available in castor is represented in this set. The panel is now ready for use in marker-trait association analyses.

Molecular characterization of core sub-set of castor germplasm

The castor core sub set (144 accessions) was genotyped with 20 additional SSR markers during the reporting period for assessing the level of genetic diversity and population structure. Overall SSR allelic diversity was observed to be low based on genotyping data of 39 SSR loci. The pairwise dissimilarity coefficient among the genotypes ranged from 0.02 – 0.67 with a mean of 0.38. The number of alleles produced by each marker ranged from 2 to 5 with a mean of 3. The average gene diversity was 0.38. The PIC values for the 39 surveyed SSR markers ranged from 0.01 – 0.60 with a mean of 0.33. No marked population structure was observed in the core set of accessions making it a good representative set for any linkage disequilibrium studies.



Hierarchical clustering of 144 accessions of castor core germplasm based on UPGMA method using genotyping data from 39 SSR loci



Inferred population structure of castor core germplasm based on alleleic data from 39 SSR loci using model based clustering software, STRUCTURE

Development of SSR and SNP markers

A set of 500 primers were synthesized based on the reference genome sequence of castor. These primers were validated using eitht diverse genotypes, which are the parental lines of mapping populations being generated. Out of 500 primers, 369 primers gave amplification of which 40 % were polymorphic across the samples.

Whole genome sequences (paired end) of 12 genotypes were generated using Illumina HiSeq® or MiSeq® platform. The high quality reads were aligned against the reference genome with a genome coverage of 92.84 to 97.02%. SNP discovery and filtration was carried out using SAMtools with standard parameters applicable for Illumina paired end reads. The number of SNPs/InDels identified between sample and reference ranged from 294,956 to 929,114. Finally, a set of 8,000 high quality SNPs that were highly polymorphic across the samples were selected for designing the chip with 3072 SNPs.

Statistics on whole genome sequencing of 12 castor genotypes

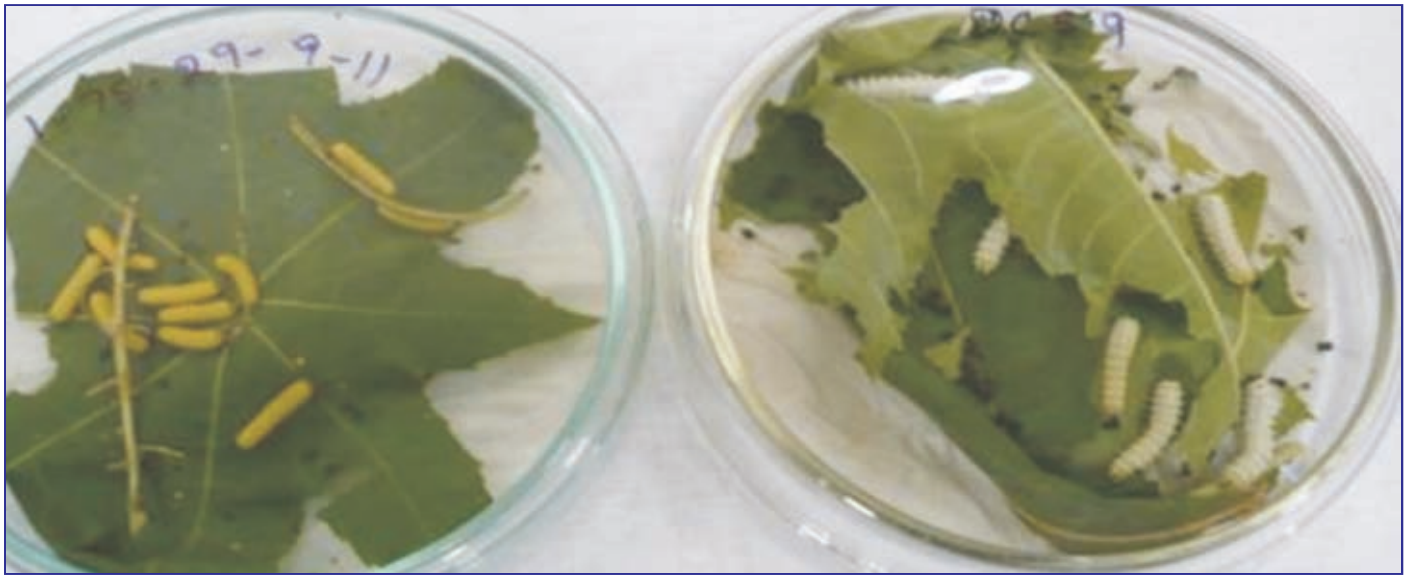
Genotype	Raw reads	Data in Gb	Filtered reads	SNPs/InDels	Genic SNVs
RG-43	12,787,405	5.90	11,622,830	3,87,297	32,010
RG-72	59,087,998	11.80	55,979,084	6,44,037	62,838
RG-1139	73,466,140	14.69	69,352,963	4,90,382	63,802
RG-2787	63,835,573	12.76	58,743,049	6,70,889	60,934
RG-2819	62,782,508	12.55	58,926,757	6,72,843	61,609
RG-3309	70,686,223	14.13	66,770,385	8,52,482	80,195
VP-1	62,126,053	12.42	58,885,533	4,40,832	53,660
DPC-9	65,820,623	13.10	60,207,321	6,04,063	56,241
48-1	51,270,973	10.25	48,407,365	5,92,812	61,035
JC-12	12,626,709	7.20	11,906,343	9,29,114	84,792
TMV-5	62,392,969	12.47	57,398,835	7,13,512	73,923
JI-220	11,251,618	5.40	10,531,223	2,94,956	29,439

QTL mapping for *Fusarium* wilt resistance

The parental line (VP-1 and 48-1) polymorphism was studied using 600 e-SSR primer pairs developed using EST database. Out of these, 156 primer pairs were polymorphic. One hundred and eighty six F_2 population of VP-1 x 48-1 was screened with all the polymorphic markers in 6% PAGE gels. The genotyping data was scored for polymorphic markers and some gap in the data was observed due to non-amplification of samples. Finally, data from 126 markers that gave good amplification with all the samples was used for construction of the linkage map. The population was advanced to F_6 by single seed descent method. F_6 lines were screened in glasshouse through root dip inoculation technique using highly virulent isolate from Palem in two replicates for wilt incidence along with parental lines (VP-1, 48-1) and highly susceptible check (JI-35). The wilt incidence was <20% in 25 lines, 20-50% in 17 lines, 50-80% in 18 lines and >80% in 33 lines. For bulk segregant analysis (BSA), pooled DNA from 10 resistant and 10 susceptible lines were screened with 126 polymorphic markers along with parents to identify marker for wilt resistance. Three markers showed polymorphism in bulks. Co-segregation of markers with the phenotype as well as testing of the identified markers with DNA from all the individual plants is in progress.

Development of transgenic castor for resistance to lepidopteran pests

Generation advancement and seed multiplication of 2 events each of *Cry1Aa* (AK1304 PB-1, 804-1) and *Cry1EC* (AMT-1, NBRI-1) was done. Laboratory bioassays to determine the level of toxicity of *Cry1Aa* events to eri silkworm were carried out. Larval weights were taken after 6 days of feeding and no mortality was observed. However, 40-50% larval weight reduction was observed in *Cry1Aa* positive plants. Larval weight ranged from 0.051 g to 0.095 g/larva in plants with *Cry1Aa* gene while in control it was 0.102 g/larva.



Growth of erisilkworm larva on *Cry1Aa* transgenic (left) and control (right) castor

ELISA at different crop growth stages in three events of Cry1Aa (804, DTS-43 and AK1304-PB-1) and two events of *Cry1Ec* (AMT-1, NBRI-PB-1) was done to determine the protein levels. For *Cry1Aa*, 62 lines from three events (two events from AK1304-PB-1, one event from 804) were advanced from T_3 to T_4 generation. PCR and ELISA characterized these plants with Cry1Ac/1Ab coated

plates. The concentration of Cry1Aa protein in T_4 generation plants ranged from 0.16 - 0.978 ng/mg of fresh leaf tissue. The concentration of Cry1Ec protein with Cry1Ec coated plates ranged from 0.192 to 2.4 ng/mg of fresh leaf tissue.

Development of strategies for obtaining *Botrytis* tolerant transgenic plants

Attempts are being made to develop *Botrytis* tolerant transgenic castor plants using different gene constructs. In line with this, multiple gene cassettes have been developed and these vectors are being validated using tobacco as a model system and simultaneously efforts are on to use them for transforming castor using meristem-based as well as *in planta* transformation methods.

In planta transformation

A modified *in planta* transformation method was adopted with the cultivar 48-1 (Jwala) using different gene constructs including reporter gene (*gus*) construct. Totally, about 625 T_0 plants were established in the transgenic green house and the T_1 seeds from each of these plants has been harvested for further analysis.

In planta transformation

Constructs used	No. of seedlings co-cultivated	T_0 plants established
GUS	100	50
ERF1 + *GUS* **	600	200
AtEBP1	400	150
BIK1	300	125
AtEBP1+*BIK1***	300	100

**Used as a concoction for co-transformation

Validation of the developed gene cassettes using tobacco as model system

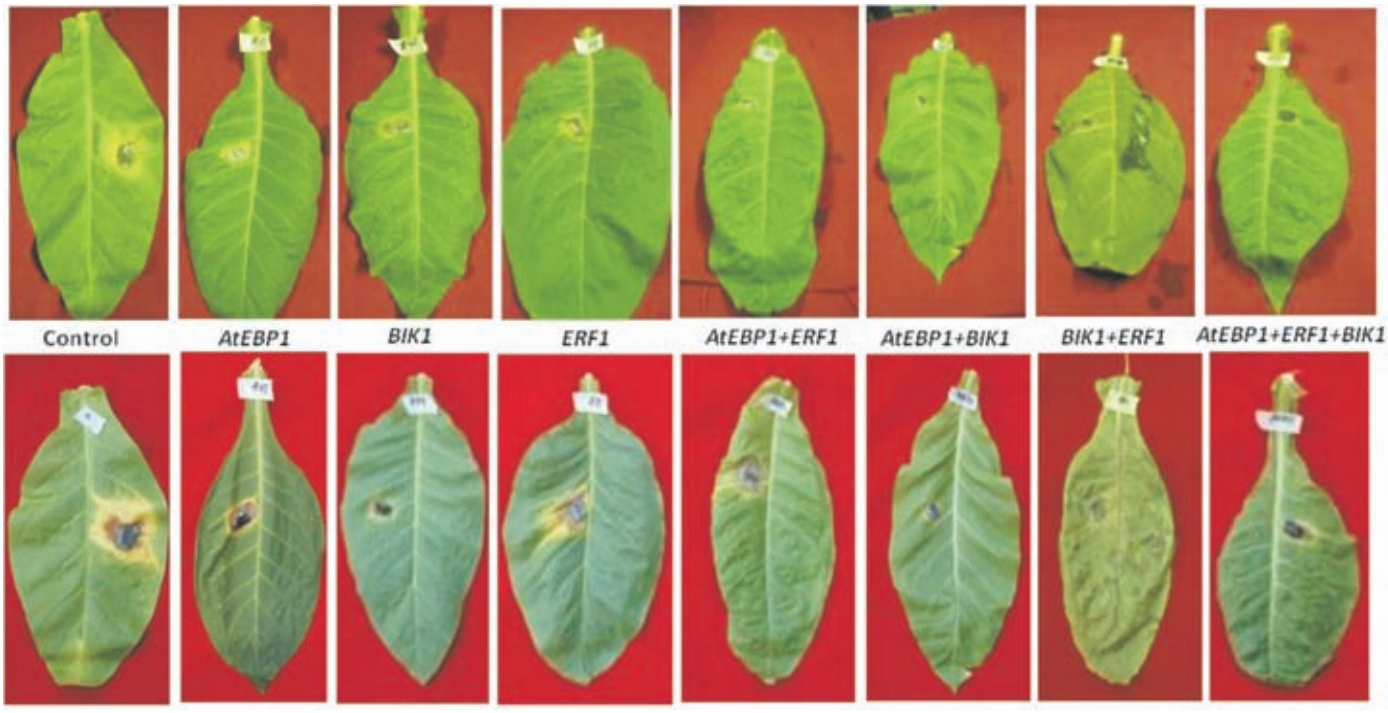
As part of the programme on genetic engineering for botrytis resistance in castor, suitable gene constructs were developed and validated for proof of concept in tobacco. As reported earlier, tobacco transgenic plants had been realized with the three single gene cassettes (*ACS4-BIK1, ACS5-ERF1* and *ACS7-AtEBP1*) independently and have been confirmed for the presence and expression of the introduced gene cassettes. To assess the cumulative effect of expressing more than one gene for imparting resistance against fungi, the gene cassettes were pyramided by crossing the plants carrying single gene cassettes. Previously, pyramiding two cassettes into the same plant had been reported. To bring three gene cassettes together, transgenic plant (BE8) that expressed two genes, *BIK1* and *ERF1*, was crossed with transgenic tobacco plant (A17) carrying *AtEBP1* and the progeny plants were analyzed for the presence of different gene cassettes using PCR with different gene specific primers. This analysis identified a number of plants carrying combinations of gene cassettes.

PCR positive plants obtained in the segregating population of the cross between BE8 (carrying both *BIK1* and *ERF1* cassettes) and A-17 (carrying *AtEBP1* cassette)

Gene cassettes carried	No. of plants
Only *AtEBP* (A)	7
Only *BIK1* (B)	2
Only *ERF1* (E)	12
Both A & E	5
Both B & E	4
Both A & B	4
All three (A, E & B)	3
NULL	22
Total	59

PCR positive plants were further analysed for the expression of the gene cassettes using RT-PCR and this confirmed expression of respective cassettes in leaves and flowers. With these analyses, plants expressing single, two or three gene cassettes were identified and these plants were subjected to disease bioassay with necrotrophic fungi *Alternaria alternata* and *Phytophthora nicotianae*. Repeated experiments have indicated that transgenic plants, irrespective of the number of transgene cassettes carried, show better tolerance than null plant or untransformed control plants.

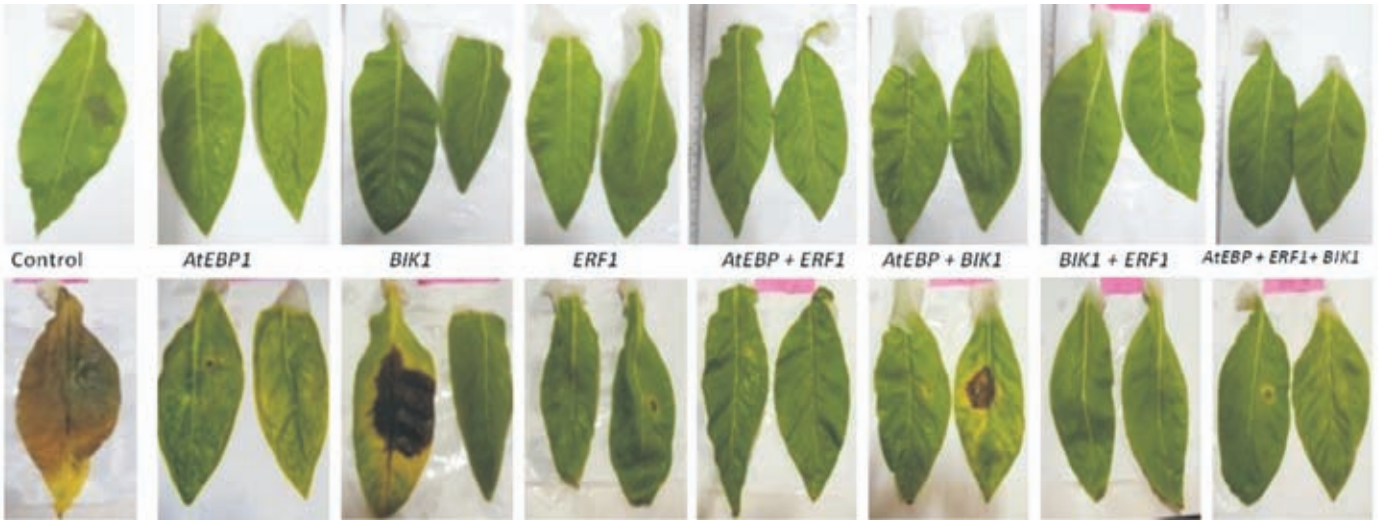
6 days post-infection



12 days post-infection

Detached leaf bioassay with *Alternaria alternata* of transgenic tobacco plants carrying different gene cassettes (Gene cassettes carried by the transgenics are indicated)

3 days post-infection



9 days post-infection

Detached leaf bioassay of transgenic tobacco plants carrying different gene cassettes with *Phytophthora nicotianeae* pathogen (Gene cassettes carried by the transgenics are indicated)

For Alternaria, transgenics with stacked gene cassettes showed better tolerance than those with single gene cassettes with *AtEBP1+BIK1* combination showing the best response. However, response to *Phytophthora* disease infection showed a different pattern with *BIK1+ERF1* and *AtEBP1+ERF1* combinations showing highest level of tolerance.

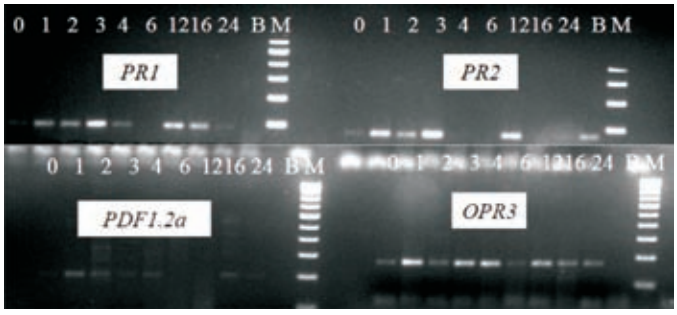
Deciphering molecular mechanism of induction of biotic stress tolerance by *Trichoderma* spp.

Colonizing ability of different isolates of *Trichoderma* spp in castor roots was assayed using plating techniques to quantify the proliferation of *Trichoderma* in the roots of castor at different time intervals 12, 24, 36, 48, and 60 dpi. The *Trichoderma* colonization studies were done by histological sectioning of the castor roots post inoculation and by checking the growth of *Trichoderma* in the rhizosphere, rhizoplane and inside the roots of the plants by plating on a selective medium at five different time intervals i.e. 12, 24, 36, 48 and 60 dpi. Statistical analyses indicated highly significant ($p<0.001$) interaction indicating an effective association of *Trichoderma* with castor roots. DCS-107 genotype showed better colonization with *N13, Th4d, TV5* and *7316* strains.

Molecular analysis of induction of systemic resistance

The interactions of the 10 strains of *Trichoderma* with castor and subsequent differential gene expression specific to various defense regulatory pathways like salicylic acid, jasmonic acid, ethylene, APO-and cytoplasmic ROS, MAMP-triggered defense, phenylpropanoid and ABA-pathways involved in induction of systemic resistance were studied, through semi-quantitative RT-PCR. Among the various genes studied *PR1, PR2* from SA-pathway and *OPR3* from JA-pathway were identified to show differential gene expression profiles at various time points i.e. 12, 24, 36, 48 and 60 dpi. It was observed that the expression of genes increased from 12 to 36 dpi and gradually decreased after 48 dpi.

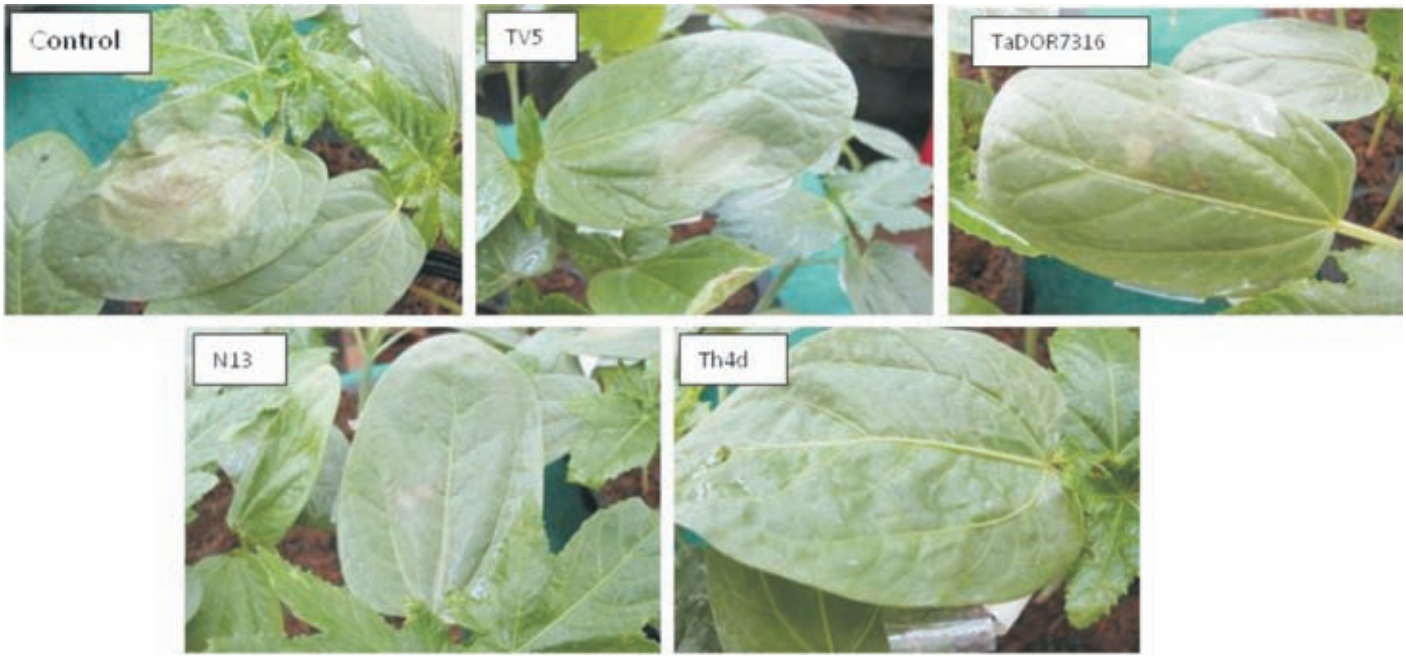
To validate *Trichoderma*-mediated ISR within 24 hours post inoculation (hpi), castor roots from 12 days-old seedlings treated with *Trichoderma* for 0, 1, 2, 3, 4, 6, 12, 16 and 24 h after inoculation were studied through RT-PCR using primers specific to *PR1, PR2, PDF1.2a* and *OPR3* genes. It was observed that there was up-regulation of these signature genes two hours post inoculation until 24 hpi. Thus, the induction of systemic resistance is initiated very early following interaction of *Trichoderma* with the castor roots.



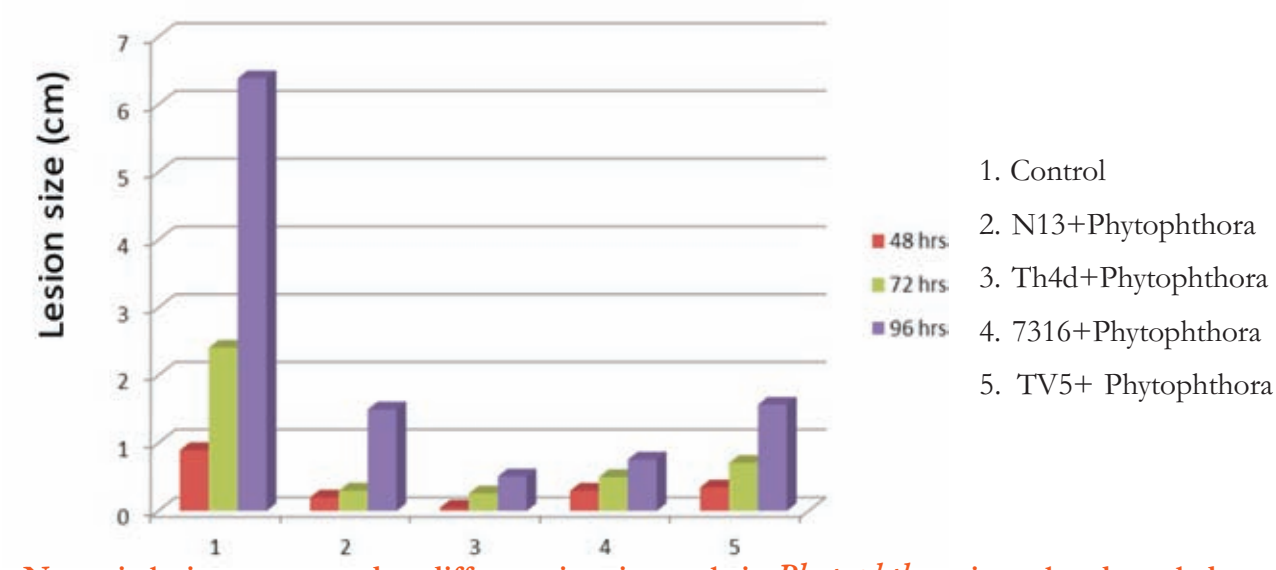
Expression of ISR signature genes at 0, 1, 2, 3, 4, 6, 12, 16, 24 hpi

Effect of *Trichoderma* mediated induced systemic resistance against *Phytophthora nicotianae*

Seeds of DCS-107 were treated with three *T. asperellum* strains *N13, TV5, 7316* and one *T. harzianum* strain, *Th4d*. After appearance of cotyledonary leaves, 10-day-old discs of *P. nicotianae* grown on corn meal agar were placed on the bottom of the leaves, supported (strapped) by cellophane tape. On each seedling, one cotyledonary leaf was inoculated with pathogen. Un-inoculated controls with each *Trichoderma* treatment were maintained. Leaf wetness, temperature (25 °C) and humidity >70% were maintained in the glasshouse. Necrosis caused by the pathogen differed among the treatments. When compared with untreated seedlings, disease severity was reduced to 85.7% in *Th4d* treated seedlings. TaDOR *7316* and *N13* showed 50% and 42.9% disease reduction over check.



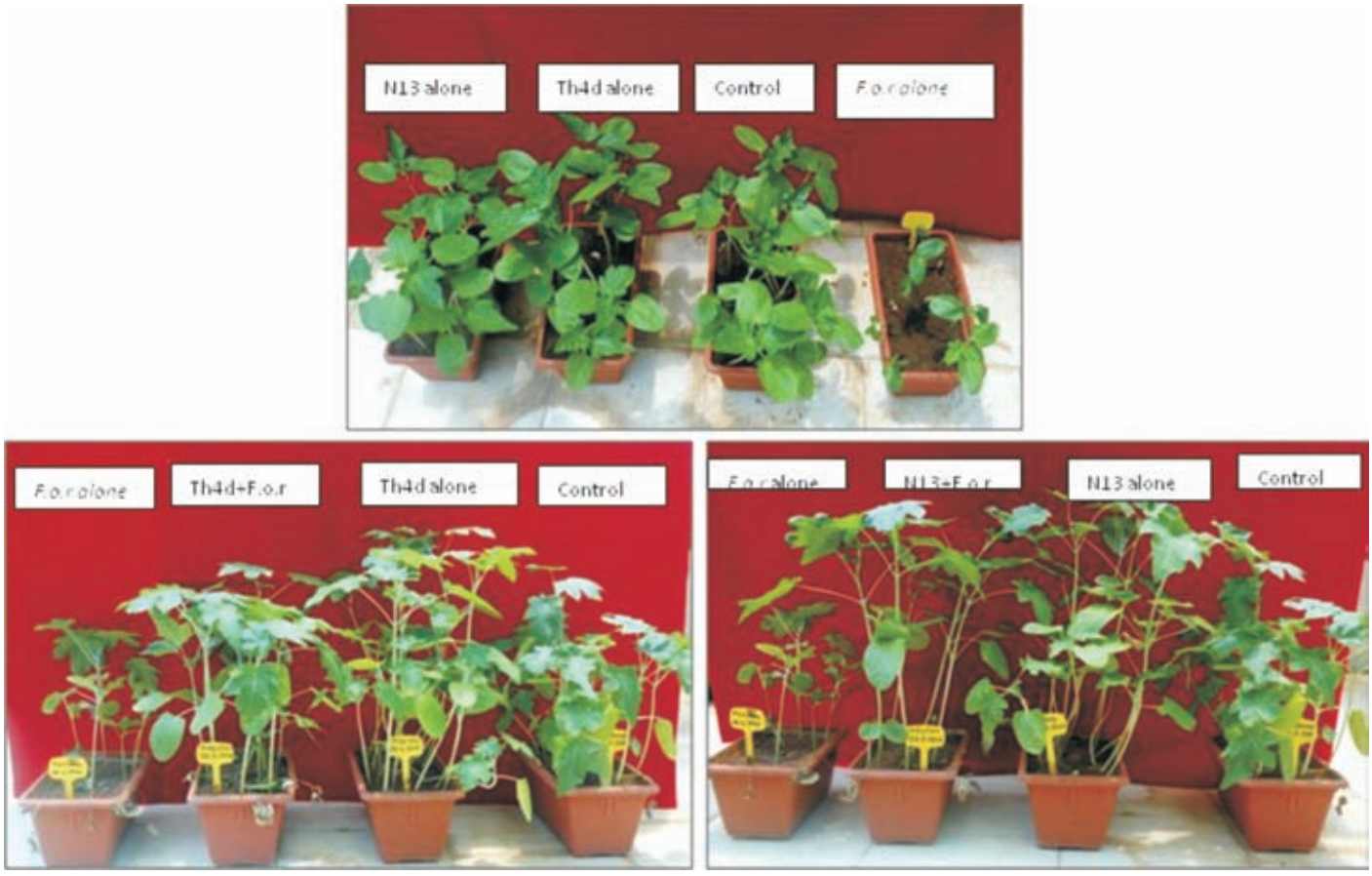
Response to *Phytophthora nicotianae* infection on castor cotyledons



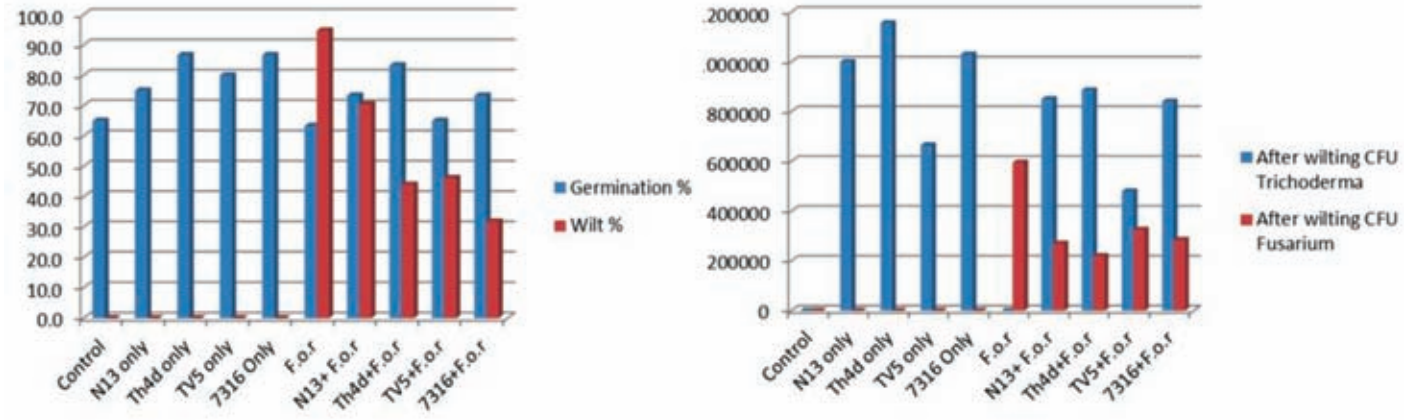
Necrotic lesions measured at different time intervals in *Phytophthora* inoculated cotyledenary leaves

Effect of *Trichoderma* mediated induced systemic resistance against *Fusarium oxysporum* f.sp. *ricini*

Seeds of variety GCH-4 hybrid were sown in sterile soil either inoculated with different isolates (*N13, Th4d, TV5, TaDOR 7316)* of *Trichoderma* alone or the pathogen *F. oxysporum* f.sp. *ricini* alone or combinations of *Trichoderma* strains and *F. oxysporum ricini* together. As control, seedlings were also grown in untreated soil. Germination percentage and wilt incidence were recorded at regular intervals. Wilt incidence was lower whenever *Trichoderma* was included in the soil along with *Fusarium* inoculum. *Th4d* treatment showed least wilt incidence (21%), followed by that with *N13* (36%), *TV5* (43%) and *TaDOR 7316* (31%). Pots with *Fusarium* inoculum alone showed 73% wilt incidence. *Trichoderma* strains also reduced the colony forming units of *Fusarium* in the soil with *Th4d* strain being the best in reducing the pathogen load in soil.



Representation of reduced wilt incidence and plant growth promotion by *Trichoderma* in castor seedlings



Reduction in wilt incidence in seedlings as well as *Fusarium* load in the soil by different *Trichoderma* strains

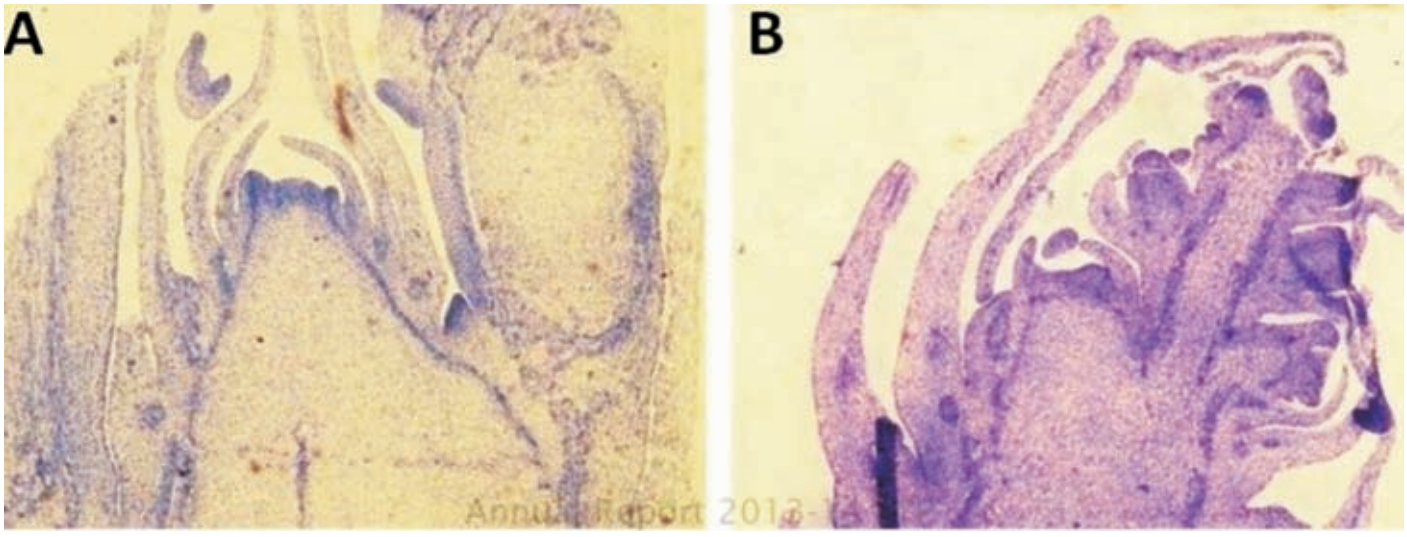
The differential gene expression studies carried out using the control seedlings and seedlings treated *Trichoderma* and *F. oxysporum* f.sp. *ricini* showed that the ISR specific genes showed elevated expression in *Trichoderma* treated castor seedlings when compared to the untreated controls.

Molecular mechanism governing sex expression

Variability in sex expression (from monoecism to completely pistillate or completely staminate inflorescence) in castor as well as sex reversion in pistillate lines is a major impediment in castor

breeding programmes. Sex reversal to monoecism affects hybrid seed purity and rouging of revertants in hybrid seed production plots is cumbersome. The molecular mechanisms governing the complex phenomenon of sex expression in castor need to be understood.

Understanding the floral developmental stages in the parental lines of castor is imperative before taking up studies on molecular mechanism(s). The floral differentiation stage was identified in two castor parental lines by histological sections. The possible role of chromosomal aberrations or anomalies was verified using cytological staining. Both meiotic and mitotic studies were initiated to observe the chromosomes. The chromosome number was verified in five parental lines of castor with three distinct sex phenotypes and the chromosome number was unaltered with 2n=20. Thus, numerical chromosomal aberrations were not involved in sex expression in castor.

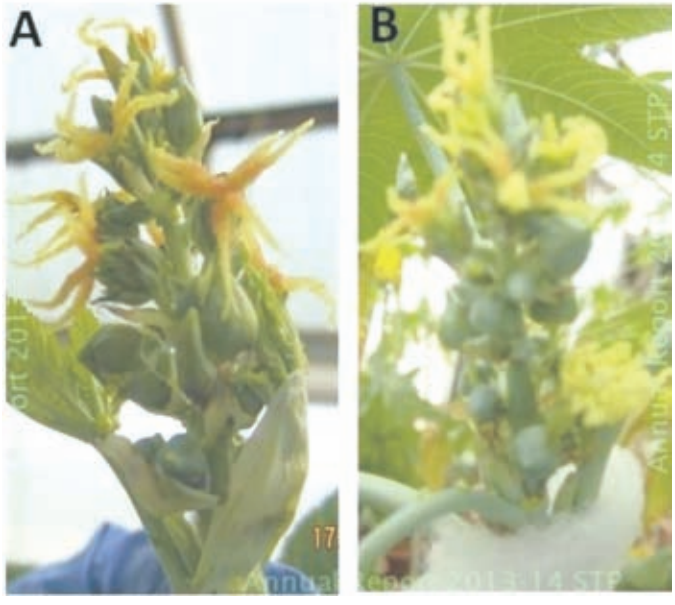


Floral differentiation stages in castor
A. Vegetative primordia before differentiation into inflorescence and
B. Floral primordia after differentiation into inflorescence

Epigenetic mechanisms play a major role in most of the development processes especially floral development. Seeds of two parental lines of castor were treated with two concentrations of epimutagen 2-deoxy 5-azacytidine and grown along with control plants. The variation in sex phenotype was monitored in the treated plants. No significant effect was noticed in the sex expression in the test lines at two concentrations. Few seed-treated plants were injected with the epimutagen. Higher proportion of male flowers was observed in two plants when compared to control.

Prediction of microRNA genes using computational tools

A database of castor protein sequences was generated using NCBI Protein database. Castor draft genome was blasted against the castor protein



Effect of epimutagen treatment on sex expression in castor
Higher proportion of male buds observed in
treated plants (B) when compared to untreated/control plants (A)

database using BlastX to detect coding regions in the castor genome contigs. A database of non-coding sequences was generated out of the contigs with no hits with BlastX. This database was used for predicting microRNAs using computational approaches.

As a first step, NOVOMIR program was used for *de-novo* prediction of probable pre-miRNAS. The program predicts miRNA genes based on computational approach and does not rely on comparative genomics and/or ***a priori*** knowledge of miRNA target. The program uses a series of filtering steps and Hidden Markov Model (HMM) to discriminate a miRNA gene from other mRNA encoding genes. In the pipeline, RNAfold and RNAshapes are incorporated for secondary structure prediction and calculations. Database containing non-coding regions of castor draft genome was made into multiple FASTA files for ease of processing with NOVOMIR. This analysis predicted 19,243 probable pre-miRNA genes from non-coding regions.

To sieve through this large number of identified pre-miRNAs and to remove such sequences which did not meet the additional features of pre-miRNAs, two most popular classification tools *viz*., HHMMiR and Triplet-SVM were employed. HHMMiR implements a Hierarchical Hidden Markov Model (HHMM) that utilizes region-based structural as well as sequence information of miRNA precursors while Triplet SVM classifier uses a set of 32 novel features of local contiguous structure-sequence information for distinguishing the hairpins of real pre-miRNAs and pseudo pre-miRNAs. Predicted pre-miRNA genes were initially classified with HHMMiR. The secondary structure was predicted for miRNAs using RNAfold and the single strand hairpin structures were extracted using JAVA program. These extracted structures were then subjected to Hierarchical Hidden Markov model. The HHMMiR classified 7,188 as true putative pre-miRNAs. Further filtration with Triplet-SVM (SVM classifier) extracted 4,054 putative pre-miRNAs as potentially true miRNAs.

CROP PRODUCTION

Enhancing resource use efficiency in castor based cropping systems

Moisture and nutrient utilization dynamics in castor – sorghum cropping system due to integrated nutrient management under rainfed conditions in Alfisols

The success of cropping in rainfed situations is a major interplay of nutrient and moisture for crop growth. The variable soil moisture due to varying rainfall affects nutrient availability and uptake. A study on castor-sorghum cropping system in Alfisols was studied for their performance under different integrated nutrient management practices in fixed plots under rainfed conditions.

The total annual rainfall at Narkhoda farm for 2013 was above normal (1066 mm in 59 rainy days as against the normal rainfall of 730 mm in 35 rainy days) and was fairly well distributed during the cropping season except for the skewed rainfall of 118 mm in 33rd and 188 mm in 43rd week with associated high RH. The cropping season received excess rainfall than normal (>50%) and did not experience any moisture stress.

Application of 5 t FYM/ha along with 100% RDF (NPK) has recorded highest seed yield (3582 and 846 kg/ha, of sorghum and castor, respectively). No manure or application of either N alone (499 kg/ha) or NP (524 kg/ha) or 50% NPK (641 kg/ha) recorded lowest seed yield. Fodder yield of sorghum was highest (4505 kg/ha) with NPK+5 t FYM/ha. In general, crop growth and yield was higher with higher level of nutrition under the conditions of non-limiting soil moisture during 2013.

Agronomy of *rabi* castor

Days to 50% primary and secondary spike initiation of three castor genotypes (DCH-519, GCH-7 and DCH-177) differed due to different sowing dates during *rabi* season. Among the different genotypes, number of days taken to 50% primary and secondary spike formation of DCH-

519 hybrid was earlier by 4-10 days compared to GCH-7 and DCH-177 in September 15th planted crop.

Public sector released castor hybrids *viz*., DCH-177, DCH-519, GCH-4, GCH-7, PCH-111, PCH-222, YRCH-1 and varieties *viz.,* DCS-107, GC-3 and 48-1 were evaluated for their suitability during *rabi* season. The growth and expression of DCH-519 and GCH-7 was superior over other hybrids while among varieties, DCS-107 performed superior over GC-3 and 48-1.

Studies on drought tolerance, water use efficiency and source - sink relationships

Confirmation of drought tolerance of castor genotypes with good root traits in field conditions was studied. Thirteen genotypes including nine germplasm lines with good root growth, two with poor root growth along with the variety (48-1) and hybrid (DCH-519) checks were sown during November 2013 and water stress was imposed from 50-125 DAS. This has resulted in reduced crop growth in terms of plant height, leaf number, branches, stem girth, leaf area index (LAI), stem, leaf, spike and total dry matter (TDM), specific leaf area (SLA) and increased relative water content (RWC), chlorophyll content (SCMR) and membrane stability (MSI) at 75 days in stress.

Genotypes with less percent reduction in TDM (<30%) and with high dry matter stress index (DMSI) (>70%) before relieving stress include RG-27, DCH-519. RG-27 recorded more SCMR, RWC, MSI under stress. Effective spike length, capsule number and seed yield of primary spike reduced significantly with drought stress. Among the genotypes studied, RG-122 (29%), RG-211 (37.4%) recorded less per cent reduction in seed yield of primary spike.

Reconfirmation of *Trichoderma* strains in imparting drought tolerance

Five *Trichoderma* isolates were used for seed treatment of DCH-519 hybrid along with untreated check and were sown in field during late *rabi* 2013-14 by imposing stress from 40-120 DAS. There was significant reduction in crop growth in terms of reduced plant height, leaf number, stem girth and total drymatter (TDM) at 77 days (before relieving) in stress. TDM showed significant reduction with different isolates tested. Primary spike length, capsule number and seed yield reduced significantly with drought stress.

In irrigated plots, TA 2, T 7316, GJ 11 and in drought stressed plots, TA 2, T 673, GJ 11A recorded higher TDM compared to other isolates. Among the different isolates tested, GJ 11A, T 673 followed by T 7316 recorded significantly higher seed yield of primaries compared to untreated checks in both irrigated and drought stressed plots and the per cent increase was more in stressed treatments.

Per cent reduction in TDM before relieving stress and primary seed yield with *Trichoderma* isolates compared to untreated checks in irrigated and drought stress conditions

Trichoderma isolates	% reduction in TDM before relieving stress		% reduction in primary seed yield	
	Irrigated	Stress	Irrigated	Stress
TA 2	-20.8	-18.3	23.2	6.4
Th 4d	21.9	3.9	3.6	9.0
T 7316	-18.1	2.1	-4.6	-18.2
GJ 11A	-19.7	-5.8	-8.2	-36.3
T 673	-4.0	-15.7	-6.1	-30.9

In vivo screening of saline tolerant *Trichoderma* isolates

A pot experiment was conducted to study the effect of five saline tolerant isolates of *Trichoderma* on the growth parameters of castor seedlings under saline (EC=2.0 dS/m) and normal (EC= 0.07 dS/m) soils at 30 days. Among the five strains, the effect of Th 4d was superior in improving germination percentage (65%), vigour index (7990) and drymatter weight (16.8 g) under salinity stress condition, the values for these parameters in untreated control were 60%, 7020 and 10.7 g respectively.

Th4d-NS **Th4d-SS**

UC-NS **UC-SS**

Growth response of castor seedlings to *Trichoderma* isolates under saline and normal soil conditions with and without *Trichoderma* isolate Th 4d at 30 days growth stage (NS: Non saline soil; SS: Saline soil; UC: Untreated control)

Quality

Three hundred castor genotypes were evaluated for ricinoleic acid content. Ricinoleic acid content ranged from 72.29 (RG-67) to 91.44 % (RG-357).

CROP PROTECTION

Wilt

Screening of parental lines and preliminary hybrids against wilt

Among 86 parental lines of castor screened against wilt disease in wilt sick plot, six lines *viz.,* Kh 12-317-2, Kh 12-1498-1, DCS-81, DCS-89, DCS-108, DCS 120 were free from wilt disease and 35 lines (Kh 12-77-2, Kh 12-86-2, Kh 12-91-2, Kh 12-91-3, Kh 12-98-2, Kh 12-111-2, Kh 12-130-3, Kh 12-320-1, Kh 12-339-2, Kh 12-367-1, Kh 12-367-4, Kh 12-1373-1, Kh 12-1422-1, Kh 12-1422-2, Kh 12-1522-2, Kh 12-1555-1, Kh 12-1841-1, DCS-86, DCS-94, DCS-64, DCS-78, DCS-102, DCS-104, DCS-105, DCS-106, DCS-107, DCS-110, DCS-118, DPC-17, M-571, M-574, DPC-23, DPC-24, DPC-25 and M-DPC-9-1) recorded less than 20% wilt disease.

Among 72 advanced breeding lines, 17 lines (PHT-2013-11, 15, 23, 27, 32, 46, PHT-11-13-56, 60, 62, 72, 73, 77, 78, 79, 80, 81 and PHT 13-2) were free from wilt disease. In national screening nursery for wilt, the breeding lines PHT-12-12, 12-17, YRCH-1106, YRCS-1205 showed < 20% wilt disease, which indicates resistant reaction.

Castor hybrids, GCH-7 and GCH-4 were susceptible to Palem isolate of *Fusarium oxysporum* f.sp. *ricini* while the same cultivars were resistant to Hyderabad and S.K. Nagar isolates. Kranti and PCH-111 were susceptible to *Fusarium* isolates of Hyderabad, S.K. Nagar and Palem.

Pathogenic variability in *Fusarium oxysporum* f.sp. *ricini*

Twenty five isolates of *F. oxysporum* f. sp. *ricini* were inoculated to castor cultivars Kranti, JI-35, VP-1, 48-1, PCS-124, DCS-9, JI-258 by root dip

inoculation method. *Fusarium* isolates, For-12-1, 3, 10, 13-19, 20 were highly virulent, while For-13-22, 13-23, 13-26, 13-28 were less virulent.

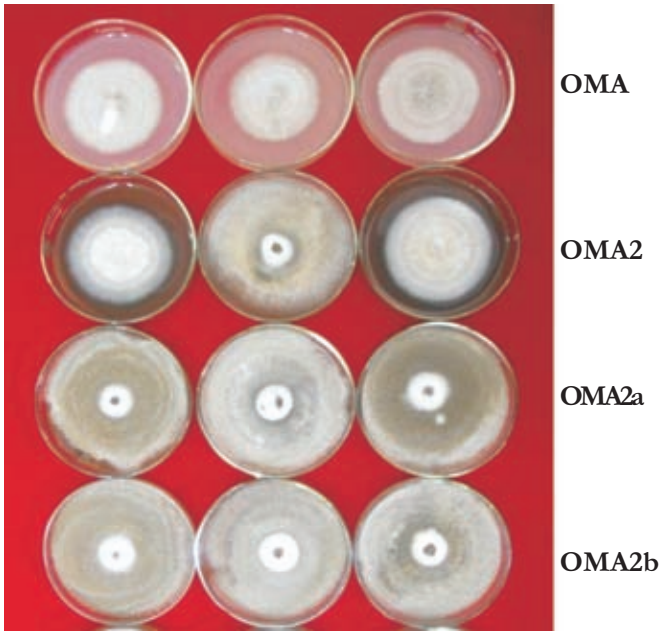
Management of wilt disease

In a field trial on management of castor wilt, the disease incidence was less (55.8%) in seed treatment with *T. harzianum*, Th4d WP @ 10 g/kg compared to control (90.4%).

Botryotinia gray rot

Growth medium for improved sporulation of *Botryotinia ricini*

Among corn meal agar (CMA), oatmeal agar (OMA), V_8 juice agar and potato carrot agar (PCA) amended with ammonium nitrate (1 g/l), yeast (1.5 g/l), gallic acid (1 g/l) and 20% castor pericarp extract per liter, OMA supported good sporulation and mycelial growth. The medium was further improved by adding amino acid L-asparagine, incubated under 12 h cycle of dark and light at 25°C temperature and humidity above 70%. OMA medium thus enriched has supported good mycelial growth and sporulation of *B. ricini*.



Growth and sporulation of *Botryotinia ricini* on enriched OMA medium

Pectin levels in castor capsules and resistance to gray rot

Pectin level was relatively low in the tolerant lines RG-1139 (27.8%), 48-1 (26.4%) and F_1 derivative of cross RG-1139 x 48-1 (26.7%) while DCH-519, a highly susceptible hybrid recorded 30% pectin. Low level of pectin in capsule pericarp attracts low disease incidence/delay in disease onset as pathogen secretes low levels of pectin degrading hydrolytic enzymes

Management of *Botryotinia* gray rot

Spray of propiconazole 0.2% and carbendazim 0.1% were found to be the most effective and recorded significantly less severity of gray rot (15.6% and 18.5%, respectively). *T. harzianum* Th4d SC @ 2 ml/l showed a disease severity of 39.8% compared to 72.3% in pathogen check. Significantly, highest seed yield (1330 g/30 spikes) was recorded in propiconazole @ 0.2% followed by carbendazim + mancozeb (1250 g/30 spikes) treatments compared to pathogen check (790 g/30 spikes).

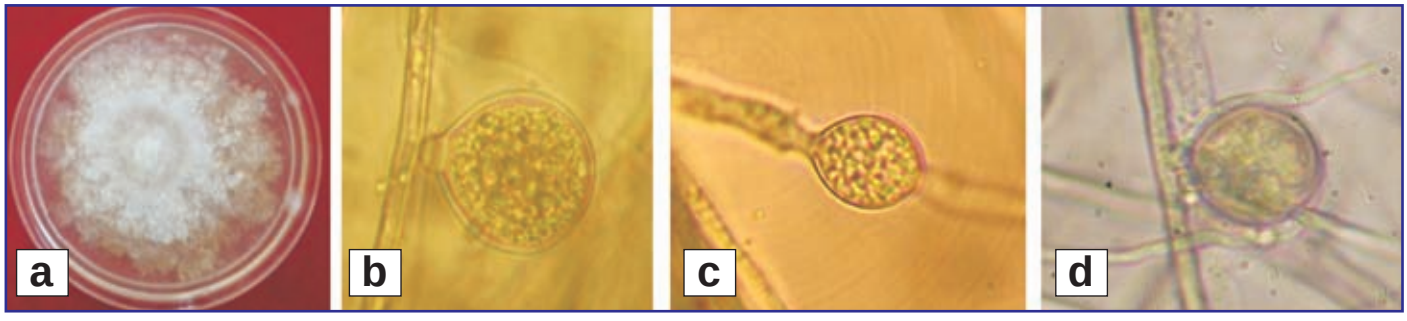
Untreated control

Effect of Propiconazole on gray rot

Effect of Carbendazim on gray rot

Phytophthora seedling blight

Twenty isolates of *Phytophthora* from different geographical areas were isolated from castor. Morphological characterization and ITS sequencing revealed that the species associated is *Phytophthora nicotianae* but not *P. drechsleri* or *P. palmivora* as reported earlier.

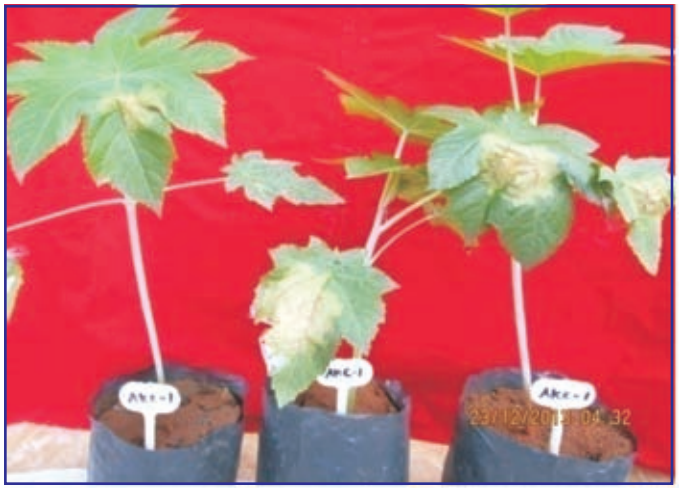


a. *Phytophthora nicotianae* on potato carrot agar (PCA), b. ovoid terminal sporangia with prominent papilla, c. intercalary sporangium, d. chlamydospore

Identification of *Phytophthora* sp.

Standardization of screening technique against *Phytophthora nicotianae*

Among different screening techniques (germination towel technique, soil/sand cup method, agar bit inoculation technique and zoospore inoculation technique), agar bit inoculation technique was found most effective compared to the other methods as leaf blight symptoms appeared within 24-48 h after inoculation. In this method, leaves were inoculated with pathogen on the reverse (abaxial) side of the leaf using a disc of agar (5 mm) colonized with *Phytophthora*. Agar bit was covered with small wet cotton and sealed with cellophane and inoculated plants were maintained in glasshouse at 25 ^{0}C temperature and humidity above 70%.



Agar bit inoculation method

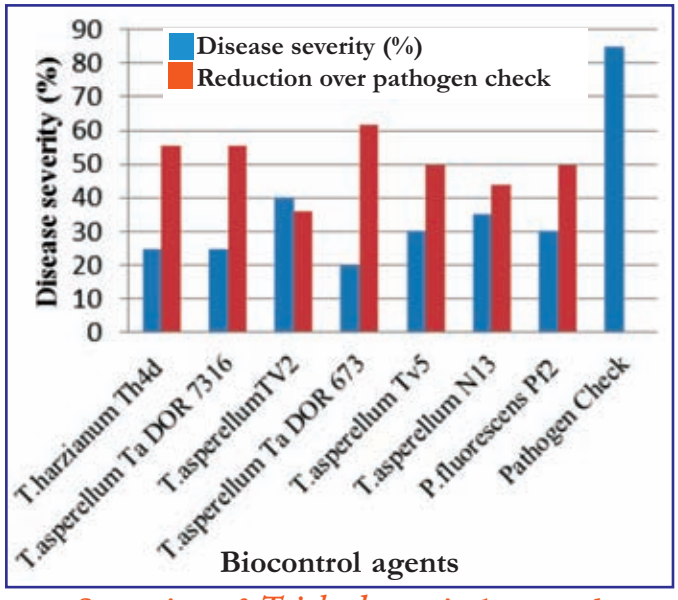
Zoospore sprayed leaves showing blight

Screening for *Phytophthora* blight reaction by different techniques

Screening and selection of potential biocontrol agents against Phytophthora seedling blight

Among the six *Trichoderma* isolates screened against Phytophthora seedling blight of castor by agar bit inoculation on detached leaves, high disease reduction (61.5%) was obtained with *Trichoderma asperellum* TaDOR673 treatment. Two isolates *viz*., *T. harzianum* Th4d and *T. asperellum* TaDOR 7316 were also effective with 55.6% disease reduction.

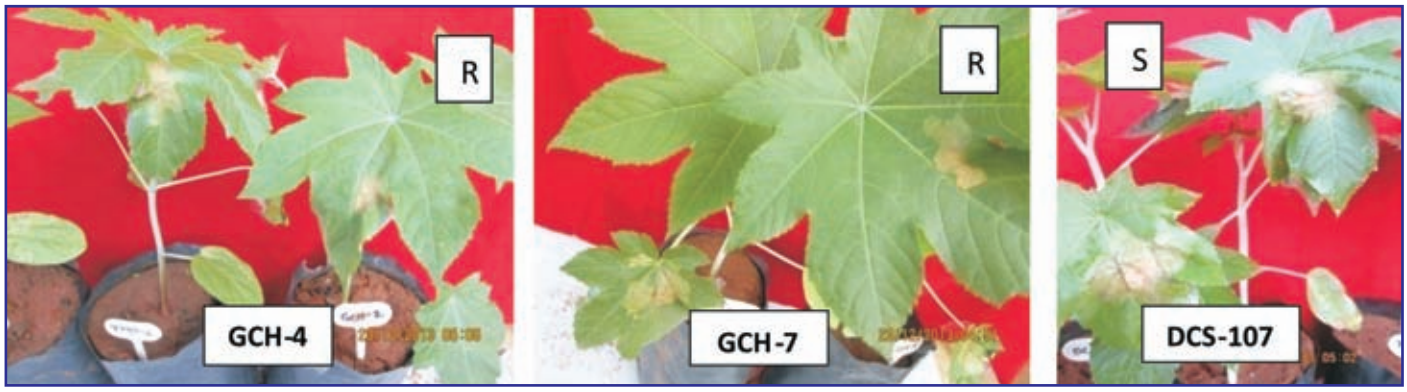
Screening of biocontrol agents against *Phytophthora* seedling blight



Screening of *Trichoderma* isolates and *Pseudomonas fluorescens* against *Phytophthora* seeding blight

Reaction of castor cultivars to *Phytophthora nicotianae*

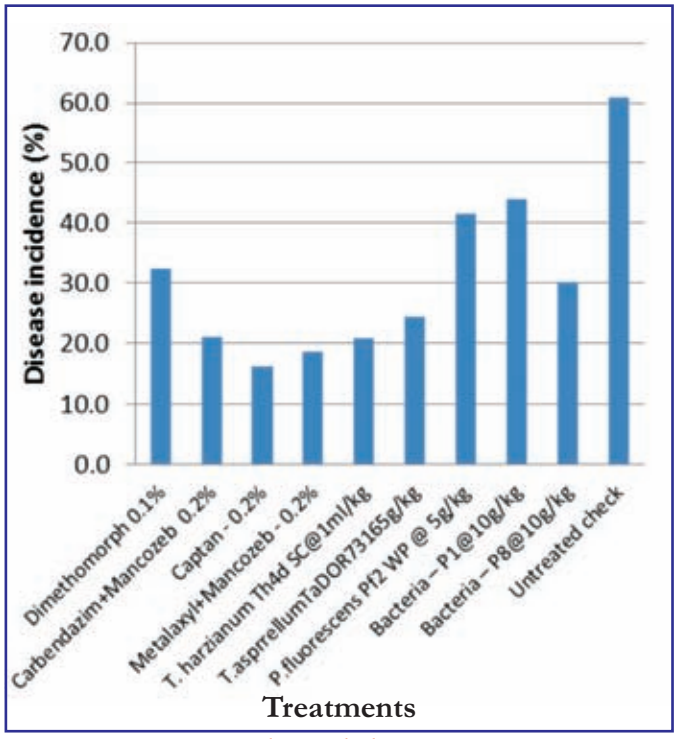
Castor genotypes *viz*., GCH-4, GCH-7 and RG-3216 R were resistant while cultivars GCH-2, GCH-6, GAUCH-1, TMU-5a and PCH-222 were moderately resistant to *Phytophthora* leaf blight.



Reaction of castor cultivars to *Phytophthora* blight

Management of *Phytophthora* damping off and seedling blight

Phytophthora disease incidence was significantly low in captan@ 2 g/kg, metalaxyl + mancozeb 0.2% and *Trichoderma harzianum* Th4d SC @ 1 ml/kg treatments recording a disease incidence of 16.2, 18.6 and 20.8%, respectively, whereas the pathogen check recorded 60.8%.



Management of *Phytophthora* damping off and seedling blight

Evaluation of advanced breeding material against leafhopper and capsule borer

Among 26 advanced lines screened, six entries *viz*., PHT-2013-14, PHT-2013-30, PHT-2013-32, PHT-2013-41, PHT-2013-46 and PHT-2013-79 were found resistant to leafhopper with a low hopper burn grade between 0.1 to 1.0 on 0-4 scale as compared to hopper burn grade of 4.0 and 3.8 in checks DCH-177 and DCS-107, respectively. Only one entry PVT-12-152 recorded lower capsule borer damage of 9.1%. Five entries (PHT-2013-32, 41, 64, PVT-12-137, 172) recorded capsule damage between 10-20%. Twenty entries recorded more than 20% capsule damage with maximum of 47.2% in PHT-2013-61.

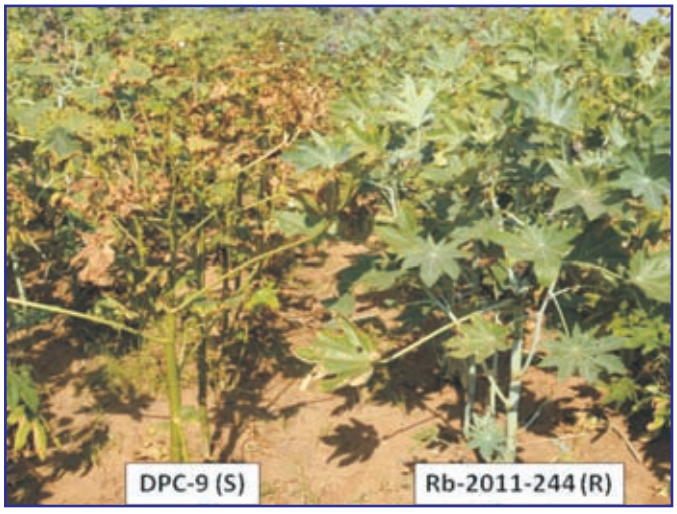
Screening of parental lines against leafhopper

Out of 34 parental lines and three checks screened, five lines *viz*., DPC-15, DPC-21, DPC-25, M-571 and M-574 were found highly resistant to leafhopper (hopper burn grade 0 on 0-4 scale). Ten lines (DPC-20, 23, 24, DCS-86, 94, 106, 109, 110, 114 and 118) were found resistant to leafhopper and recorded hopper burn grade between 0.1 to 1.0. Six lines (M-DPC-9-1, DCS-78, 81, 84, 89, 120) were found moderately resistant to leafhopper (hopper burn grade 1.1 to 2). Among checks, DCH-519 did not exhibit any hopper burn and was found highly resistant, where as DCH-177 and DPC-9 were highly susceptible with a maximum hopper burn grade 4.0.

Confirmation of leafhopper resistance in mutant DPC-9 lines

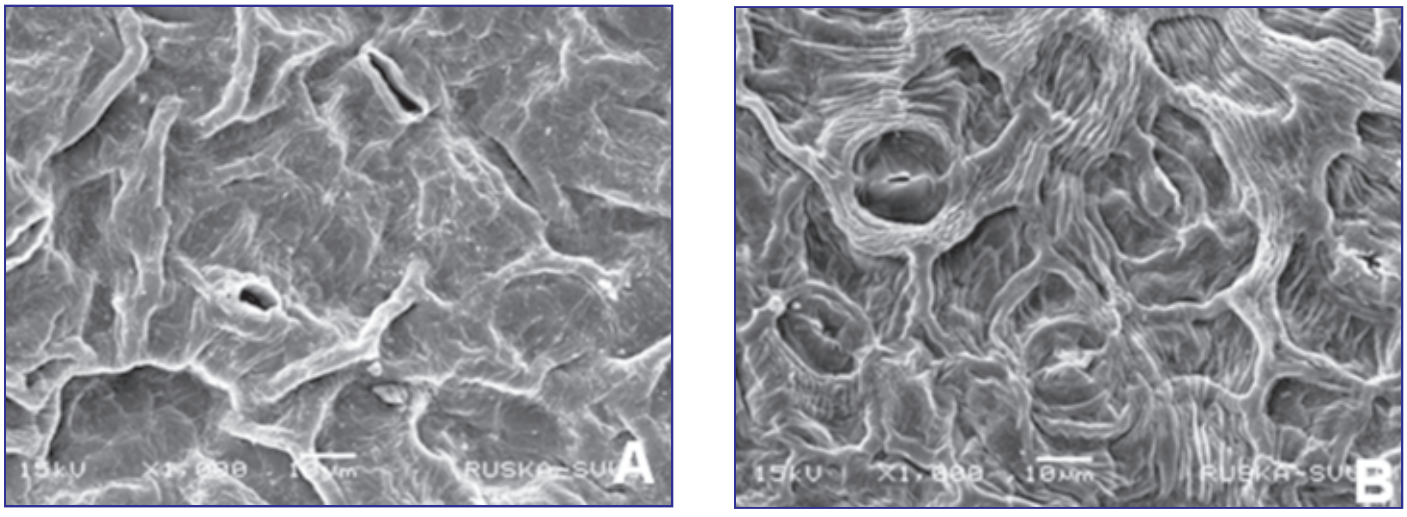
Screening of nine promising mutant DPC-9 selections was carried out for confirmation of

leafhopper resistance. Seven mutant selections (Rb-2011-244, 217, 213, 216, 231, 228 and 214) and resistant checks (DCH-519 and M-574) were found resistant to leafhopper with a low hopper burn grade between 0.2 to 0.6 on 0 to 4 scale. Two entries, Rb-2011-258 and 276 (hopper burn grade 2.4 and 3.3, respectively) and checks DPC-9 and DCH-177 (hopper burn grade 4.0) were found susceptible to leafhopper. A highly significant and negative association between leaf wax content and hopper burn was observed. Scanning electron microscopy revealed prominent epicuticular wax layers on the lower leaf surface of resistant mutant DPC line as compared to DPC-9.



Leafhopper susceptible (DPC-9) and resistant (Rb-2011-244) lines

Leafhopper resistant (Rb-2011-217) and susceptible (Rb-2011-258) lines



Scanning electron micrographs of lower leaf surface of leafhopper resistant Rb-2011-217 line (A) and susceptible DPC-9 (B)

Evaluation of newer insecticides against leafhopper

Among the newer and conventional insecticides tested against leafhopper, thiamethoxam (0.4 g/l), acetamiprid (0.2 g/l), dimethoate (1.7 ml/l), profenofos (1 ml/l), monocrotophos (1.6 ml/l) and acephate (1 g/l) gave more than 90% mean reduction in leafhopper population over untreated control. The other insecticides *viz.*, flubendiamide (0.2 ml/l), chlorantraniliprole (0.3 ml/l), fipronil (1 ml/l) and methomyl (1 g/l) resulted in 28.5 to 79.6% reduction in leafhopper population over untreated control.

Evaluation of pest management modules

IPM module (mechanical control of defoliators, need based application of thiodicarb 0.075% for defoliators, indoxacarb 0.015% for capsule borer and dimethoate 0.05% for leafhopper) in castor was evaluated in three cultivars *viz*., DCH-177, DCH-519, DCS-107 and compared with farmers' practice and untreated control. Avoidable yield losses through adoption of IPM module in DCH-177, DCH-519 and DCS-107 were 84.8, 37.4 and 80.6% over untreated control, respectively. Avoidable yield losses over farmers' practice in DCH-177, DCH-519 and DCS-107 were 78.8, 11.4 and 76.2% over untreated control, respectively.

Development of suspension concentrate formulation of *Bacillus thuringiensis* var. *kurstaki* (strain DOR *Bt*-1) and efficacy evaluation

Boric acid (BA) was found to be synergistic to DOR *Bt*-1 and could replace 25% of the *Bt* requirement. Suspension concentrate (SC) formulation based on mineral oil was developed using *Bt* along with BA and bioassayed against seven days old *A. janata* and six days old *H. armigera* larvae. LC_{50} of the SC formulation against *A. janata* was 0.98 µl/ml and 1.85 µl/ml against *H. armigera* larvae 2 DAT.

Bt*-1 SC formulation sprayed castor plant with a dead larvae of *A. janata

Control castor plant with high foliar damage due to feeding by castor *A. janata* larva

Field testing of DOR *Bt*-1 SC formulation on castor

Field testing of the DOR *Bt*-1 SC formulation @ 1.0, 1.5 and 2.0 ml/l against *A. janata* larvae on castor resulted in 90-100% reduction of larvae within three days after spray (DAS) caused by larval mortality due to *Bt* with all the three doses and efficacy on par with the insecticidal check profenophos @ 1.0 ml/l.

Laboratory bioassays of suspension concentrate (SC) formulations of DOR *Bt-1* and combination of *Bt* and *B. bassiana* against capsule borer

Bioassays undertaken against capsule borer *Conogethes* (*Dichocrocis*) *punctiferalis* larvae through diet incorporation method revealed LC_{50} values of 1.0 ml/l and 2.06 ml/l for combination formulation of Bt + *B. bas*siana and DORBt-1 SC formulations, respectively.

Enhancing fecundity and hatchability of capsule borer on natural hosts

Among host stages of castor and maize, capsule borer preferred both immature and half-mature castor capsules (23.8 to 28.4 eggs) and maize cobs (17.2 to 25 eggs) for oviposition. Hatching rate was more in castor (69.4 to 73.8%) compared to maize (55.9 to 63.1%). No oviposition was recorded in fully mature castor capsules and maize cobs. Semisynthetic diet incorporated with corncob was found ideal for rearing capsule borer larvae.

Oviposition and multiplication of capsule borer on immature maize cob

Calling behaviour of capsule borer and male response to pheromone gland extracts

Female calling behaviour and electrophysiological response of male to pheromone gland extracts of capsule borer, *C. punctiferalis* were studied under laboratory conditions. A maximum of 74% male and 66% female moths emerged during the scotophase between 20:00 to 23:00 h. Females exhibited a characteristic calling posture by extruding the pheromone gland from the tip of the abdomen. Initiation and maximum calling occurred during second scotophase (46.7%). Most of the female calling (41.2%) occurred during 8th hour of the scotophase (01:00 to 02:00 h). The male responded to the female calling by bending of abdomen with extrusion of hair pencils. Extracts of female pheromone gland assayed in electroantennogram elicited hypersensitive reaction in male moths with a response of -2.467 mV.

Calling posture of *C. punctiferalis* female (Arrow indicates exposed pheromone gland)

Evaluation of pheromone blends on catches of *C. punctiferalis*

Trapping efficiency of two different blends (found promising during 2012-13) of indigenously, synthesized (IICT) sex pheromone components of *C. punctiferalis* impregnated in rubber septa was evaluated in castor during *kharif* 2013. Blend-2 was found effective consistently in attracting capsule borer moths with maximum catches of 4.75 to 5.25 moths/trap/week recorded during 47th and 48th MW (3rd week of November to first week of December, 2013). Moth catches in blend-4 ranged between 0 to 1.0 moths/trap/week. Incidence of capsule borer larvae was observed during 40th MW (first week of October) and remained active until harvest of the crop with peak during 49th to 52nd MW (2.8 to 4.4 larvae/plant). Parasitism of capsule borer larvae by *Eriborus trochanteratus* (upto 15.6%) and braconid parasitoid (2.6%) was recorded in the field.

Monitoring seasonal activity of *S. litura* using pheromone trap and analysis of effect of abiotic factors on the population fluctuation

Seasonal activity of *S. litura* has been monitored in two locations (Rajendranagar and Narkhoda) using pheromone traps during castor cropping seasons (July 2013 to February 2014). Two peak trap catches were observed, first during 34th to 35th MW (second fortnight of August) and second during 41st to 43rd MW (October). Highest peak catches of *S. litura* in two locations ranged from 54.5 to 73.3 moths/trap/week. Trap catches declined from 44th MW to 5th MW (November first week to February first week). Significant positive relation was found between egg-masses in castor and trap catches (r=0.61 to 0.82). Moth catches were found to have significant positive correlation for

minimum temperature (r=0.45 to 0.46), evening relative humidity (r=0.49) and rainfall (r=0.56). Peak egg-masses (5.8 to 8.2/5 plants) and larval incidence (30.8 to 48/5 plants) was observed during 40 to 41st MW and 41 to 42nd week, respectively. Egg-masses count was found to have significant positive correlation with mean temperature (r=0.39 to 0.41) and larval incidence was found to have positive relation with rainfall (r= 0.42). The response of *S. litura* to light trap (0 to 16 moths/week) was lower than sex pheromone trap. Significant positive correlation between number of egg-masses in castor and light trap catches (r=0.66) was observed in Rajendranagar, whereas it was found non-significant at Narkhoda.

Evaluation of pheromone based management method against *Spodoptera litura*

Mating disruption technique with synthetic sex pheromone of *S. litura* [(Z,E)-9,11-14Ac and (Z,E)-9,12-14Ac in 10:1] @ 10 mg/dispenser (50 g a.i./ha) was evaluated in castor during *kharif* 2013-14. *S. litura* moth catches in pheromone traps were low in mating disruption plot (10 to 21 moths/trap/week) compared to control plot (30.5 to 69 moths/trap/week). However, no significant difference in egg-masses and larval population was observed in mating disruption (0.4 to 5.2 egg-mass and 2 to 22.6 larvae/5 plants) and control plot (0.8 to 4.6 egg-mass and 3.4 to 21.2 larvae/5 plants).

Identification of effective synthetic attractants for *Spodoptera litura*

Electroantennographic response of one-day old male and female *S. litura* moths to six synthetic kairomonal attractants (benzaldehyde, benzyl acetate, P-anisaldehyde, phenyl acetaldehyde, 2-phenyl ethanol and methyl salicylate) was studied at two different concentrations (0.1 and 1 µl). Female antennal response to synthetic attractants was significantly more pronounced than that of males. In both the concentrations, female moths showed significant hypersensitive reaction to 2-phenylethanol (-1.531 to -1.578 mV) and phenyl acetaldehyde (-1.518 to -2.221 mV). Male moths did not show much variation in response to synthetic attractants.

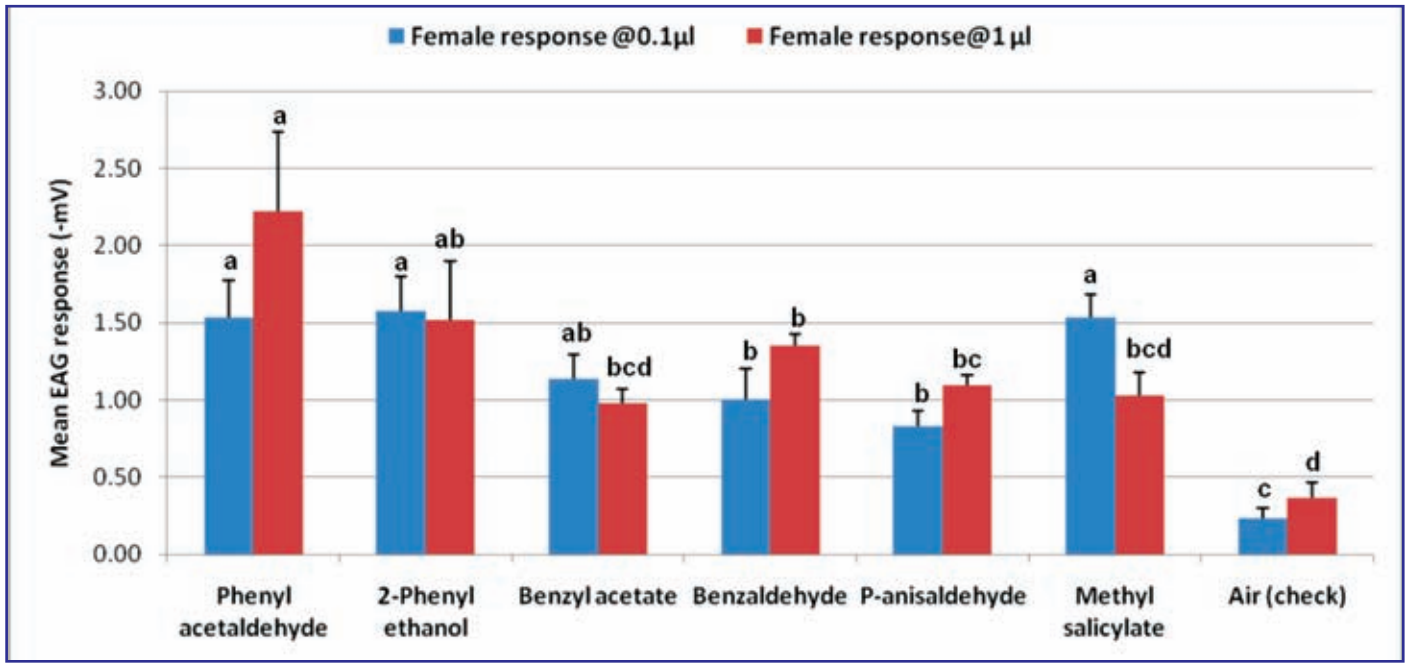
Pheromone impregnated dispenser tied for mating disruption

Evaluation for attractiveness and efficacy of poison baits against *S. litura*

Effectiveness of four baits using rice and wheat bran with sugarcane and palm jaggery was evaluated to attract fourth instar larvae of *S. litura* by free-choice test. Wheat bran with sugarcane or palm jaggery attracted more larvae (16.8 to 25.6% at 48-h after release) as compared to rice bran based baits (5.2 to 7.6% at 48-h after release). Wheat bran + palm jaggery bait mixed with novaluron 10EC / chlorpyriphos 20EC resulted in more than 90% mortality of *S. litura*.

Castor - A new host to Root-knot nematode, *Meloidogyne incognita*

Although considered a poor host to root-knot nematodes, castor was found severely infected by root-knot nematodes at Sirohi district of Rajasthan. Survey of different villages *viz.* Danpura, Varman, Jiraval, Harniamarapura, Dontrai, Amirpura, Mohanpur and Rauva in Revdar mandal revealed



Electroantennographic response of *S. litura* moths to synthetic kairomonal attractants

rampant growth of galls on castor roots. Infected crop showed yellowing and stunting. Soil nematode population varied from three to 36 per CC soil. Population of egg masses on roots ranged from 121 to 357 per root.

Galls on castor root **Galls - Close-up view**

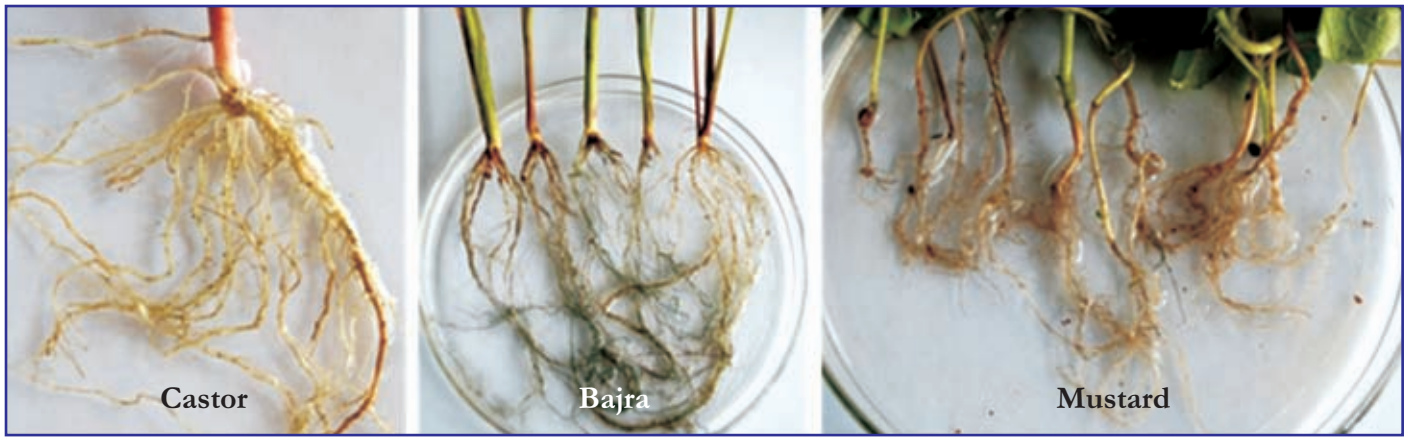
Castor plant infested with root-knot nematode

Survey on plant parasitic nematodes

Sampling of soils in DOR research farms revealed the presence of plant parasitic nematodes belonging to *Tylenchida* (reniform nematode, *Rotylenchulus reniformis*, spiral nematode, *Helicotylenchus* sp., lance nematode, *Hoplolaimus* sp., stunt nematode (*Tylenchorhynchus* sp.) and Aphelenchida (*Aphelenchoides* sp.). Reniform nematode is the only plant parasitic nematode of economic importance and its population density in Rajendranagar and Narkhoda farms ranged between 0 to 1.0 nematode per CC soil in both *kharif* and *rabi* seasons. The nematode was absent in soils of DOR-ICRISAT farm.

Race studies on reniform nematode

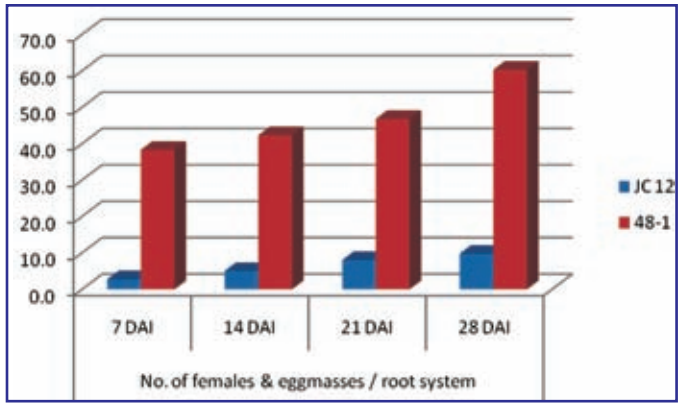
Host differential experiment pertaining to race identity of reniform nematodes occurring in soils of Rajendranagar and Narkhoda farms undertaken by growing castor (48-1), bajra (Pusa 23) and mustard (Pusa bold) on nematode sick soil revealed that both populations were reproducing on castor with average root population of 25.6 and 23.0 egg masses, respectively. However, they failed to reproduce on either bajra or mustard as visualized by the absence of any nematodes/egg masses on the roots. Thus, they belong to race A-1.



Host differential experiments with reniform nematodes

Penetration and developmental studies of reniform nematode on resistant and susceptible genotypes

Penetration behaviour of reniform nematode on resistant (JC-12) and susceptible (48-1) genotypes of castor showed large number of nematodes entering the roots of 48-1 than JC-12 with an average root population of 60.3 and 9.8, respectively. Delayed nematode development and reproduction was evident on roots of JC-12 as average number of egg masses at 7, 14, 21 and 28 days after inoculation were 2.8, 5.0, 8.0 and 9.8, respectively. Corresponding values of 48-1 were 38.3, 42.3, 46.3 and 60.3, respectively. Thus, the resistant genotype harbored a smaller proportion of nematode population with delayed development and reduced reproduction.



Penetration behaviour of reniform nematode on resistant (JC-12) and susceptible (48-1) genotypes of castor

Screening JC-12 to different isolates of *Fusarium* wilt fungi through root-dip inoculation method

Reaction of nematode resistant genotype JC-12 to three different isolates of *Fusarium oxysporum* f. sp. *ricini viz.*, DOR, Palem and SK Nagar showed that it was resistant to DOR and SK Nagar isolates but susceptible to Palem isolate with percent wilt incidence of 70%.

Effect of different isolates of *Trichoderma* on egg hatch and mortality of reniform nematode

Among seven *Trichoderma* isolates (*T. asperellum* N-13, *T. asperellum* Tv-2, *T. harzianum* Th4d, *T. asperellum* Tv-2 B76, *T. asperellum* 673, *T. asperellum* 7316 and *T. asperellum* Tv-5) tested for hatching inhibition of reniform nematode, *T. asperellum* Tv-2 B76 performed better with average nematode hatch of 28.5 per egg mass followed by *T. harzianum* Th4d (34.9) than control (65).

Sources of resistance to diseases and insect pests

Wilt

Confirmed wilt resistance (0-10% wilt incidence) in 10 accessions, RG-2432, RG-2781, RG-2746, RG-386 (IC-432910), RG-3018, RG-2090, RG-2430, RG-1624 (IC-373981), RG-3093 and RG-2787 (IC374338/IC346591) and susceptible reaction in susceptible check, JI-35 (85.7%) in pots using in root dip inoculation. Nineteen accessions *viz.,* RG-1624 (IC-373981), RG-1834, RG-2430, RG-2746, RG-2781 (IC-374333/IC-346585), RG-2787 (IC-374338/IC346591), RG-2800 (IC-346604), RG-2809 (IC-346613), RG-2970, RG-155 (EC-154818), RG-611 (IC-432957), RG-817, RG-1148 (EC-13338), RG-1151 (EC-14806), RG-3105, RG-3322 (EC-625819), RG-3340 (EC-633124), RG-3359 (EC-633143), and RG-3361 (EC-633145) recorded less than 20% wilt incidence in wilt sick plot.

Reaction of wilt susceptible (left) and resistant accessions (right) when screened using root-dip inoculation method

Botrytis gray mold

Two accessions *viz.,* RG-3344 and RG-2761 (IC346564) were found to be resistant to *Botrytis* gray mold with 3.7% and 7.1% disease severity while accessions RG-2043, RG-2118 and RG-2949 were moderately resistant (11.5%, 16.6% and 18.1% disease severity, respectively) and the susceptible check, DCH-519 had 100% disease severity under artificial epiphytotic conditions.

Botrytis gray mold susceptible check, DCH-519 (left) and resistant RG-3344 (right)

Confirmation of resistance to leafhopper

RG-2661 (IC374272) confirmed high resistance to leafhopper (hopper burn grade 0 on 0-4 scale) and 12 accessions (RG-43/ IC0584671, 631, 1468, 1621, 2093, 2266, 2462, 2469, 2498/IC374208, 2526, 3060, 3067) confirmed resistance reaction against leafhopper with hopper burn grade between 0.1 to 1.0 as compared to DPC-9 and DCH-177 (hopper burn grade 4.0 on 0-4 scale).

Confirmation of serpentine leaf miner resistance

Among 47 self-generation progenies of papaya leaf morphotype, RG-1771 screened against leaf miner, 44 progenies recorded leaf infestation between 2.6 to 23.1% (Grade 1 on 0-4 scale) and 3 plants had leaf infestation between 26.7 to 28.6% (Grade 2) due to leaf miner confirming resistance reaction of RG-1771.

RG-2661(R) DPC-9(S) DPC-9(S) RG-43(R) RG-631(R)

Reaction of resistant (R) accessions and susceptible check (S) against leafhopper

Reaction to capsule borer

Among eight castor germplasm accessions screened against capsule borer, RG-2774 (IC346578/IC374330) recorded lower capsule borer damage of 25.8% as compared to 85.5% in susceptible check, DCS-9.

Capsule borer damage in RG-2774 (left) and susceptible check, DCS-9 (right)

SOCIAL SCIENCES

Impact of frontline demonstrations and improved technologies with special reference to technology adoption, constraints and socio-economic factors

Frontline demonstrations (FLDs) are conducted to show the productivity potential and profitability of improved technologies *vis-à-vis* farmers' practices and encourage the farmer to adopt improved technologies at field level and spread the technology to other farmers. AICRP-Castor centre, Bawal, Haryana has conducted FLDs on castor for the last five years. Farmers of the region normally follow mung-mustard and mung-wheat cropping systems. In recent years, collar rot incidence and orobanche weed infestation has increased in mustard crop. Owing to these biotic stresses, yield of mustard is continuously decreasing in the South-Western districts of Haryana. Farmers were looking for an alternate crop to mustard and a suitable intercrop with mung. AICRP-Castor centre (Bawal) has conducted FLDs on castor + mung intercropping systems to assess the profile characteristics, motivational factors for cultivation of castor, impact of castor FLDs on yield and on farmers' income.

Primary data was collected from 90 farmers (45 each of FLD and non-FLD farmers) of Fatehabad, Mahendragarh, Mewat, Rewari and Sirsa districts of South-Western Haryana.

The profile characteristics of selected respondents indicated that majority of castor farmers were middle aged (35-55 years) and with middle to high school education. Most of FLD (45.9%) and 50% of non-FLD farmers belonged to medium level (2-5 ha) of land holding category. Frontline demonstration (36.6%) and non-FLD farmers (40%) had 10-20 years experience in agriculture. However, all the farmers had less than 10 years experience in castor cultivation. Eighty five per cent of FLD farmers attended the training programme on castor once as compared to only 25 per cent of non-FLD farmers. High per cent (85.4) of FLD farmers were members in one organization as against only 2.5% in non-FLD farmers. Almost all the FLD farmers (92.7%) contacted researchers at least once as compared to 10% of non-FLD farmers. The information resources on castor production technology for farmers were ranked based on the farmers' response. Scientists of KVKs & AICRP centre at Bawal, ranked first followed by friends and traders. The officials from department of agriculture ranked fourth.

In castor with mung as intercropping system, castor yield ranged from 1750 to 3500 kg/ha with an average of 2635 kg/ha and mung yield was 500 kg/ha. In farmers practice of mung-mustard system, the yield of mustard was 2125 kg/ha and that of mung as *kharif* crop was 750 kg/ha. In mung-wheat system, the yield of wheat was 4438 kg/ha and that of mung was 750 kg/ha. The economics indicated that the additional net returns were highest in castor with mung intercropping system (₹ 66,650/ha) as against ₹ 45,875 in mung-mustard and ₹ 60,125/ha in mung- wheat sequence.

The major motivational factors for adoption of castor were low risk associated with cultivation of the crop, its suitability for intercropping and local conditions, easy for adoption of technologies and low cost of cultivation.

The major constraints experienced by farmers were non-availability of quality seeds, high cost of labour and their shortage at critical periods, poor marketing facilities for the produce, fluctuating market prices affecting the decision to sow castor, increasing cost of inputs, yield losses due to wilt incidence, frost during crop growth and lack of awareness on improved production technologies.

At present, the hybrid DCH-177 was grown by the farmers and has shown very good yield potential of 2-3 t/ha in the study area. Feedback from farmers indicated that there is a need to develop frost tolerant varieties as frost is one of the major problem. Proper policy planning for good remunerative prices and training to farmers on production technologies are essential. Farmers

preferred castor cultivation as intercrop with short duration pulses rather as a sole crop. The crop has good scope for its spread in districts like Mewat, Rewari, Mahendragarh, Fatiabad, Jhajjar, Hisar and Gurgaon.

Frontline demonstrations

Fifty FLDs were conducted on castor in Anantapur, Mahabubnagar and Ranga Reddy districts of Andhra Pradesh. Of these, 42 demonstrations were conducted in *kharif* and eight were conducted in *rabi*. During *kharif*, 32 FLDs were conducted in Chitlampalli of Guntakal and 10 in Kalyandurgam Mandals of Anantapur Dt. Six FLDs in Hazpalli, Mahabubnagar district and two FLDs in Kurmagouda, Ranga Reddy district were conducted during *rabi*. The *kharif* sowing was done with early onset of monsoon in Guntakal, while sowings were delayed (last week of July-2013) at Kalyandurgam.

Owing to prolonged dry spells, six FLDs in Kalyandurgam and three in Chitlampally were vitiated. In Kalyandurgam, farmers gave one protective irrigation to castor crop. Among the hybrids, DCH 177 performed better than the local variety. The results indicated 33% improvement in mean seed yield of castor through improved technology (DCH-177/DCH-519/DCS-107). In Chitlampally, the seed yield increased by 43% and 28% in IT (DCH-177 and DCH-519) with additional net returns of ₹8271 and ₹4368/ha, respectively. The mean seed yield of DCH-177 and DCH-519 in Chitlampally was 1090 and 916 kg/ha, respectively as against 760 and 713 kg/ha in farmers' practice. The demonstrations on DCS-107 increased the seed yield by 22% as compared to farmers' practice of growing GCH-4. The additional net returns accrued were ₹6188/ha.

Tribal sub-plan

Five hundred and twenty six demonstrations in castor, 60 in sunflower and 100 in safflower were conducted during 2013-14 in districts of Prakasam, Kurnool, Mahabubnagar and Ranga Reddy. Three NGOs *viz*., Agri-Biotech Foundation (ABF), Vikashith Bharath Foundation (VBF) and Rural Environment Education Development Society (REEDS) conducted the demonstrations under the guidance of DOR. Productivity potential and economics of demonstrations conducted by DOR are presented.

Productivity potential and economics of demonstrations on castor during *kharif* 2013-14

Village name	Demonstrations	Yield (kg/ha)		% increase	Additional return (₹/ha)	B:C ratio	
		IT	FP			IT	FP
Banala	2	1488	1063	40	9190	2.7	1.9
Ambagiri	6	1579	1188	33	9772	3.2	3.1
Srirangapur	4	1550	1188	31	8235	3.2	3.0
Appaipalli	8	1503	1188	27	6559	3.0	2.9
Chenchugudem	3	1542	1208	28	9277	3.4	3.0
Varavarlapalli	15	820	758	8	-650	2.1	2.3
Kudichinthala bayalu	4	813	719	13	2274	2.2	2.0
Lakshmapur	14	991	804	23	3215	2.3	2.3
Sarlapalli	4	813	750	9	625	2.1	2.1
Mean	60	1233	985	24	5389	2.7	2.5

IT = Improved technology (Hybrids: DCH-177 and DCH-519); FP = Farmers' practice (local cultivar/PCH-111)

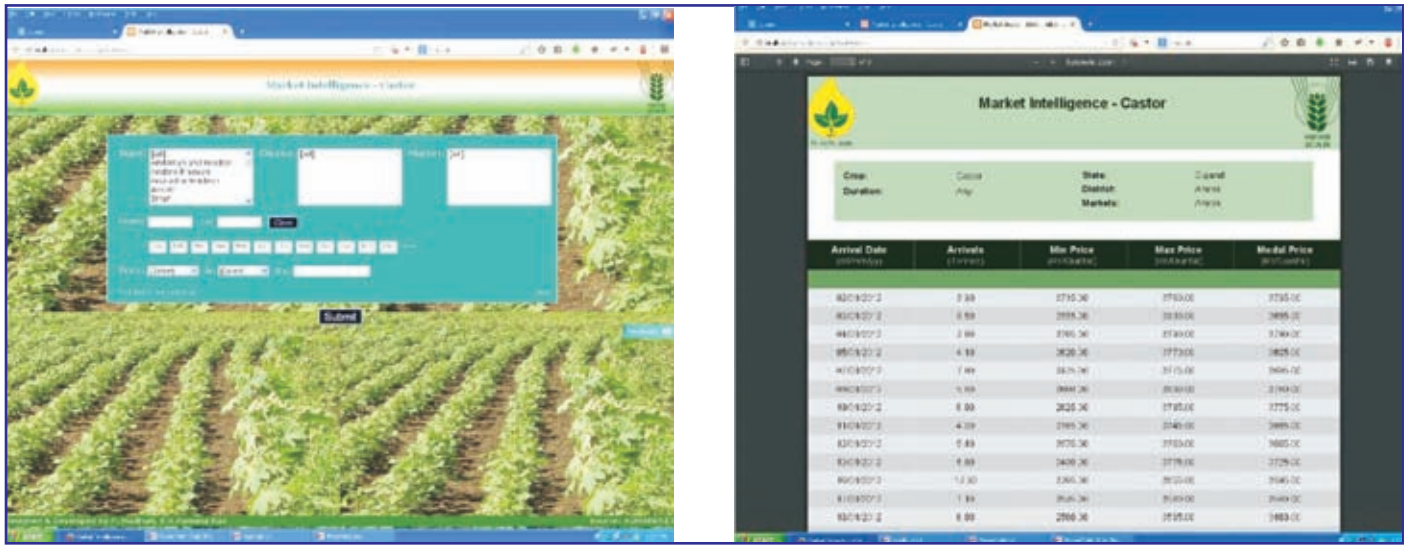
Demonstrations on castor were conducted in nine villages of chenchu and lambada communities belonging to two mandals namely Balmoor and Amrabad, Mahabubnagar district. The villages Banala, Ambagiri, Srirangapur, Appaipalli, and Chenchugudem have received good rains with well distribution and sowings were completed in July. The results showed that highest mean seed yield was 1579 kg/ha at Ambagiri followed by 1550 kg/ha in Srirangapur, 1503 kg/ha in Appaipalli and 1425 kg/ha in Banala. The highest additional net returns were ₹13390/ha at Banala followed by ₹12677/ha at Chenchugudem. The other villages *viz.*, Vattavarlapalli, Kudichinthalabayalu, Sarlapalli and Laxmapuram have received heavy rains during crop growth period and suffered with botrytis disease. The yield obtained under improved technology was 820 kg/ha at Vattavarlapalli as against 750 kg/ha in farmers' practice and similar trend was observed in other villages. The overall mean seed yield obtained from the nine villages was 991 kg/ha as against 804 kg/ha in farmers practice. The mean seed yield in demonstrations increased by 23% over farmers practice, despite heavy rains and loss due to *Botrytis* under rainfed situation. The mean additional net returns accrued were ₹5389/ha with B:C ratio of 2.7 in IT and 2.5 in FP.

Interactive Kiosk for dissemination of technologies

Castor information portal was developed with eight modules, which includes the information pertaining to cultivars, the suitable areas for cultivation, average yield, oil content, etc. The module on management practices includes the climatic conditions, suitable soils, spacing, land preparation, seed treatment, sowing time. Various crop sequences and intercropping systems followed in different regions are described under cropping systems module. The nutrient deficiency symptoms are well described in a separate module. The symptoms of various diseases and their management practices are included in the diseases module with photographs. The details of various pests of castor, their activity period, cultural and management practices are described with photographs in pest module. Various parts of castor plant have different uses, which are explained well under uses module.

Screen shots of castor information portal

Market intelligence system on castor was developed which includes the daily information on prices and arrivals of major markets in various states. The information like maximum/minimum prices of the produce on a particular date in particular market/markets, fluctuating prices over a period across markets can be retrieved easily. The price of the produce for a particular period over the years can also be retrieved. The information with respect to any state/district/market can be uploaded into the information module using the administrative privileges. The retrieved information can either be exported into excel sheet and saved for further use or it can be directly saved into PDF format.



Screenshots of Market Intelligence Portal

Developing mobile phone based knowledge modules

Improvised software platform for disseminating text based SMS in regional language was developed jointly by NIC and DOR. The platform is being used for dissemination of text messages and vKVK platform for dissemination of voice messages to sunflower and castor farmers.

For identifying a suitable voice for developing agro-advisories, a voice competition was conducted among the staff of DOR. The best voice suitable for mobile-based dissemination was identified and voice messages (less than a minute duration) on sunflower and castor production technologies were recorded. The messages were pre-tested during *kharif* with small group of scientists and farmers and fine-tuned based on the feedback. Disseminated 32 voice messages each on sunflower and castor on production and protection technologies to 300 farmers (150 castor and 150 sunflower farmers) during *rabi* 2013.

Evaluation of mobile phone based dissemination programme was done using 'logic model' with 150 farmers each from Prakasam and Mahabubnagar districts of Andhra Pradesh. The data on farmers' listening behaviour, perceptions and opinions of utility of messages, knowledge, adoption and economic benefits were collected through a field survey. The results indicated that majority of the farmers (57.3%) felt the messages were timely, highly relevant (72%), quality of audio was fair (47%). Forty five per cent of surveyed farmers felt the messages were highly technical, 52% expressed the need for more details and less than 50% expressed the content was very useful.

The farmers were categorized into three groups (low, medium and highly knowledgeable) based on the knowledge level. About 48% of the farmers

were in medium knowledge category at pre-dissemination and this increased to 66% at post-dissemination. The farmers under low knowledge category decreased from 26.3 to 10.0% and high knowledge category increased from 13.7 to 24%. The adoption scores showed slight improvement post-dissemination (30 to 38), but were not statistically significant. The seed yield (1650 kg/ha and 1825 kg/ha) and economic returns (₹ 49,500/ha and ₹ 53,750/ha) have not shown any significant improvement post-dissemination. The knowledge scores showed significant improvement, while adoption and yield was not significant between pre- and post-dissemination of messages.

Three hours of video recording was done on various production and protection technologies of sunflower and castor for developing video version of package of practices (PoPs) on sunflower and castor.

Number of messages disseminated during 2013-14

Message	Number of farmers		Number of messages			
	Sunflower	Castor	Sunflower	*Kharif* Castor	Sunflower	*Rabi* Castor
Voice	150	150	13	15	32	32
Text	400	200	30	30	36	40

SAFFLOWER

CROP IMPROVEMENT

Management of genetic resources

A core subset of 148 accessions was evaluated for 8 quantitative traits during *rabi* 2013-14. Wide variability was recorded for plant height (67-100 cm), primary branch length (20.6-59.2 cm), branch angle (17-47°), number of branches (4-19), branch height (3.8-54.2 cm) and number of effective capitula (10-51). A total of 218 safflower accessions including trait specific sets for oil content and oil yield were raised for confirmation during *rabi* 2013.

Mean seed yield over two years (2012-13) of 59 accessions ranged from 1.2 to 32.9 g/plant, 100-seed weight from 1.8 to 7.8 g and oil content from 16.2 to 29.4%. The accession IC 413049 was identified for high seed yield/plant (33 g). Seed yield for 1260 exotic key accessions ranged from 14-907 g/plot, 100 seed weight from 1.92 to 6.73 g and oil content from 18.5-38.1%. Among them, 15 accessions with higher seed yield than checks were identified. Ten high oil accessions with oil content >35% were identified. GMU 972 (EC 181180) recorded highest seed yield (907 g/plot) in comparison to best check, Bhima (488 g/plot) and national check, A-1 (437 g/plot). Accessions GMU 1437 (EC 181737) and GMU 1731 (EC 182117) recorded high oil content of 38.8 and 38.1%, respectively compared to the checks, A-1 (28.7%) and Bhima (31.7%). Nine thin/partial hull single plants were identified for high seed yield (>30 g/plant) and oil content (>35%) out of the 305 plants evaluated.

Maintenance, conservation, documentation and supply

One thousand two hundred and eleven accessions were rejuvenated and 214 accessions were multiplied. About 1946 accessions were submitted in triple layered aluminium foil pouches for conservation in DOR Gene Bank under MTS. Data was sorted and excel file for e-catalogue comprising 1139 accessions including DOR core subset (148), Indian accessions with updated passport data (889), exotic key accessions (56) and exotic trait specific accessions (46) has been prepared. A total of 1892 samples of 880 germplasm accessions were supplied to different AICRP (Safflower) centres for multi location evaluation and utilization in breeding programmes.

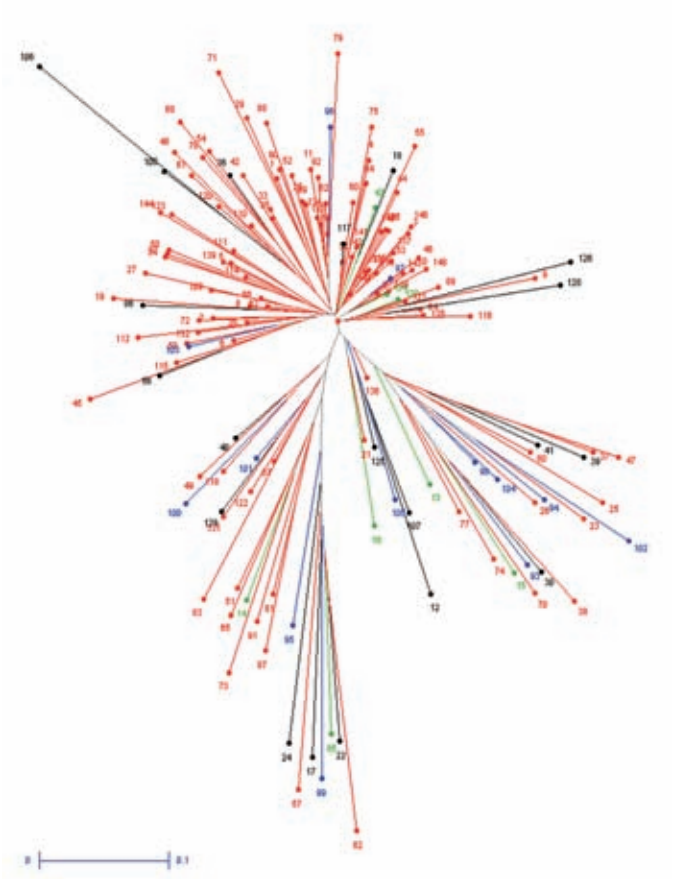
Development of core subset based on quantitative descriptors

A sub core set of 148 (25% of core set) accessions was established using Ward's minimum variance method. These 148 accessions arrayed into 25 distinct clusters based on 13 quantitative descriptors. Differences among means of the entire collection and core subset for the descriptors used in development of the core subset were not significant, and the variances of the entire collection and core subset were homogeneous for all the traits. The core subset captured 100% of the variation for the 13 descriptors. The differences among means and variances of the entire collection and core subset for the 13 agronomic descriptors were also not significantly different. About 150 sub core accessions are being evaluated at two centres *viz*., DOR and Solapur using Alpha design with two replications.

Molecular genetic diversity and population structure in sub core collection as revealed by SSR markers

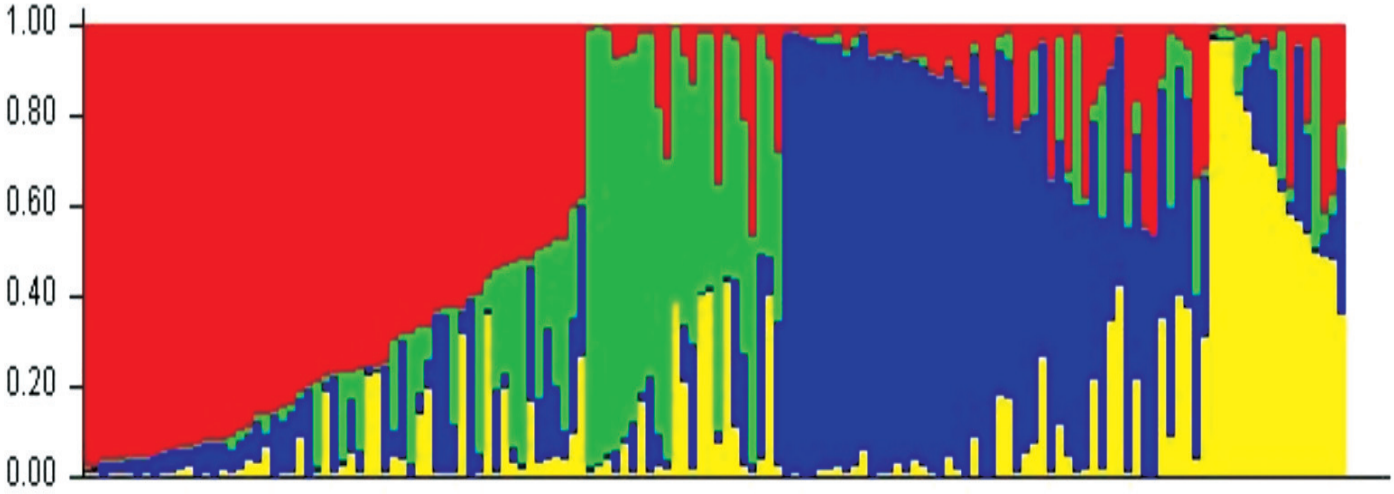
Genetic diversity and population structure were analyzed in a collection of 148 safflower accessions, which represented 16 countries [India (107), Mexico (13), USA (8), Italy (3), Turkey (3), Afghanistan (2), Iran (2), Sudan (2), Pakistan (1), Israel (1), Azores Island (1), Australia (1), Hungary (1), Portugal (1),

Belgium (1) and China (1)] using 50 SSR loci from 10 linkage groups. Number of alleles ranged from 1 to 15 with an average of 3.08 per SSR locus. The major allele frequency ranged from 0.244-1.000 with an average of 0.824. The PIC values of SSR primers pairs ranged from 0.000-0.853 with an average of 0.244. The genetic relatedness among genotypes was determined by neighbor-joining cluster analysis using simple matching dissimilarity co-efficient as implemented in DARwin V.5.0.158. Cluster analysis indicated seven major groups within the collection of 148 accessions.



Neighbour-Joining tree showing genetic relationship among 148 safflower accessions

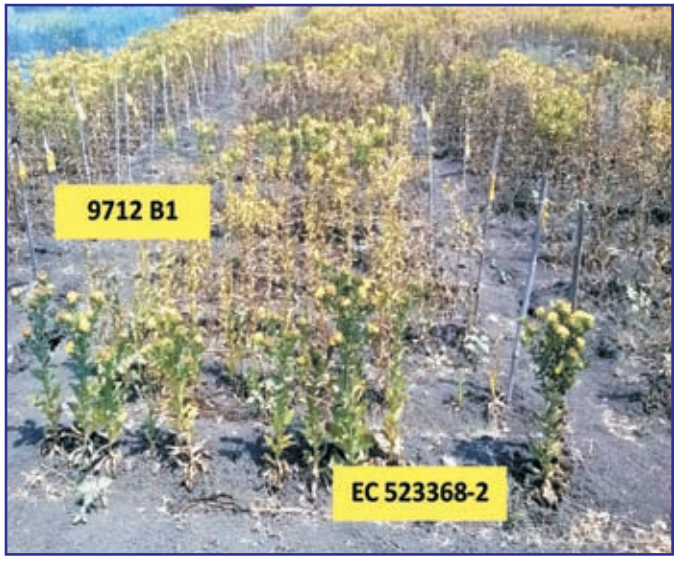
The genotypic data were analyzed in the STRUCTURE 2.3.3 program to detect the number of populations and the extent of genetic admixture in the germplasm collection. The delta-K analysis of *mean* posterior probability [*LnP(D)*] *values* per cluster (K) showed a sharp peak at K=4, suggesting four sub-populations (Po1, Pop2, Pop3 and Pop4) within the collection. The membership of each genotype was tested using the admixture model by assuming four populations. Accessions were assigned to specific populations when the membership coefficient exceeded ≥0.75 and the rest were considered as admixture. The pair-wise *Fst* values of the sub-populations and admixture group ranged from 0.040-0.486. Overall, the results suggested a low level of SSR allelic variation, presence of modest population structure and relatively high level of population differentiation (high *Fst* values) in the sub-core collection.



STRUCTURE bar diagram showing the model based clustering of 148 safflower accessions in four populations

Screening against aphids

Thirty fresh germplasm accessions were screened for aphid resistance under artificial release method. Among them, 9712 B1 was moderately



Screening against aphids under artificial release method

resistant to aphids. The selection EC 523368-2 was found resistant for the 3rd consecutive year under artificial release of aphids in field.

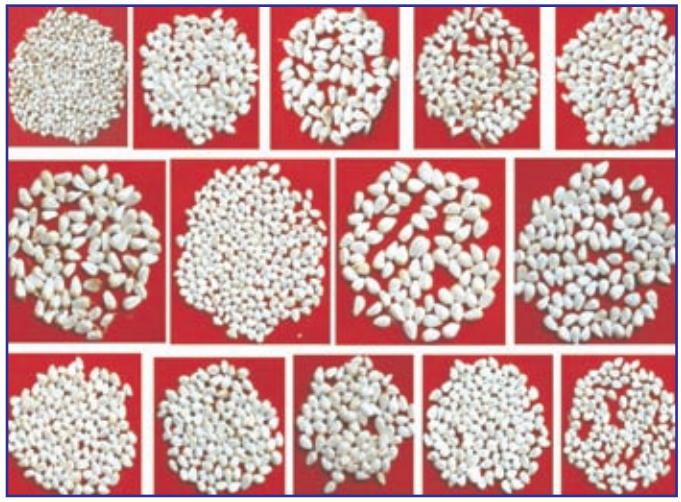
One hundred and eleven accessions which were identified as aphid tolerant sources under natural field infestation in earlier trials, were rescreened under artificial release method. Among them, 66 were found highly susceptible to aphids under artificial screening.

Germplasm registration

Germplasm IC 13884 (NIC 7133(SD5-1278)/ GMU 4983) identified for resistance to *Fusarium* wilt caused by *Fusarium oxysporum* f.sp. *carthami* was approved for registration by PGRC at its XXVIII meeting at NBPGR, New Delhi. It has been allotted the registration number INGR14002.

Development of improved varieties and hybrids

The nucleus seed of 14 A-lines was produced by pair-wise crossing (A x B) and seven B-lines by self-pollination under nets. Male sterility ranged from 96 to 98% in progenies of 1665 (A x B) pair-wise crosses. Diversity existed among A-lines for various seed traits. Male sterility in A-133 was not influenced by location and was maintained with a sterility of 97.5% at Indore and 99% at Mauranipur.



Diversity for seed traits among A lines

Identification of first CMS-based hybrid

The first CMS based hybrid, DSH-185 was identified by Varietal Identification Committee for cultivation in all India.

Two wilt resistant hybrids, DSH-250 and DSH-249 were promoted from Initial Hybrid Trial (IHT) in coordinated multi location trials. Among five CMS-based hybrids, evaluated in multi location preliminary hybrid yield trial (PHT) at four locations, DSH-253 recorded 17% higher seed yield (1734 kg/ha) than the hybrid check, NARI-H-15 (1510 kg/ha. Eight new CMS hybrids, DSH-256, DSH-263, DSH-264, DSH-265, DSH-269, DSH-271, DSH-272 and DSH-273, recorded 17-30% higher seed yield (2038-2266 kg/h) than the hybrid check, NARI-H-15 (1746 kg/ha) and 56-74% higher than the varietal check, PBNS-12 (1299 kg/ha) in PHT at DOR, Hyderabad under rainfed conditions.

Among 28 F_1 combinations developed under national crossing programme, the hybrids with high mean seed yield *viz*., MS-6 (Y) x PBNS-12 (1437 kg/ha), MS-6 (Y) x PKV Pink (1391 kg/ha), MS-6

(Y) x PBNS-72 (1379 kg/ha), MS-6 (Y) x ASD-09-3 (1354 kg/ha) and MS-6 (Y) x JSI-120 (1351 kg/ha) over nine locations will be further used to generate high yielding diverse parental material.

Development of early maturing, high oil male lines with resistance to major diseases

A new early maturing male line 5390 was identified with 60 days to 50% flowering and 105 days to maturity after planting while the check variety, PBNS-12 took 85 and 124 days to flowering and maturity, respectively.

Early maturing male parental line (5390)

Among 14 advanced generation lines bred for high oil content, SFS-9943 recorded the highest oil content (37%) followed by DSF-2014 (35%), DSI-113 (34.1%), and two wilt resistant lines *viz.,* W-05-2050-9-p2-p2-p4 and W-05-2039-p10-p2-p1 (34%) while the remaining recorded 32% oil content. The 100-seed weight among these lines ranged from 4 to 6 g.

Five advanced generation parental lines *viz.,* Ole-9-p5-p7, W-05-2039-10-P2-P3-DNA-P4, W-05-2037-3(M)-P1-P7-DNA-P1-P25, H-P4-OP-P5-P1-P12 and DSI-107 confirmed wilt resistance reaction (0-10% wilt incidence) in wilt sick plot for the third consecutive year while three parental lines *viz.,* DSI-109, DSI-110, 3941-P3-P6-P8-P1 showed moderate wilt resistance reaction (20-21% wilt incidence).

Four interspecific derivatives confirmed their resistance reaction for the second year to Alternaria (up to 20% severity) under high disease pressure in the field.

Alternaria leaf blight resistant interspecific derivative (left) and susceptible check (right)

Three parental lines *viz.,* W-05-2028, W-2026 and W-2037-9 exhibited 20% seedling blight (*Phytophthora parasitica* var. *nicotianae*) disease severity while susceptible check, PBNS-12 showed 85% disease severity when screened using agar disc inoculation technique in green house.

Phytophthora **infection in resistant W-05-2028 (left) and susceptible PBNS-12 (right) under artificial inoculation conditions**

Identification of SSR markers linked to *Fusarium* wilt

The F_1 generation of *C. tinctorius* x *C. oxyacantha* was wilt resistant. Wilt incidence in F_2 generation of the cross was 8.5% while it was 8.1% in F_3, 11% in F_4, 10% in F_5 generation and 7% in BC_1F_2 generation in wilt sick plot. Wilt incidence in F_1, F_2, F_3, F_4 generations of *C. tinctorius* x *C. palaestinus* cross was 6%, 15%, 13% and 16%, respectively. In F_2 and F_3 generations of *C. tinctorius* x *C.turkestanicus* cross, wilt incidence was 10% and 14%, respectively. The F_3 and F_4 generations of the cross, *C.tinctorius* x *C.lanatus* exhibited 8% and 15% wilt incidence, respectively in wilt sick plot.

Thirty eight SSR markers showing ploymorphism among 7 wild and cultivated species and EST-SSR marker flanked to wilt resistance in *C. palaestinus* and resistant F_2 plants and F_2 resistant bulk of *C. tinctorius* x *C. palaestinus* were identified.

Seed yield improvement in interspecific derivatives

Among 28 BC_1F_6 interspecific derivatives of (*C. oxyacantha* x *C. tinctorius*) x *C. tinctorius*, six derivatives recorded 32 to 54% higher seed yield (6.16-7.2 kg/plot) than the best check, PBNS-12 (4.65 kg/plot) and the wild species, *C. oxyacantha* (0.7 kg/plot). All BC_1F_6 families were non-shattering, early to 50% flowering (78-85 days) and maturity (127-135 days) with high 100-seed weight (3.5-6.1 g) compared to the shattering and late maturing wild species with low seed weight (0.8 g). Among the wild species, 28 accessions of *C. oxyacantha* and four selections of *C. palaestinus*, three each of *C. lanatus*, *C. glaucus* and *C. turkestanicus* and one of *C. creticus* were maintained and multiplied through self-pollination for pre-breeding activity.

Seed yield of high yielding BC_1F_6 families of (*C. oxyacantha* x *C. tinctorius*) *C. tinctorius*

BC_1F_6	Seed yield/ plant (g)	Seed yield/plot (kg) *
1527	49.8	6.22 (33%)
1670	53.5	6.68 (43%)
1696	49.35	6.16 (32%)
1712	52.1	6.51 (40%)
1723	49.9	6.23 (34%)
1730	57.6	7.2 (54%)
A-1 (Check)	32.1	4.01
PBNS-12 (Check)	37.2	4.65
SD	3.38	0.5
SE diff.	3.05	0.383

*Plot size: 11.25 sq.m; Figures in parentheses are per cent increase over the best check, PBNS-12

Plant type of *C. oxyacantha* (left) and BC_1F_6 (*C. oxyacantha* x *C. tinctorius*) *C. tinctorius* (right)

Seeds of *C. oxyacantha* (left) and BC_1F_6 of (*C. oxyacantha* x *C. tinctorius*) *C. tinctorius* (right)

Yellow leaf variegated mutant

The F_2 and F_3 generations of four crosses between yellow leaf variegated mutant and A-line, B-line, GMS line and A1-134-76 exhibited three types of variegated mutants at different stages such as mutants having variegated leaves from cotyledon leaf stage to rosette stage; stem elongation stage to lateral stages, and at all growth stages of the plant.

Safflower mutant having variegated leaves (arrow) at rosette stage only

Improvement of *C. palaestinus*

C. palaestinus selections maturing about 15 days earlier than the parental accession (135-140 days) were stabilized for early maturity. *C. palaestinus* selections yielding higher (41-110 g/plant) than the parental accession (7.6-22.7 g/plant) were isolated.

Early selection (left) and parental line of *C. palaestinus* (right)

Improvement of oil content

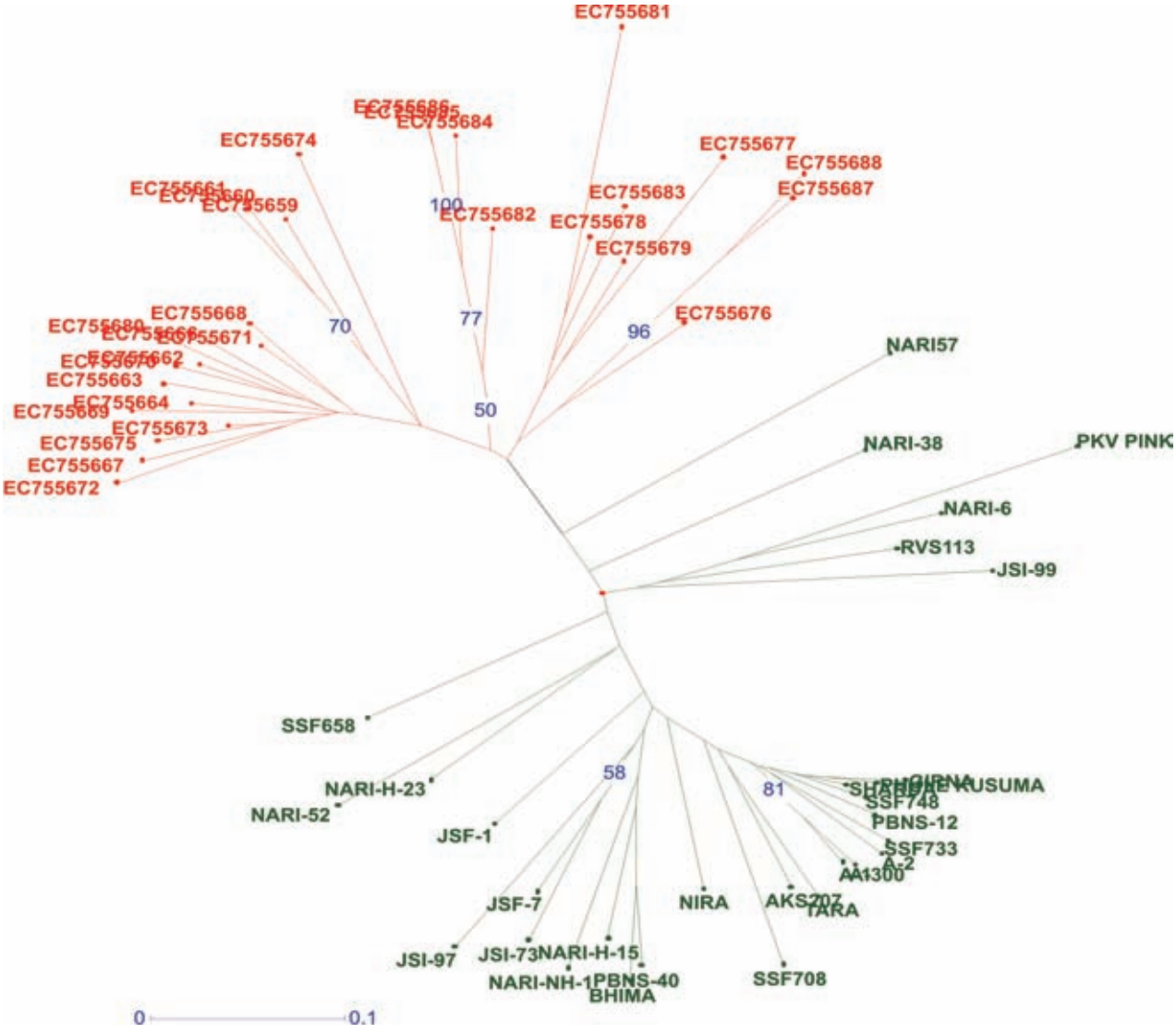
Development of microsatellites markers

A microsatellite-enriched genomic library was constructed based on the modified biotin-streptavidin capture method from A-1 variety of safflower. DNA was digested in separate reactions with seven restriction enzymes: *Eco*RV, *Dra*I, *Sma*I, *Pvu*I, *Alu*I, *Hae*III, and *Rsa*I and fragments ranging from 300 to 1,500 bp were eluted from the gel, and then ligated with T4 DNA ligase at 14 °C overnight to adaptors AP11 and AP12. The adaptor-ligated DNA was hybridized with the biotinylated microsatellite probes. Hybridization was performed and DNA fragments were captured with streptavidin-coated magnetic beads. The captured DNA fragments were eluted and amplified by PCR with the AP11 primer and then cloned into the pGEM-T Easy vector. Initially 310 clones were sequenced, out of which 108 sequences had 87 perfect Class I and 21 compound and Class II SSRs. 89 primer pairs were designed using SSR locater as some sequences had SSRs in flanking regions. Newly developed genomic SSR sequences were submitted to NCBI (DOR-1 to DOR-100) Acc. Nos. KJ586129-KJ586228).

Genetic distinctiveness between Indian and Mexican varieties revealed by SSR markers

Sixty safflower cultivars including 30 from Mexico and 30 from AICRP centres in India (A-1,

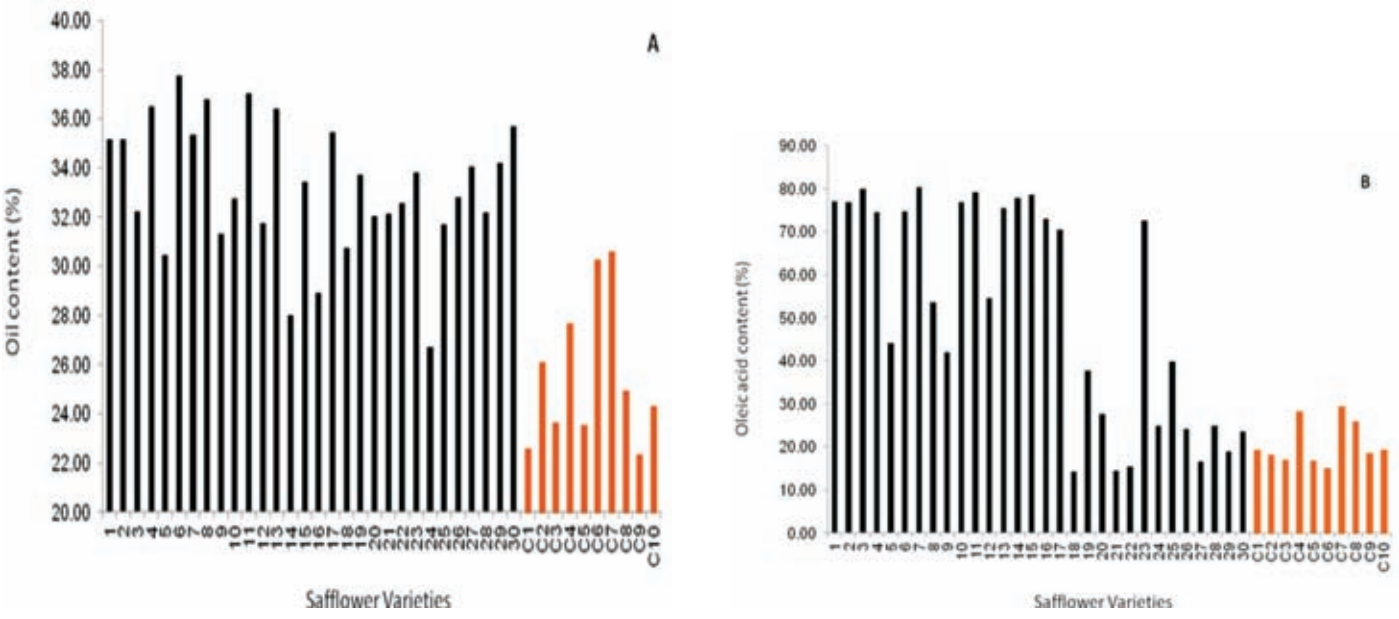
A-2, A-300 from Annigeri, NIRA, NARI-6, NARI-38, NARI-52, NARI-57, NARI NH-1, NARI-H-15 and NARI-H-23 from Phaltan, AKS-207 and PKV Pink from Akola; Bhima, Phule Kusum, Girna, Tara, SSF-658, SSF-708, SSF-733 and SSF-748 from Solapur; PBNS-12, PBNS-40 and Sharda from Parbhani and JSF-1, JSF-7, JSI-97, JSI-99, JSI-73 and RVS-113 from Indore were genotyped using 48 randomly chosen SSR loci. Ten out of 48 primers produced monomorphic alleles. The rest 38 primer pairs produced a total of 120 alleles. The allele number per locus ranged from 1 to 10 with a mean of 2.7. The observed heterozygosity per locus ranged from 0 to 1 with a mean of 0.09. The PIC value of each SSR primer pair ranged from 0 to 0.75 with a mean of 0.29. The genetic relatedness among cultivars was analyzed with the genotypic data of 33 polymorphic loci by neighbor-joining (NJ) tree based cluster analysis using simple matching dissimilarity co-efficients as implemented in DARwin (Dissimilarity Analysis and Representation for windows) V.5.0.158. The NJ tree clearly showed that Indian and Mexican cultivars were in two different clusters. The results suggested that Mexican varieties are genetically distinct from Indian cultivars and thereby would be useful to generate new variability for important traits like oil content and quality.



NJ tree displaying genetic relatedness between Indian (black font) and Mexican (red font) safflower cultivars

Evaluation of Indian and Mexican cultivars for oil content

Preliminary field trial of 30 safflower varieties of Mexico (EC755659, EC755660, EC755661, EC755662, EC755663, EC755664, EC755665, EC755666, EC755667, EC755668, EC755669, EC755670, EC755671, EC755672, EC755673, EC755674, EC755675, EC755676, EC755677, EC755678, EC755679, EC755680, EC755681, EC755682, EC755683, EC755684, EC755685, EC755686, EC755687, EC755688) along with 10 Indian check varieties (A-1, Bhima, PBNS-12, NARI-6, Phule Kusum, NARI-52, NARI-57, SSF-708, SSF-748 and PBNS-40) was conducted at ICRISAT-DOR (Vertisols) farm, Hyderabad to verify oil content and fatty acid composition under Indian conditions. Mexican varieties recorded oil content of 26.7 to 37.8% compared with checks (22.6-30.6%). The checks, A-1 and SSF748 recorded the lowest oil content of 22.6 and 22.3%, respectively. The oleic content in the Mexican varieties ranged from 14.3 to 80.4% compared to checks (15.1-29.4%) . Overall, the results indicated that at least 10 of the Mexican varieties possess about 10% higher oil content compared to the most popular variety A-1 and also provide new sources of high oleic trait for Indian breeding programmes. Re-evaluation of these promising Mexican varieties for oil content, fatty acid composition, seed and oil yield is in progress.



Variation for oil and oleic acid contents across 30 safflower varieties (numbered 1-30) from Mexico compared to 10 Indian check varieties (numbered C1-C10)

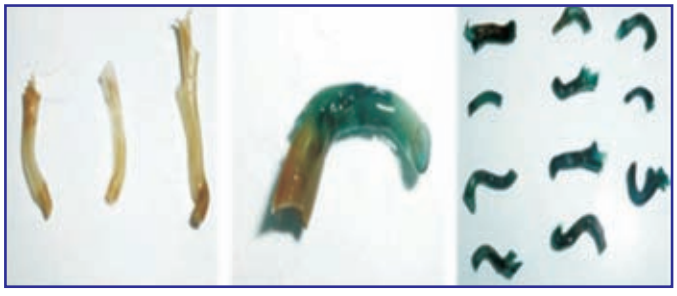
Development of high oleic acid genotypes for Indian conditions

A total of 341 F_5 families were morphologically characterized and advanced to next generation. All F_5 families maintained genetic uniformity. Of the 341 F_5 families, 195 were tested for oleic acid content; 81 of these had high oleic acid content ranging from 72.37-81.86%. Among 81 high oleic acid F_5 families, six families had 80.27-80.85 oleic acid, three families possessed 81.1-81.86% oleic acid content while the check A-1 had 14% oleic acid content. In addition, 16 F_5 families recorded medium oleic 40.54-56.89%, and 24 F_5 families recorded 30-39% oleic acid content. In addition to oleic acid content, oil content was also assayed in 385 F_5 families which ranged from 16.8 to 40.24%. Thirty five F_5 families recorded 32-40% oil content.

Development of high oil by multigene engineering

Safflower transformation

Using *in vitro* regeneration protocol, 50 putative transgenic shoots were developed with the double gene cassette (*GPAT9* + *DAGAT*). Thirty two of these putative transgenic shoots with well elongated internodal region were grafted on to control root stocks. Out of these grafted shoots only three shoots established *in vitro* but dried during acclimatization. Because of the inherent problems associated with the safflower regeneration, an alternate transformation method, *in planta* transformation was attempted using a reporter gene (*gus*) construct. Preliminary *GUS* analysis carried out with the transformed seedling explants showed intense *GUS* expression. Based on these encouraging results, *in planta* transformation was carried out with 1200 seedlings using *Agrobacterium* carrying double gene cassette and with 400 seedlings using mixture of *Agrobacterium* strains carrying the two single gene cassettes (*GPAT9* and *DAGAT*). Out of these transformed seedlings, 300 plants with double gene cassette and 30 plants with the concoction of single cassettes survived and set seeds. T_1 seeds from these plants have been harvested and will be tested for transgenicity in the next generation.

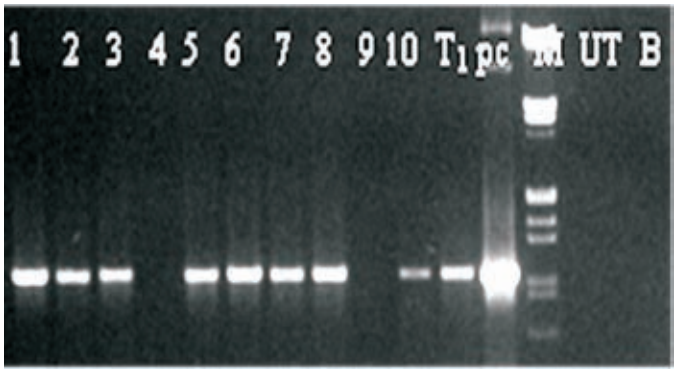


Untransformed **Transformants**

***GUS* analysis of *in planta* transformed seedling explants of safflower**

Arabidopsis transformation

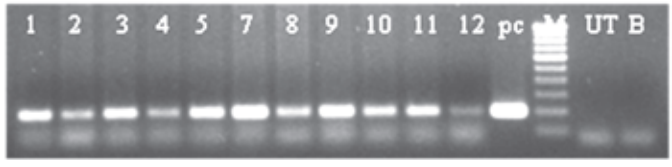
Arabidopsis transformants were obtained with empty (basal) pCAMBIA 1300 vector for using them as appropriate controls for comparing with transgenics obtained with other gene cassettes. T_1 progeny were analyzed by PCR and RT-PCR. T_1 plants which were positive for PCR and RT-PCR were advanced to the next generation. T_2 plants of two events showed 3:1 of segregation while one event showed multi copy insertion pattern.



PCR analysis of the T_2 plants of one of the Arabidopsis events carrying basal vector

Lanes: 1 to10 T_2 Arabidopsis basal vector transformants; T_1: Mother T_1 plants; pc: positive control; UT: untransformed Arabidopsis; B: blank; M : *Eco*RI + *Hind*III digested λ DNA marker

T_2 generation transgenic plants carrying single gene cassettes of *GPAT9* or *DAGAT* or *G3PDH* as single copy inserts were advanced to the next generation. The T_3 transformants of two events of *GPAT-9*, three events of *DAGAT-1* and two events of *G3PDH* were analysed by PCR and RT-PCR and the homozygous lines from these events were identified.



RT-PCR analysis of the T_3 *G3PDH* Arabidopsis transformants

Lanes 1 to12; T_3 Arabidopsis *G3PDH* transformants; pc: positive control; UT: untransformed Arabidopsis; B: blank; M: 100 bp DNA marker

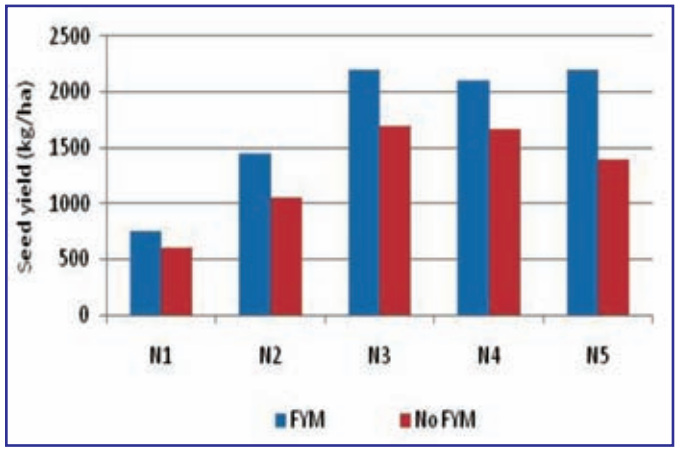
Seed oil estimation of transgenic as well as untransformed control plants, was carried out at Oxford Scientific, Mumbai by non destructive Nuclear Magnetic Resonance and at DOR by destructive Gas Chromatography method. These analyses have indicated that the oil content is altered

in transgenic plants with up to 3.3% increase in absolute oil content compared to the untransformed control plants. Seed oil content in all the homozygous transgenic lines will be analysed to confirm the results obtained in preliminary analysis of oil content.

CROP PRODUCTION

Sustainability of safflower based cropping systems with reference to input management

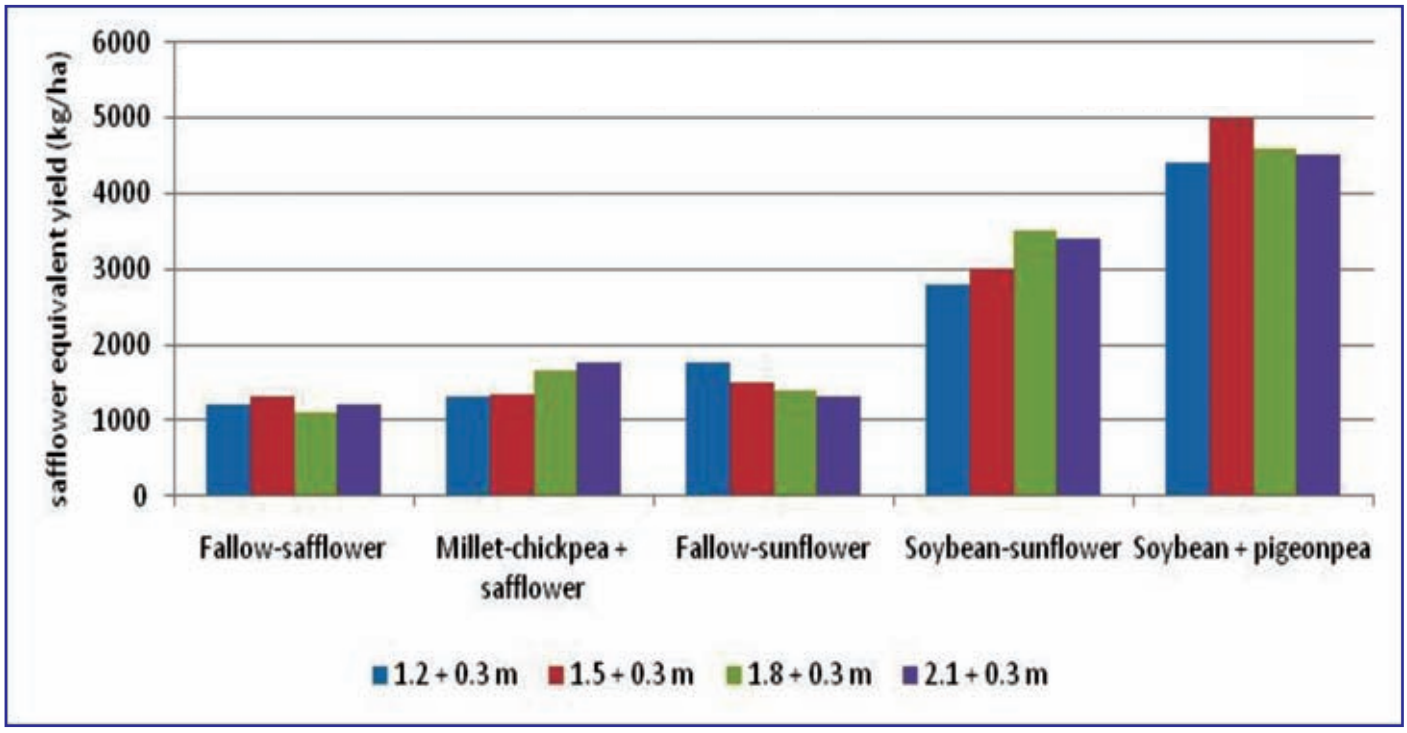
Different integrated nutrient management (INM) practices were evaluated with an objective to develop site specific nutrient management for sustainable productivity of safflower. Five INM practices (N1: No fertilizer, N2: Recommended fertilizer, N3: STCR equation based fertilizer application, N4: STCR equation based fertilizer equation + Zn 5 kg/ha + S 10 kg/ha , N5: STCR equation crude method (+25% of recommended fertilizer if soil nutrient availability is deficient, recommended fertilizer if soil nutrient availability is medium, -25% of recommended fertilizer if soil nutrient availability is high) were evaluated with 5 t FYM/ha and no FYM in main plot treatments in split plot design. Seed yield response to FYM application, INM practices and interaction effect was found to be significant. FYM application significantly improved the seed yield by 36% over no FYM application. The INM treatments N3, N4 and N5 were significantly superior in terms of seed yield (1950, 1880, 1800 kg/ha) over N2 and N1. The difference between no fertilizer (N1) and recommended fertilizer (N2) in the presence of FYM was significant. Different STCR equation based fertilizer application (N3, N4 and N5) did not differ significantly in the presence of FYM, however they were superior over no fertilizer and recommended level of fertilizer. Similar trend was noticed with respect to no FYM application. Response to FYM was significant only in treatment of STCR crude method (N5); however in other treatments the differences were not significant.



Effect of site specific nutrient management practices on safflower

Sustainability of oilseed based cropping systems with reference to conservation agricultural practices in Vertisols

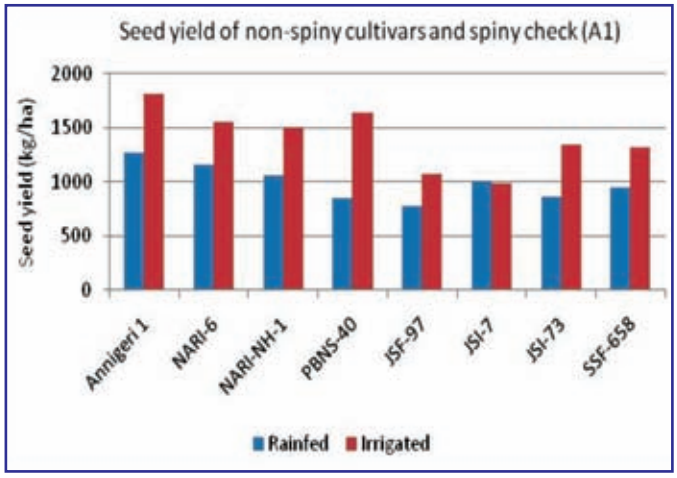
Five oilseed based cropping systems *viz*., fallow-safflower, pearlmillet-safflower, fallow-sunflower, soybean-sunflower and soybean+pigeonpea were evaluated for their productivity potential under four land management practices *viz*., 1.2 m broad bed and 0.3 m furrow, 1.5 m broad bed and 0.3 m furrow, 1.8 m broad bed and 0.3 m furrow and 2.1 m broad bed and 0.3 m furrow in unreplicated trial. Experiment was conducted under rainfed conditions and the total amount of rainfall received during the cropping period (June to February) was 1012 mm. The magnitude of response of oilseed production systems to land management practices was highly variable. The degree of variability was minimum (SD: 82) in fallow-safflower system and was maximum in soybean-sunflower (S.D: 330) and soybean+pigeonpea systems (S.D: 263). The degree of variability of system productivity within land configuration treatment was minimum in 1.2 m broad bed and maximum in 1.5 m broad bed.



Effect of land configuration on system productivity of oilseed based cropping systems

Crop management options to make safflower cultivation profitable for small farmers through enhanced utilization of safflower petals

Seven non-spiny cultivars of safflower (NARI-6, NARI-NH-1, PBNS-40, JSF-97, JSI-7, SSF-658 and JSI-73) were evaluated along with spiny check (A-1) for their seed and petal yield under both rainfed and irrigated conditions. Under rainfed conditions, the seed yield of non-spiny cultivars of NARI-6 and NARI-H-15 was on par with that of A-1. All other non-spiny cultivars recorded low yield than A- 1. Rainfall received in the month of March affected the petal quality and were not economical to harvest. Under irrigated conditions, the seed yield of non-spiny cultivars NARI-6, NARI-H-15 and PBNS-40 was on par with A-1. All other cultivars recorded significantly low seed yield. The highest petal yield was recorded in NARI-NH-1 which was on par with NARI-6.



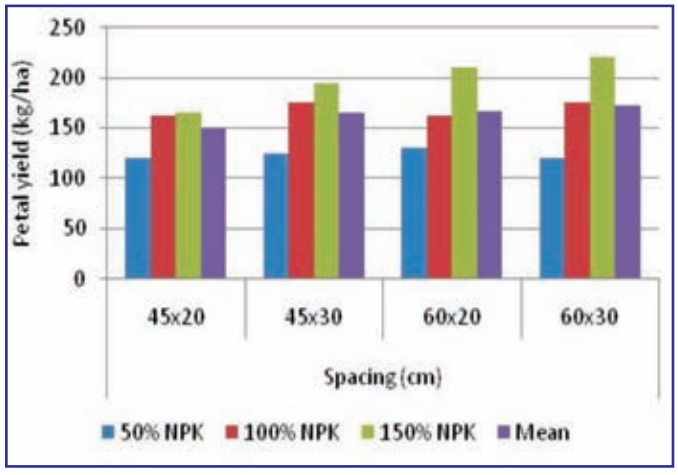
Productivity and profitability of non-spiny cultivars under low, medium and high input environments

Productivity and profitability of non-spiny safflower was quantified under low, medium and high input environments. The inputs were fertilizer (50%, 100% and 150% NPK), spacing (30x20 cm, 30x30 cm, 45x20 cm, 45x30 cm, 60x20 cm, 60x30 cm), cultivars (variety, hybrid) and soil moisture (rainfed, irrigated).

Rainfall received during cropping season (*kharif-rabi*) was 1012 mm which was 35% higher than that of long term average. The mean seed yield of

NARI-6 and NARI-NH-1 was 1030 and 1240 kg/ha, respectively. Fertilizer application significantly influenced the seed yield of both NARI-6 and NARI-NH-1. The per cent increase in seed yield over 50% NPK fertilizer was 49% and 84% with 100% NPK and 150% NPK, respectively in NARI-6. Similarly, with NARI-NH-1 it was 57% and 87% with 100% NPK and 150% NPK, respectively. Different levels of plant population significantly influenced the productivity of both NARI-6 and NARI-NH-1. The seed yield of NARI-6 was the highest with wider spacing of 45x30 cm (1133 kg/ha) which was on par with that of 45x20 and 30x30 cm spacing. Closer spacing of 30x20 cm recorded the lowest seed yield (920 kg/ha) while application of 150% NPK and plant spacing of 45x30 cm, NARI-6 recorded the highest seed yield (1500 kg/ha) which was on par with that of 150% NPK with 45x20 cm and 30x30 cm spacing and 100% NPK with 45x30 cm spacing. Similarly, the seed yield of NARI-NH-1 was the highest with 150% NPK fertilizer application (1565 kg/ha) and 45x30 cm plant spacing (1417 kg/ha). Interaction effect of 150% NPK and 45x30 cm recorded the highest seed yield (1825 kg/ha) which was on par with that of 150% NPK with 45x20 cm (1725 kg/ha), 100% NPK with 45x30 cm plant spacing (1530 kg/ha).

Under irrigated conditions, the mean seed and petal yields of NARI-6 were 1565 kg/ha and 163 kg/ha, respectively, whereas, the mean seed and petal yields of NARI-NH-1 were 1760 kg/ha and 176 kg/ha, respectively. Fertilizer application and plant spacing significantly influenced the seed and petal yields of NARI-6. The per cent increase in seed yield with 100% NPK and 150% NPK over 50% NPK was 23% and 49%, respectively. The seed yield was the highest with wider spacing of 60x30 cm (1717 kg/ha) which was on par with that of 60x20 cm plant spacing (1650 kg/ha). Closer spacing of 45x20 cm recorded the lowest seed yield (1427 kg/ha). Application of 150% NPK with plant spacing of 60x30 cm, NARI-6 recorded the highest seed yield (2200 kg/ha) which was on par with 150% NPK with 60x20 cm spacing (2100 kg/ha). With respect to petal yield the per cent increase with 100% NPK and 150% NPK over 50% NPK was 36% and 59%, respectively. Wider plant spacing 60x30 cm recorded the highest petal yield (172 kg/ha) and the lowest with closer spacing of 45x20 cm spacing (149 kg/ha). Application of 150% NPK with plant spacing of 60x30 cm recorded the highest petal yield (220 kg/ha) which was on par with that of 150% NPK with a spacing of 60x20 cm plant spacing (210 kg/ha). Similar trends were observed with NARI-NH-1.



Petal yield of NARI-6 under irrigated conditions

Quality

Out of 1000 safflower accessions analysed maximum oil content was recorded in EC-181737 (38.8) followed by EC-182117 (38.1%). Oleic acid ranged from 14.6 (EC-156786) to 79.9% (EC-182117).

CROP PROTECTION

Reaction to *Phytophthora nicotianae* leaf blight

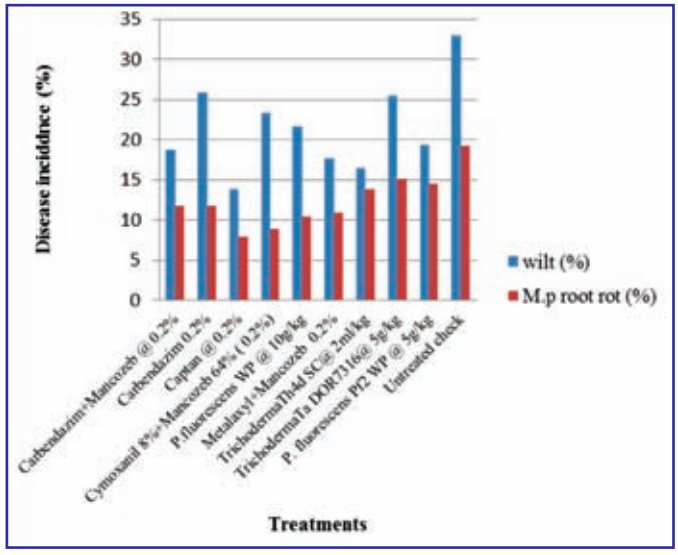
Among safflower cultivars screened against *Phytophthora nicotianae* leaf blight, the disease severity was low (30%) on Bhima and Phule Kusum, whereas the disease severity was more than 60% on cultivars SSF-658, SSF-708 and PBNS-12.

Bhima **Phule Kusum** **SSF 658** **SSF 708** **PBNS 12**

Reaction of different safflower cultivars to *Phytophthora* blight

Management of wilt and root rot diseases

Seed treatments with captan @ 0.2% and *T. harzianum* Th4d SC @ 2ml/kg were most effective with *Fusarium* wilt incidence of 13.8 and 16.5%, respectively as against 33.0% in pathogen check under field conditions. Captan @ 0.2% and cymoxanil 8% + mancozeb 64% (Curzate M) treatments showed low incidence of *Macrophomina* root rot (7.9% and 8.9%) whereas the untreated check recorded 19.3% disease incidence. Significantly highest seed yield (2350 kg/ha) was recorded in captan @ 0.2% followed by *T. harzianum* Th4d SC (2230 kg/ha) treatment compared to pathogen check (1290 kg/ha).



Effect of fungicides and biological agents on wilt and root rot

Captan @ 0.2% ***T. harzianum* Th4d SC @ 2 ml/kg** **Untreated check**

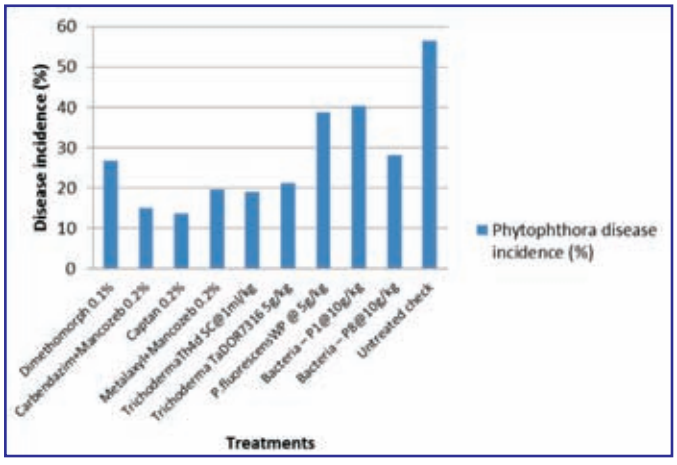
Plant stand and diseases incidence in captan and *Trichoderma* treatments

Evaluation of thermo tolerant *Trichoderma* against wilt

Trichoderma asperellum TaDOR673WP (10 g/kg) and carbendazim (2 g/kg) seed treatments were most effective and recorded significantly low Fusarium wilt incidence of only 4.4%. Significantly high seed yield (1129 kg/ha) was recorded in carbendazim @2 g/kg followed by *T. asperellum* T 673WP (1089 kg/ha) treatment compared to the pathogen check (613 kg/ha).

Management of Phytophthora damping off and seedling blight by chemical and biological agents seed treatment

Phytophthora disease incidence was significantly low in captan@ 2 g/kg, carbendazim + mancozeb 0.2% and *T. harzianum* Th4d SC @ 1 ml/kg treatments recording disease incidence of 13.7, 15.1 and 19.1%, respectively whereas the pathogen check recorded a disease incidence of 56.5%.

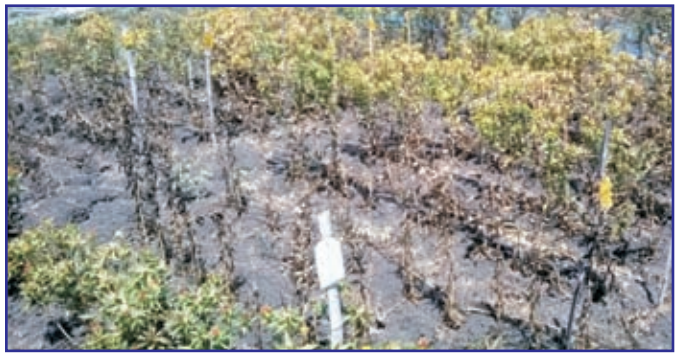


Effect of seed treatment with chemical and biological agents on *Phytophthora* damping off and seedling blight

New screening method for aphid resistance

A new mass screening technique for identification of resistance to aphids was developed and evaluated. Due to heavy rains during the period of study, aphid incidence occurred late. Infested plants were uprooted and spread evenly in the field. The damage reaction was uniform in both the replications compared to the existing method based on natural infestation in the field where there was poor and uneven distribution of aphids. The susceptible check, CO-1 recorded 1.6, 1.3 and 1.4 damage rating on a 1-5 scale in three replications in the existing method compared to the scale of 5 in all the three replications in the new method based on artificial release. During the *rabi* season, 110 lines of safflower were screened using this new technique of which 66 lines were found highly susceptible.

Poor reaction of safflower lines including susceptible check under natural infestation



Differential reaction under new artificial release method

Field screening of safflower against aphid

Identification of the most vulnerable stage to aphids

Susceptible (CO-1), moderately resistant (SSF-658) and resistant (A-1) genotypes were raised in a staggered manner in the *rabi* season. Aphids were released uniformly on 30 to 80 day old safflower plants of all three varieties. Both CO-1 and SSF- 658 were knocked out at stem elongation

stage but not A-1. However, susceptible CO-1 plants were killed at later stages also but not SSF-658 and A-1. Stem elongation stage is therefore the most vulnerable stage to aphids and gives most susceptible reaction and hence, most crucial for screening of safflower.

50 day old – susceptible and moderately resistant varieties died

80 day old – only susceptible variety died

100 day old – all varieties survived

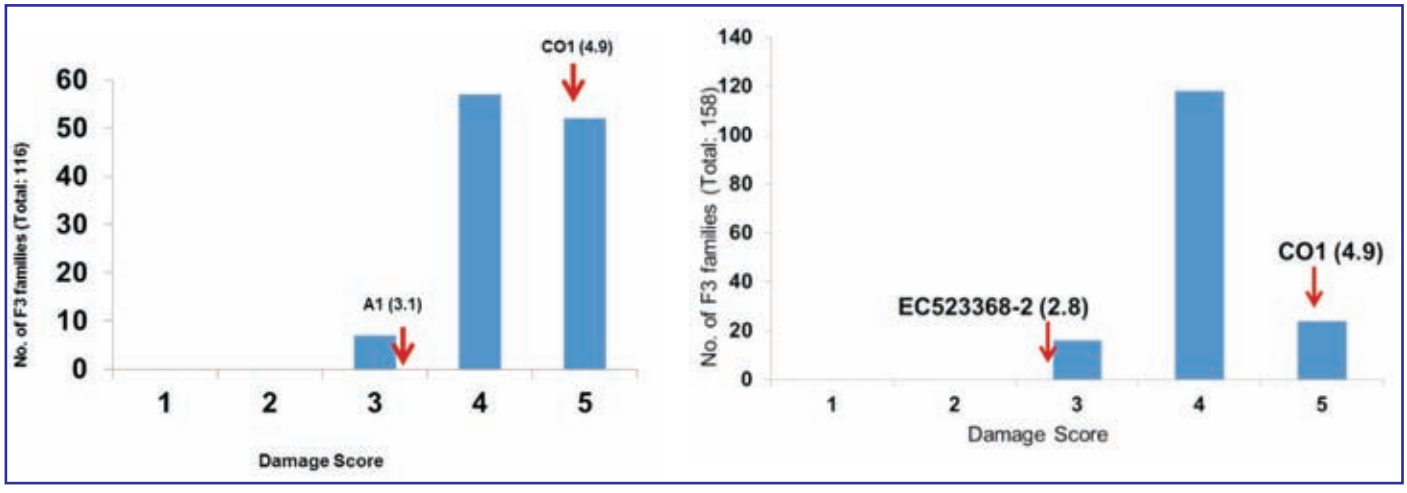
Identification of most vulnerable stage for aphids

Mechanisms of resistance to against aphids

In a choice test, EC-523368-2 (resistant) was less preferred by adult aphids (9.7%). There was no difference between other lines/varieties and susceptible cultivar CO-1 which attracted adult aphids (12.5 to 13.9%). In a no choice test, 50% adults deserted the EC 523368-2 (resistant) plants 24 h after release. This suggests that antixenosis is operating against adult aphids in the initial stages in case of EC523368-2. However, duration for development of nymph to adult remained the same in resistant and susceptible line/ variety suggesting little or no role of antibiosis. Multiplication of aphids on EC523368-2 in the initial stages was 40 to 50% slower than other lines, A-1 and CO-1. The parameters for tolerance like FLPI and PD loss were in favour of EC523368-2 suggesting inherent ability of this line to tolerate aphid damage and stay green compared to other lines.

Genetic analysis of aphid resistance

To understand the genetics of resistance of safflower to aphids, 116 F3 families of cross CO-1 x A-1 and 158 F3 families of cross CO-1 x EC523368-2 were evaluated for their reaction to aphids during *rabi* 2013. From the frequency distribution of segregated reaction of crosses and their parents it appeared that inheritance pattern of resistance in safflower against aphids is quantitative in nature.



Frequency distribution of resistance against aphids

SOCIAL SCIENCES

Supply chain scenario

During the period under report, the work was undertaken for safflower crop in Karnataka and Maharashtra regions of the country. Compound growth rates of safflower area and productivity at national level were -4.52 and -2.3 per cent for the period 2000 to 2011. The compound growth rates for production was 2.32. Similar trend prevailed in major safflower states. Inroads of bengalgram and its relative benefit cost ratio affected safflower economy at the macro level. Instability in area and production of safflower was 35 and 41 per cent.

The productivity of safflower in Maharashtra was 7.98 q while that of soybean (*kharif*) and bengalgram was 14.12 and 9.70 q, respectively. The per hectare net returns accrued in safflower, soybean and bengalgram was ₹ 15685, ₹ 16793 and ₹ 22755, respectively. Highest B: C ratio of 1.53 was obtained in safflower as against soybean (1.36) and bengalgram (1.06). Lower cost of cultivation in safflower *vis-à-vis* the other crops was responsible for the higher B:C ratio. In Kopalla and Bellary districts of Karnataka, the productivity of safflower was 5.98 q/ha while that of bengalgram was 10.02 q/ha. The net returns realized was ₹ 12349 and ₹ 6659 in bengalgram and safflower with B:C ratio of 0.76 and 0.65, respectively. The production function analysis revealed that seed and fertilizers were showing a positive and significant affect on production in Maharashtra. In Karnataka, seed, manure, and plant protection measures were affecting positively to the productivity. Thus, productivity can be increased by reorganization of the resource mix in the two states. The major constraints confronted in the production were non availability of quality seed, lack of awareness about the good agricultural practices, high cost of machinery for harvesting, untimely availability of machinery, aphid attack and low market price.

The processing aspects of local ghanis/expellers revealed that the oil recovery was 22-25 kg/q. The cost towards crushing was ₹ 200-240/q. with overall maintenance charges of ₹ 200/q. The cake was sold to the traders from Sangli district and from other states (Karnataka and Tamil Nadu) primarily for feed purpose.

Major marketing channels prevailing in Maharashtra and Karnataka

Channels	Per cent production	
	Maharashtra	Karnataka
Producer-village level merchant-processor (Local)	40	10
Producer-village level merchant-processor	35	80
Producer-local ghanis	25	10

On the processing front, the oil recovery was 20-24 kg/q. from local ghanis/expellers. The cost towards crushing was ₹ 200-240/q. with overall maintenance charges of ₹ 200/q. The cake was sold to the traders from Taavaragere, Koppala and Gadag in Karnataka.

The project enabled in fostering direct link between the farmers and the private industry. The quality HYV seed was provided to the farmer by the industry while DOR provided the capacity building aspects on the production technology coupled with frequent monitoring of crop at various stages. The output was directly purchased by the private industry from the farmer thus, completely eliminating the role of intermediaries. This initiative was tried on 500 acres in varied agro-ecological regions in Anantapur, Mahabubnagar and Ranga Reddy districts of A.P; Bellary district of Karnataka; Latur and Osmanabad districts of Maharashtra.

SESAME

Augmentation of sesame wild species

Twenty seven accessions of the following five wild species collected from Dharwad (2), Jalgaon (2), Mandor (5), Vriddhachalam (5), NBPGR, New Delhi (13) are being maintained at DOR.

Wild species	Number of accessions
S. mulayanum	10
S. malabaricum	7
S. radiatum	3
S. alatum	4
S. laciniatum	3
Total	**27**

An exploration trip was conducted in Kerala state in collaboration with NBPGR Regional Station, Thrissur and 15 accessions of three wild species *viz*., *S. malabaricum* (11), *S. radiatum* (1) and *S. laciniatum* (3) were collected.

Collection of sesame wild sp. from Kerala state

Wild species	Place of collection
S. malabaricum	Palakkad (Vattapara, Molamphuza dam hills), Alaphuza (Ulavakkadu), Kannur (Kakampara,Thalaserry) Kasaragod (Kaithakadu), Nedunganda, Kunjia, Idiadaka-perla, Nellikaff (Thoyamal)
S. laciniatum	Palakkad (Molaphuza dam), Thrissur (Perambayar) Malappuram (Moodalu)
S. radiatum	Alappuzha (Chandiroor)

S. malabaricum *S. laciniatum*

Sesame wild spp collected from Kerala

Establishment of *S. laciniatum*

National crossing programme

A new initiative was taken up to estimate the extent of heterosis in sesame. Sixty good combiners from six AICRP centres (Amreli, Jagtial, Jalgaon, Dharwad, Mandor, Vridhachalam) were collected. Four good combiners from each centre were selected based on the earlier literature. Twenty four common male parents were distributed to all the six centres to initiate a crossing programme with their respective three females to develop 72 new

crosses. At DOR, 69 new crosses were generated by crossing a set of 24 common male parents with three females (DS-1, DS-5 and DSS-9) during *kharif* 2013.

Among 69 experimental hybrids evaluated for heterosis and combining ability in s*ummer* 2014 in DOR, four early experimental hybrids *viz*., DSS-9 x MT-10-81, DSS-9 x Prachi, DS-5 x JLS-9707-2 and DSS-9 x DS-30 were identified. A similar trial is being conducted at Dharwad in summer.

Research Advisory Committee and scientists visiting the sesame experimental field

OTHER SCIENTIFIC ACTIVITIES

Central Sector Scheme for Plant Variety Protection and Farmers Rights Authority

Sunflower

DUS testing for sunflower was conducted in *rabi* 2013-14 for 25 candidate varieties with 12 reference entries. Three separate replicated trials were conducted. The A-line trial comprised of 13 candidates and 5 reference entries whereas the R-line trial had 6 candidates and 4 reference entries. The hybrid trial was conducted for 6 candidates and 3 reference entries. Data for 26 DUS traits was recorded in accordance with the DUS test guidelines.

The monitoring team visited the sunflower DUS trial on January 22, 2014 under the Chairmanship of Dr. D.M. Hegde, Ex-Project Director, DOR, Hyderabad. The other members were representatives from 4 private seed companies and Dr. N. Mukta (Nodal Officer), Dr. C. Lavanya (Associate Nodal Officer) and Dr. Mangesh.Y. Dudhe (Associate) from DOR, Hyderabad. The team was satisfied with the crop expression and documentation of data.

Castor

DUS testing for 2 candidate varieties of castor was conducted during *kharif* 2013 as 2 separate replicated trials with 4 checks and data recorded for 29 traits. Final consolidated report was submitted to PPV&FRA for one VCK of Castor based on DUS trial conducted during *rabi*, 2012-13 for 30 DUS traits at two centres.

Registration certificates received from PPV&FRA for extant sunflower cultivars

Sunflower hybrid DRSH-1 and varieties DRSF-113 and DRSF-108 were registered under extant category by the Protection of Plant Varieties and Farmers Rights Authority, New Delhi and certificates were received.

Awareness-cum-training programme conducted

An awareness-cum-Training programme on Protection of Plant Varieties and Farmers Rights was conducted at Sri Aurobindo KVK, Gaddipalli village (Garidipalli mandal) Nalgonda district on December 19, 2013. One hundred participants including KVK personnel from Zone V from both Govt. and NGO Sector, and innovative/progressive farmers from 2 districts of Andhra Pradesh *viz.* Nalgonda and Krishna attended the programme which was sponsored by PPV&FR Authority, New Delhi.

Institute technology management unit (ITMU)

The ITMU of this Directorate has facilitated to license 2 technologies (*Bt*-1 and *B. bassiana* formulations) to bio-pesticide entrepreneurs; initiation of the contract research project on "Developing High Oleic Safflower Cultivars and Protocols for Marker –Assisted Selection for high Oleic Traits in Safflower for Indian Conditions" sponsored by M/s MARICO Ltd., at the cost of ₹1.35 crore; contract service on "Evaluation of Drip Irrigation for Productivity of Safflower" Sponsored by M/s Jain Irrigation System Ltd. and ₹ 46.07 lakh has been generated through these processes. The complete specification on "A novel composition comprising thermotolerant and saline tolerant *Trichoderma asperillum*" was submitted for Indian patent.

An Interface meeting with bio-pesticide entrepreneurs was held on 27 July, 2013 under the Chairmanship of Dr. K. S. Varaprasad, PD and was attended by 30 participants from 24 firms dealing with bio-pesticide production and sale in India. Dr. K. S. Varaprasad, PD in his introductory remarks mentioned that the meeting aimed at fostering public-private partnerships in the area of bio-pesticide production and commercialization in India. He opined that there is an ample scope for organization of a consortium between DOR and the bio-pesticide industry and also undertaking collaborative work on bio-pesticides including contract research. The technologies available for licensing (DOR *Bt*-1 W.P. formulation and DOR *B. bassiana* SC formulation) as well as those in pipeline (*Trichoderma harzianum* SC formulation and *T. asperellum* W.P. formulation) were presented by Dr. P. S. Vimala Devi, Principal Scientist (Entomology) and Dr. R. D. Prasad, Principal Scientist (Pl. Pathology), respectively. This was followed by an active interaction with the entrepreneurs covering issues like consortium formation including membership fee, industry requirement for contract research as well as issues pertaining to commercialization of DOR technologies. The broad guidelines on biopesticide consortium were discussed and finalized.

Interface meeting with Biopesticide Entrepreneurs

Patents filed

"A novel composition comprising a thermotolerant and saline tolerant *Trichoderma asperellum* TaDOR 673 isolate (2129/2014/CHE)".

Technologies ready for transfer

- *Trichoderma harzianum* Th4d 20% SC (Suspension Concentrate) formulation with extended shelf life (more than 18 months), low dosage (1 or 2 ml/kg seed/l water), effective against many plant diseases (broad host range), symbiotic root colonizer, induces defense response in plants against pathogen and promotes plant growth.
- A thermotolerant, symbiotic *Trichoderma asperellum* TaDOR 7316 5% WP for use as biocontrol agent, defense inducer and plant growth promoter
- Two isolates of *Bt* effective against *Spodoptera litura*, *Helicoverpa armigera* and *Achaea Janata* have been deposited with NBAIM vide accession No. NAIMCC-B-01463 and NAIMCC-B-01464.
- Novel cry1Aa delta endotoxin from the local strain DOR Bt-6 (NAIMCC-B-00167) belonging to *Bacillus thuringiensis* var. kurstaki has been designated as cry1Aa24 by NCBI.

- The transgenic event SF 481-cp developed and having resistance to sunflower necrosis disease is under process of licensing for commercial utilization; MTA/MOU were signed (awaiting for clearance from National Biodiversity Board (NBA)

Agriculture knowledge management unit (AKMU)

The AKMU at this Directorate is involved in creation and updating of databases on the area, production and productivity of annual oilseed crops at the national and state level. The unit is also involved in updating of database on the price information system for the DOR mandate crops for the major Agricultural Produce Market Committees (APMC) trading the oilseeds. The data on arrivals, minimum price, maximum price and modal price for the date wise transactions at the major APMC's for the year 2013 are uploaded to the database. The price signals are transferred to the contact farmers in different agro-ecological regions of the country with the objective of reducing the asymmetry of information on the prices thereby facilitating the farmers for a better bargaining price. Under the e-Granth project, KOHA was implemented and 8785 records were imported. CDs in searchable format were brought out for the annual progress reports of AICRP on castor, safflower, sunflower, sesame and niger, linseed; all annual reports of DOR, FLD annual reports, DOR foundation day lectures and important DOR publications. Under the Agropedia project, the content was developed for the portal oilseeds.agropedia.in and digital objects numbering 1596 (1141 documents, 426 images, 23 videos and 6 videos) were uploaded. The objects encompassed domains *viz.*, POP's, Advisories, Miscellaneous, Demonstrations, Alerts, Articles, Research Reports, Success stories, Announcements and brochures.

Priority setting, monitoring and evaluation (PME) cell

The PME cell has been functioning and discharging its duties. The thrust areas of research programs to be undertaken at this Directorate in XII plan were identified and prioritized. PME cell has prioritized the researchable areas based on the recommendations of RAC and QRT and accordingly the activities have been incorporated in the Institute research projects. Also, it has been ensured that the projects are addressing the thrust areas identified in XII five year plan and in vision document of the Directorate. Six project proposals were evaluated for ICAR research platforms, 6 project proposals for funding under NFBSFARA, DBT and AMAAS. One contract research project proposal was also evaluated which was sponsored by M/s MARICO Ltd. The database on publications, technology developed, IP assets and consultancy have been updated. Six monthly reports on targets and achievements in HYPM have been updated. It has coordinated and arranged Institute Research Committee meeting to review the progress of ongoing projects and externally funded projects.

Seed production

DOR is the nodal centre for the production of breeder seed of mandate crops. It also includes monitoring of the breeder seed production with co-operating centres spread all over the country. The produced breeder seed of varieties and parental lines of castor and sunflower hybrids released through AICRP was distributed to the indenting agencies through Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India. The Seed Section at DOR has produced and distributed breeder and truthfully labeled seeds of hybrids and varieties released by DOR under the ICAR Seed Project "Seed Production in Agricultural Crops".

Production of parental lines of castor and sunflower hybrids

Breeder seed of the castor parental lines *viz.*, DPC-9, DCS-9, M-574, DCS-78 and 48-1 was produced at DOR-ICRISAT farm and NBPGR farm. Parental lines of sunflower hybrid DRSH-1

viz., ARM-243 A, ARM-243 B and RHA-6 D-1 and variety DRSF-108 were produced at DOR-Narkhoda farm.

Production of sunflower hybrid

Seed of sunflower hybrid DRSH-1 was produced both at DOR-ICRISAT and DOR-Narkhoda farms in about 8 acres during *rabi*/ summer 2013-14. The total yield was about 15 q.

Seed production through tribal farmers

Production of Araku local niger seed was taken up with 36 tribal farmers in about 40 acres under TSP-Seed Production of ICAR Seed Project in different villages of Araku Valley of Visakhapatnam district of Andhra Pradesh. The farmers were imparted training in quality seed production of niger. Each farmer was given one storage drum of 200 l. capacity to prevent rodent damage to the stored seeds and farm implements such as pick-axe, panjas, etc. A total of 12 hand operated wind fans were given to farmers on community basis to facilitate easy winnowing of the harvested produce.

Trainings organized in seed production

Trainings in quality seed production of castor, sunflower, sesame and niger were organized for the farmers and scientific and field staff of DOR under ICAR Seed Project. A two day training programme was organized to over 100 tribal farmers at Araku valley of Andhra Pradesh. Sunflower and Safflower field day cum training in seed production was organized for scientific, technical personnel and over 100 farmers at DOR-ICRISAT farm on 15 March, 2014. Another training programme on castor and sunflower seed production was organized for over 200 farmers besides other technical personnel at DOR-Narkhoda farm on 28 March, 2014.

Breeder seed production at DOR

Crop	Parent/Variety	Quantity (q)
Castor	DPC-9	3.0
	DCS-9	1.0
	M-574	1.5
	DCS-78	0.5
	48-1	1.5
	Total	**7.5**
Sunflower	ARM-243 A	1.5
	ARM-243 B	1.5
	RHA-6 D-1	0.5
	DRSF-108	1.5
	Total	**5.0**

AICRP ON SUNFLOWER, CASTOR AND SAFFLOWER

The significant research achievements of AICRP on sunflower, castor and safflower during the period under report are as follows:

Sunflower

- Four genotypes DRSF-108-P12 (44.1%), GMU-520-1 (41.6%), GMU-520-2 (44%) and GP6-79 (42.8%) were identified for high oil content at Raichur.
- SS-808 (1595 kg/ha) was identified as highly promising population in comparison to the check SS-2038 (1241 kg/ha) in advanced/ multi-location trials in Maharashtra.
- Promising hybrids reported in station trials at different centres are: SAHT-Kh-13-12 (2365 kg/ha); SAHT-Kh-13- 01 (2337 kg/ha) at Bengaluru; CSFH 8031 (2402 kg/ha) and CSFH 12205 (3002 kg/ha) at Coimbatore; HSFH-1549 (3038 kg/ha), HSFH-1213 (2756 kg/ha), HSFH-1553 (2727 kg/ha), HSFH-1551 (2685 kg/ha) and HSFH-1547 (2654 kg/ha) at Hisar; PSH 1903, PSH 1904, PSH 1913 and PSH 1964 at Ludhiana; PSCHT-26 at Nimpith; RSFH-1887 (2546 kg/ha), SMLHT-KH-13-05 (2332 kg/ha) at Raichur.
- Under National Crossing Programme, most of the combinations with HA-430A gave high seed yield per plant at Latur. At Bangalore, UK-90 x RCR-19 gave a significantly high seed yield of 3103 kg/ha; Under NCP-II, the cross between HA44 x PISF-1R was early (55 days to first flowering) as against 69 to 72 days in checks KBSH-44 and DRSH-1, respectively. This combination was early at all the centres. The CMS lines SUN-35 and CHA-98A with DS-2 gave higher yield (80 g/plant) as compared to check hybrids (60 g/plant).
- Based on the standard norms of considering superiority over best check over seed yield (>10%), oil yield (>5%), statistically at par seed or oil yield with best check and coupled with resistance to diseases, the following entries were promoted to next level of testing.

Entry	Sponsoring centre
Entries promoted from IHT to AHT	
BSH-71	UAS, Bengaluru
SFH-011-384	Kaveri Seeds, Hyderabad
Laxmi-225	Yaganti Seeds, Hyderabad
BSH-72	UAS, Bengaluru
Entries promoted from AHT-I to AHT-II	
SFH-1201	Nirmal Seeds, Pachora
SFH-1009	Nuziveedu Seeds, Hyderabad

- In zone-I, NK-ARMONI-VT recorded the highest seed yield of 2761 kg/ha. With regard to oil content, the hybrid KSFH-284 recorded the maximum of 40.1%. NK-ARMONI-VT recorded the highest oil yield (1094 kg/ha).

- In zone-II, RSFH-10-600 recorded the highest seed yield of 1626 kg/ha. Check hybrid DRSH-1 recorded the highest oil content (37.7%). For oil yield, hybrid RSFH-10-600 recorded a maximum of 593 kg/ha.

- Across the zones, RSFH-10-600 recorded the highest seed yield of 1888 kg/ha. With regard to oil content, the check hybrid DRSH-1 recorded the maximum of 38.7%. For oil yield, RSFH-10-600 recorded a maximum of 711 kg/ha. Nine hybrids recorded zero incidence of downy mildew.

- As against the target of 2.56 q of breeder seed of different varieties and parental lines of hybrids, the centres have produced 14.95 q.

- Dual seed inoculation of *Azospirillum* and *Azatobacter* can save 25-50% of N when applied along with 75% recommended N for sunflower under rainfed condition and under paddy fallow conditions with *rabi* sunflower at Nimpith in West Bengal and Hisar in Haryana.

- Sunflower needed 120 kg N and 90 kg P_2O_5/ha at Hisar under irrigated conditions, 90 kg N and 90 kg P_2O_5/ha at Nimpith under rice fallow situation as against the present recommended dose of 60 kg each N and P_2O_5/ha. The response was only up to 60 kg N /ha at Savalvihir during *kharif* season under rainfed conditions.

- Intercropping of sunflower + mungbean in 2:2 paired rows recorded significantly higher sunflower equivalent yield (3399 kg/ha), net-returns (₹ 51321/ha) and B:C ratio (2.19) over other row ratios/ planting of sole sunflower at Dholi.

- Site specific (soil test based) target yield NPK + S + limiting micronutrient was found promising and was equal to that of soil test based target yield NPK + S + limiting micronutrient + 5 t FYM/ha + crop residue incorporation with *Trichoderma viride* in most of the centres.

- Application of pendimethalin @ 0.75 kg a.i/ha + intercultivation at 30 DAS + hand weeding at 40 DAS was effective as that of weed free check in realizing higher weed control efficiency, seed yield and economic returns. Post emergence spray of Quizalofop ethyl, Propaquizofop and fenoxyprop ethyl did not show any detrimental effect on sunflower in most of the centres.

- Two sprays of Difenoconazole @ 0.05 per cent at 45 and 60 DAS was effective in most of the centres for the management of powdery mildew which reduced disease severity by 85% and increased seed yield.

- For the management of collar rot, the treatment (ST with *T. viride* (0.4%) +*P. fluorescens* (0.4%) + soil application of *T. viride* @2.5 kg/ha); and treatment (ST with *T. viride* @ 0.4% + soil application of *T. viride* @2.5 kg/ha + *P. fluorescens* @2.5 kg/ha) were equally effective to reduce the disease intensity by 75% and 68%, respectively.

- Sunflower germplasm lines GMU-407, 434, 441, 460, 485, 496, 656, 665, 671, 675, 1010, 1062, 1064, 1069, 1082 and 1092 were found promising against leafhopper with injury grade 1 at Akola. At Latur, stem borer infestation was low in GMU-577 (8.33%) compared to 61.1% in Morden.

- Under uniform pest nursery (UPN) sunflower germplasm lines GMU-1029, 1036, and 1085 were found promising against leafhopper with injury grade 2 to 3 at Akola and Hyderabad. GMU-1057 had least stem borer infestation (5.56%) compared to 36.11% in Morden at Latur.

- Diverse pollinators were observed on sunflower. In general the activity of all these pollinators was more between 9.00 and 12.00 hrs. *A. dorsata* was the predominant pollinator in sunflower with its activity from 7 to 18 hrs. Seed yield of variety DRSF-108 and hybrid DRSH-1 was higher in open pollinated plots (1680 and 2352.3 kg/ha, respectively) followed by plots with honey bee colony (*A. ceranaindica*) under insect proof net (1423.6 and 1983.5 kg/ha, respectively) and plots under insect proof net without honey bee colony (123.7 and 876.8 kg/ha).

- Bio intensive IPM (BIPM) module involving KBSH-53 a powdery mildew tolerant sunflower hybrid, seed treatment with Imidacloprid @ 5 g/kg and Metalaxyl @ 2g/kg, hand picking and destruction of early stage larvae of Spodoptera and Bihar hairy caterpillar and application of Spinosad @ 0.1 ml/l was found effective with 1389, 1709, 2216 and 1233 kg seed yield/ha and incremental benefit cost ratio (IBCR) of 4.23, 4.04, 5.23 and 1.33 in Akola, Latur (Maharashtra), Bengaluru and Raichur (Karnataka), respectively.

- LSFH-171 recorded higher values and was superior to KBSH-44 with respect to root traits (74 cm root length, 103.3 cc root volume, 12.8 g root weight as against 67.2 cm, 85.8 cc 11.8 g, respectively in check) at Hyderabad.

- CSFH-5060 showed tolerance to water (> 50% germination at - 0.8 MPa) and salt stress (>60% germination at 200 mM) at seedling level.

- Oleic acid content showed strong and positive correlation with minimum temperature (r=0.82**) followed by mean temperature (r= 0.71*).

- PAC-3793 recorded maximum oleic content of 84.1% compared to other high oleic hybrids at DOR, Hyderabad with July planting with prevailing flowering to harvest weather conditions of 22.1 °C minimum temperature of and 25.9 °C mean temperature.

- Dual seed inoculation of *Azospirillum* and *Azotobacter* along with 75% of recommended N can save 25% of N requirement of *rabi* sunflower under paddy fallow conditions leading to higher profitability at Nimpith in West Bengal.

- In southern dry zone of Karnataka, maintaining 33% higher plant population (74074 plants/ha) of KBSH-53 hybrid and application of 125% RDF+S+$ZnSO_4$ has resulted in increased *kharif* sunflower yield (1922 and 1802 kg/ha, respectively) and contribute for higher income (B:C ratio 2.56) at Bengaluru in Alfisols.

Technologies Recommended

- Apply 100% NPK + Sulphur @ 20 kg/ha through gypsum + boron @ 1 kg/ha as borax in alternate years + Zn @ 10 kg/ha to the *kharif* sunflower and 100% NPK to *rabi* chickpea in Sunflower-Chickpea cropping system in northern dry zone of Karnataka to increase the system yield and get economic benefit.

- Apply 100 % recommended NPK + 5 t FYM/ha for sunflower in *kharif* and application of 100% RDF for succeeding

groundnut in Tamil Nadu to increase the system yield and get the economic benefit.

- Apply 100 % recommended NPK + S @ 40 kg/ha as single super phosphate in western Maharashtra region to increase seed yield and economic returns of *kharif* sunflower.
- Apply 100 % N + *Azospirillum*+*Azotobacter* seed treatment to increase the seed yield (11.7%) and economic returns in *kharif* sunflower in western Maharashtra region.

Castor

- Collected 118 accessions from Rajasthan through an exploration in collaboration with NBPGR, Regional Station, Jodhpur
- Seven trait-specific germplasm accessions identified at DOR, Hyderabad for specific traits such as extra-early maturity (RG-22), long primary spike covered by capsules (RG-2375), high oil (as high as 52%) (RG-3206, RG-3262) and high seed yield (3.11 to 4.14 kg/net plot) (RG-1647, RG-3242, RG-3291) maintained the specific traits at multilocations under rainfed and irrigated conditions.
- A wilt resistant selection, RG-2818 (IC346622; INGR14004) developed by DOR, Hyderabad was registered with PGRC, NBPGR, New Delhi.
- Castor germplasm-cum-breeders days was conducted during 25-26 October, 2014 at DOR, Hyderabad. Around 123 accessions comprising 14 wilt resistant, 2 root rot resistant, 2 leafhopper resistant, 1 leafhopper and wilt resistant, 3 putative drought resistant, 10 early, 1 dwarf plant type, 19 high yielding and 60 high yield traits were indented. Nineteen of these were commonly indented by participants possessing wilt resistance (4), leafhopper resistance (1), early maturity (4), high yield (5) and high yield traits (5).
- A monoecious gene pool constructed in the previous year at DOR and supplied to the centers has been allowed for second cycle of random mating by growing in isolation.
- MCI-8 a high yielding, wilt resistant variety was identified for irrigated conditions of Rajasthan by the State Varietal Release Committee, Rajasthan.
- A perennial, wilt resistant, high yielding (2 kg/pl/year) male line, YRCS-1205 developed at Yethapur, with red stem, double bloom, spiny capsules, 18 nodes to primary, long productive pistillate spike, high branching, bold seed with high hundred seed weight (45 g).
- Two wilt resistant male lines *viz*., DCS-110 and DCS-118 (<20% wilt incidence) compared to the susceptible check JI-35 (96.4%) were also resistant to leafhopper (grade 0.1 to 1) under severe pest infestation.
- New inbred lines were developed at Junagadh (JI-426, JI-427, JI-428, JI-429, JI-430), Palem (PCS-301, PCS-302, PCS-303, PCS-304) and SK Nagar (SKI 387, SKI 388, SKI 389, SKI 390, SKI 391, SKI 392, SKI 393, SKI 394, SKI 395, SKI 396, SKI 397).
- DPC-16, a pistillate line with unique morphotype of hermaphrodite flower at tip in addition to red stem colour, zero bloom was registered by the Plant Germplasm Registration Committee in its XXVIII meeting held on January 31, 2014 with national identity, IC0598621 and registration number INGR14003.
- New pistillate lines developed are SKP- 84, JP-65 and DPC-9 at Anand; DPC-23, DPC-24, DPC-25 resistant to wilt (<20 % wilt

in sick plot) and leafhopper (0-1 grade) at DOR, Hyderabad.

- New Promising hybrids developed are: SKP84 x PCS106 (1685), DPC9 x PCS106 (1625), DPC9 x PCS262 (1596), M574 x PCS262 (1584) at Palem, SHB999 (3363), JHB1037 (3082), SHB997 (3061), SHB1000 (2995), SHB1001(2792) at SK Nagar, YRCH1214 (1629), YRCH1308 (1327), RSCH 1 (2901), RSCH 5 (2161), R 2012-044 (2772), R 2012 - 9 (2408) at Yethapur and CEH-68 (6017), CEH-134 (6047), CEH-108 (6458) , CEH-133 (5772) at DOR, Hyderabad.

- Against the target of 6.32 q of breeder seed of varieties and parental lines of hybrids based on DAC indent, an excess of 12.66 q breeder seed was produced to meet the demand of seed producers, progressive farmers and researchers.

- Response to bio-phos (*Chaetomium globosum*) application to utilize unavailable phosphorus present in soil for plant nutrition varied in different centres. Application of 20 kg P_2O_5/ ha + biophos, 60 kg P_2O_5/ha + biophos resulted in significant improvement in seed yield at Kanpur (2667 kg/ha) and Junagadh (2500 kg/ha), respectively. There was no distinct response of biophos application within the same level of P application at SK Nagar. At Bawal and Palem, application of 20 kg P_2O_5/ha + biophos resulted in significant improvement in yield. At Yethapur, 60 kg P_2O_5/ha +biophos resulted in highest yield (2581 kg/ha) in low P soils. In soils with medium available P, decrease in phosphatase enzyme activity was observed without addition of P_2O_5/in soils at SK Nagar, Junagadh and Kanpur.

- In Southern Telangana region of Andhra Pradesh (Palem), higher *rabi* castor yield higher castor seed equivalent yield (3060 kg/ha) and higher economic returns were realised when the preceding *kharif* crop was either maize or mungbean or clusterbean compared to fodder jowar and application of 120 kg N/ha to castor recorded the higher seed yield (2250 kg/ha) and economic returns (B:C ratio 2.19).

- Multi-location testing of 19 castor genotypes for oil quality and ricinoleic acid content revealed significantly higher oil content in genotype RG-329 (52.8%) and lowest oil content in genotype DCS-119 (34.2%). Mean value of oil content at SK Nagar (51.4%), Junagadh (50.4%) and Palem (38.8%) was significantly different from the initial oil content. The ricinoleic content was found to be the highest in DCS-119 (92.5%) and lowest in RG-3451 (86.5%). The ricinoleic acid content did not vary significantly across locations.

- Foliar application of $ZnSO_4$ @ 0.5% twice at 50 and 90 DAS was found to be better than soil application of $ZnSO_4$ or $FeSO_4$ at either of doses (15 or 25 kg/ha) at Palem (1698 kg/ ha) and Hiriyur (2692 kg/ha) under rainfed conditions. However, both soil and foliar application of zinc and iron did not significantly influence the seed yield of castor under irrigated conditions of Rajasthan (Mandor).

- Under irrigated conditions of Mandor, sowing of castor at 120x90 cm plant geometry resulted in higher seed yield (4278 kg/ha) of GCH-7. Application of 40 kg K_2O/ha significantly improved the seed yield of castor over control. At Bawal, the crop (DCH-177) responded significantly up to 20 kg K_2O/ha.

- The impact of selective mechanization of critical operations like sowing, intercultivation and shelling on productivity of castor revealed significant seed yield improvement by 13.2%,

14.6 and 15%, at Palem, Hiriyur and Yethapur, respectively. Selective mechanization reduced the labour requirement, time of operation and cultivation cost resulting in higher economic returns across locations.

- SHB-896 with overall 23% yield increase over DCH-519 (2546 kg/ha) coupled with wilt resistance in sick plot of SK Nagar (19.6%) and NCH-1 hybrid and SKI-346 variety, though low yielding were promoted to next trial.

- *Botryotinia* gray rot severity was more in July 15th sown crop and the weather parameters i.e., temperature of 28 to 30 °C, relative humidity of >85% and more number of rainy days coupled with cyclonic rainfall during the 2nd and 3rd weeks of September contributed for severe disease build up at Palem. July sown castor crop recorded maximum gray rot severity than June sown crop at Yethapur also.

- Pathogenic variability studies revealed that isolates differed in expressing the wilt disease reaction with different castor cultivars. 48-1, Haritha and DCS-9 cultivars showed resistant reaction to most of the isolates while cultivars Kranti, J1-35 and VP-1 showed susceptible reaction. Isolates *For*- 12-1, 3, 10 were highly virulent.

- Five accessions *viz.,* RG-1624 (IC-373981), RG-2746, RG-2787 (IC-374338 / IC346591), RG-2800(IC-346604), RG-3105 were identified as wilt resistant at three wilt sick plots of DOR-Hyderabad, Palem, SK Nagar and four accessions *viz*., RG-2809(IC-346613); RG-1834, RG-2430, RG-2781 (IC-374333/IC-346585) were wilt resistant at two places. Two accessions *ie*., RG-3344 and RG-2761 were found resistant (<10%) to gray rot and nine accessions *viz*., RG-2787 (IC-374338 / IC346591), RG-3018, RG-2719, RG-2722, RG-2809 (IC-346613), RG-2818, RG-2819, RG-2822, RG-2829 showed resistant reaction to root rot. Two accessions RG-2787 (IC-374338 / IC346591), RG-2809(IC-346613) were resistant to both root rot and wilt diseases and can be used in breeding programme.

- Out of 21 germplasm accessions screened against wilt, four entries *ie* RG-2430, RG-2746, RG-1624 (IC-373981), RG-2787 (IC374338/ IC346591) showed confirmed resistance at 3 locations of DOR- Hyderabad, Palem, S.K. Nagar and six accessions RG-386 (IC-432910), RG-2781 (IC-374333/IC-346585), RG-2800, RG-3093, RG-3020 RG-3105 at two locations under artificial inoculation conditions. None of the germplasm accessions showed resistant reaction to gray rot and RG-104, RG-529 was resistant to root rot.

- Seed treatment and soil application of *Trichoderma harzianum*, Th 4d WP recorded low wilt incidence and more seed yield at Yethapur and moderate to high wilt incidence recorded in the trial at DOR, Hyderabad and SK Nagar.

- Spraying of Propiconazole, Carbendazim 0.1% two times at 10 days interval were found effective with low *Botryotinia* gray rot severity and high seed yield. Among biocontrol agents, *Trichoderma asperellum* Tv673 WP found effective in reduction of grey rot at Yethapur.

- Survey on castor crop in different villages of Revdar mandal, Sirohi district of Rajasthan revealed that castor was severely infected by root-knot nematode, *Meloidogyne incognita*. Infected crop showed yellowing and stunting with abundant root galls.

- Among 22 promising germplasm accessions screened against leafhopper, nine entries *viz*., RG-43, RG-631, RG-1621, RG-2093, RG-2266, RG-2462, RG-2661, RG-3060 and RG-3067 were found resistant to leafhopper

in all three locations (Hopper burn grade 0 to 1 on 0-4 scale compared to grade 4 in DPC-9 and DCH-177). The resistant accessions will be evaluated further to explore mechanisms of resistance.

- Out of eight least susceptible germplasm accessions screened against capsule borer, only one entry RG-2774 recorded lower capsule borer damage in all three locations (0 to 25.8% capsule damage) compared to maximum of 19.1% in RG-845 at Yethapur, 57.5% in RG-3124 at Palem and 85.5% in DCS-9 at DOR, Hyderabad. The entry will be further screened under controlled conditions and high pest pressure to corroborate antixenotic and antibiotic resistance.

- Among 16 parental lines screened, two female lines (M-574 and VP-1) and one male line (TMV-5-1) found resistant to leafhopper in all three locations (Hopper burn grade 0 to 1 on 0-4 scale). Only one line *viz*., 48-1 recorded lower capsule borer damage (0 to 17.7%) in all three locations. The lines will be retested for their reaction to use in breeding programmes.

- The newer insecticides *viz*., chlorantraniliprole (0.3 ml/l) and flubendiamide (0.2 ml/l) were found effective against defoliators (semilooper, *Spodoptera* and hairy caterpillars) and capsule borer across centres and resulted in higher yields (1035 to 1985 kg/ha) over conventional insecticides (942 to 1567 kg/ha) and untreated control (572 to 1443 kg/ha). The newer insecticides can be opted for inclusion as a component in the IPM in castor.

- The loss in seed yield due to insect pests (semilooper, *Spodoptera,* hairy caterpillars, leafhopper and capsule borer) in popular cultivars at Palem, Yethapur and DOR, Hyderabad revealed minimum yield loss in DCH-519 in both *kharif* (12.5 to 46.2%) and *rabi* (3.7 to 28.4%) seasons as compared to cultivars 48-1 (21.3 to 56.4% in *kharif* and 16.4 to 47.2% in *rabi*) and DCH-177 (23.8 to 83.9% in *kharif* and 61.5 to 100% in *rabi*). In SK Nagar, the loss in seed yield due to thrips, whitefly and leafhopper was estimated to be 2.8 to 9.6% and 6.5 to 19.9% during *kharif* and *rabi* seasons, respectively. The information will be utilized to determine relative importance of the pests and to develop location specific pest management strategies.

Promising technologies for validation through on-farm trials

- Under irrigated conditions, application of biophos (*Chaetomium globosum*) @30 g inoculant/50 g seed along with 20 kg P_2O_5/ha, 40 kg P_2O_5/ha + biophos, 60 kg P_2O_5/ha + biophos resulted in higher seed yield and economic returns at Kanpur (2667 kg/ha), Bawal (3432 kg/ha) and Junagadh (2500 kg/ha), respectively. Under rainfed conditions at Palem with medium P soils, application of 20 kg P_2O_5/ha + biophos resulted in higher seed yield (1416 kg/ha). At Yethapur, 60 kg P_2O_5/ha +biophos resulted in highest yield (2581 kg/ha) in low P soils. (AICRP centres- Kanpur, Bawal, Junagadh, Palem and Yethapur)

- In Southern Telangana zone of Andhra Pradesh (Palem), higher *rabi* castor yield and higher economic returns was obtained when the preceding *kharif* crop was either maize or mungbean or clusterbean and 120 kg N/ha was recommended to *rabi* castor for realizing higher yield (2250 kg/ha) and economic returns (B: C ratio 2.19). (AICRP centre-Palem).

  Foliar application of $ZnSO_4$ @ 0.5% twice at 50 and 90 DAS resulted in higher seed yield (1698 kg/ha) of castor and higher economic

returns (B:C ratio2.60) on red sandy loam soils under rainfed conditions at Palem (AICRP centre-Palem).

Technologies Recommended

- Pre-emergence application of pendimethalin @ 1kg/ha + one inter cultivation at 40 DAS resulted in better weed control efficiency to realize higher seed yield and net returns under rainfed conditions of Hiriyur (1195 kg/ha), Yethapur (2337kg/ha) and irrigated conditions at Bawal (3216 kg/ha). (Hiriyur, Yethapur and Bawal)
- Under rainfed condition of Tamilnadu (Yethapur), adopting wider spacing (120x90 cm) resulted in higher seed yield (1840 kg/ha) and economic returns (B:C ratio 2.1) of YRCH-1 hybrid. (Yethapur).
- For irrigated *rabi* castor (GCH-7) in South Gujarat condition, application of 120 kg N/ha in 3 equal splits is recommended to achieve higher seed yield and economic returns. (Navasari).

Safflower

- Two hundred and seven accessions of the USDA safflower core set were added to the germplasm repository at DOR, Hyderabad.
- 15 promising accessions for seed yield (536-907 g/plot) and 10 for oil content (35.4-38.9 %) were identified.
- Two CMS hybrids developed at Akola recorded higher seed yields (1979 and 1859 kg/ha) than the check variety, PKV Pink (1409 kg/ha) in preliminary hybrid yield trial conducted at Akola under rainfed conditions which received 1.5 mm total rain during safflower crop season.
- Ten TGMS hybrids developed at Phaltan and five CMS hybrids developed at DOR, Hyderabad were evaluated at DOR, Hyderabad, Indore, Parbhani and Phaltan in a replicated trial. The CMS hybrid DSH 253 recorded the highest mean seed yield (1734 kg/ha) followed by DSH 252 (1731 kg/ha), DSH 254 (1710 kg/ha), DSH 255 (1690 kg/ha) and the TGMS hybrid, NARI-H-3(1683kg/ha) while hybrid check NARI-H-15 registered 1510 kg/ha seed yield.
- At national level, none of the entries in IVT recorded 10% increase in seed and oil yields over the check, PBNS-12. However, one entry, PBNS-120 recorded only 3% increase in both seed (1489 kg/ha) and oil (429 kg/ha) yields over check PBNS-12 (1439 kg/ha and 418 kg/ha).
- In IHT, NARI-H-29 recorded the highest seed yield (1679 kg/ha) with 23% increase over the hybrid check, NARI-H-15 (1365 kg/ha). It also recorded the highest oil yield (525 kg/ha) with 26% increase over NARI-H-15 (417 kg/ha). The other hybrids *viz.,* NARI-H-27 recorded 21% increase in seed yield (1658 kg/ha) and 24% increase in oil yield (561 kg/ha) while NARI-H-28 registered 19% increase in both seed (1623 kg/ha) and oil (496 kg/ha) yields, DSH-250 recorded 19% increase in seed yield (1618 kg/ha) and 13% increase in oil yield (473 kg/ha), NARI-H-30 recorded 15% increase in seed yield (1569 kg/ha) and 14% increase in oil yield (474 kg/ha).
- In AHT II, at the national level, DHS-185 recorded the highest seed yield (1891 kg/ha) with 19% increase in seed yield and 10% increase in oil yield (534 kg/ha) over check hybrid, NARI-H-15 (1594 kg/ha and 486 kg/ha). NARI-H-25, which recorded 6% increase in seed yield (1695 kg/ha), registered 11% increase in oil yield (538 kg/ha) over NARI-H-15.

- The two high oil type reentered hybrids *viz.,* NARI-H-57 and NARI-H-52, which exhibited 33 and 35.8% seed oil content at national level, recorded 3 (469 kg/ha) and 4% (465 kg/ha) lower oil yields and 19 (1295 kg/ha) and 12% (1401 kg/ha) lower seed yields, respectively over hybrid check, NARI-H-15 (1594 kg/ha and 486 kg/ha).

- A total of 65.4 q breeder seed of eight varieties and parents of hybrid NARI-H-15 was produced against the target of 27.7 q.

- Eight AICRP (Safflower) centres produced 1331 q of TFL seed and 185.5 q of breeder/ foundation seed of nine varieties under buy-back agreement arranged by AICRP (Safflower) with Marico Ltd. in public-private partnership mode.

- In mungbean-safflower system under rainfed conditions, application of safflower residues back to the field could save 50% recommended NPK of mungbean; and application of residues of mungbean or 6 t FYM/ha to safflower could substitute 50% recommended NPK of safflower for the Vidarbha region of Maharashtra (Akola).

- In soybean-safflower system under irrigated conditions, 50% recommended NPK of soybean could be substituted with the application of 2.5 t FYM/ha + safflower residues; 50% NPK of safflower could be substituted with the application of 3 t FYM/ ha + 3 t/ha of soybean residues for the Marathwada region of Maharashtra (Parbhani).

- For scarcity rainfall zone of Maharashtra (Solapur), 50% recommended P of blackgram can be substituted through seed treatment with PSB; 50% recommended NP of safflower can be substituted through seed treatment with *Azotobacter*/ *Azospirillum* and PSB in blackgram-safflower cropping sequence under rainfed conditions.

- Under rice fallows of Chhattisgarh plains (Raipur), sowing of crop during second fortnight of November yielded better than that of crop sown during December. Varieties Bhima and PBNS-12 yielded better than A-1, PBNS-40 and NARI-6.

- Under rainfed conditions soaking of seeds for 12 hrs before sowing at Malwa plateau region (Indore); in Westerm Maharashtra region (Phaltan) 24 hrs seed soaking before sowing improved the seed yield. However under rice fallows of Chhattisgarh plains (Raipur), soaking of seeds before sowing was not required.

- FLDs on whole package (improved cultivar, recommended dose of fertilizers and need based plant protection) under irrigated conditions, recorded a mean safflower seed yield of 1205 kg/ha in FLD plots as compared to 1045 kg/ha in farmers' practice (FP). Whereas, under rainfed conditions, FLD plots recorded a mean safflower seed yield of 808 kg/ha as compared to FP plots (623 kg/ha).

- By adoption of improved production technologies, it was estimated that safflower production in the country during post-rainy season could be increased from 0.86 lakh tonnes to 1.05 and 1.46 lakh tonnes by bridging yield gaps I and II, respectively.

- Germplasm accessions *viz.*, GMU-4854 and IC 13884 (GMU 4983) were moderately resistant to wilt with less than 20% disease incidence (Solapur).

- In uniform disease nursery, the entries EC 181448 (GMU 1139), IC 338441 (GMU 3661), IC 13884 (GMU 4983) and GMU 7017, SAF-

1244 (11-7-1-3) were found to be resistant to wilt with less than 10% wilt incidence and the entry SAF-1244 (11-7-1-3) was found promising with lowest wilt incidence (4.5%) and significantly superior seed yield (596 kg/ha) whereas A-1 (NC) recorded 30.4% wilt incidence and seed yield of 452 kg/ha (Solapur).

- Cymoxanil+mancozeb @ 0.2% (Solapur), *T. harzianum* Th4d SC @ 2ml/kg (Parbhani), vitavax powder @ 2 g/kg (Annigeri), captan @ 0.2% (DOR), were most effective in reducing seed and soilborne diseases incidence.
- In Marthwada region of Maharashtra, Propiconzole (0.1%) sprayed twice at 15 days interval was very effective against Alternaria leaf spot with lowest disease severity (26.1%) and high seed yield (1137 kg/ha) and high C:B ratio (2.09).
- Clothianidin @ 50 g/ha and Chlorpyriphos+ Cypermethrin @ 1000 ml/l were found very effective against aphids at Hyderabad and Solapur for the third consecutive year and was at par with the check insecticides like dimethoate, acephate and imidacloprid.
- In uniform pest nursery, 10 accessions – AKS-322, SAF-11-24, SF-14, SF-9, SAF-11-13, SAF-15, SAF-11-35, SAF-11-12, SAF-11-25 and SSF-902 were found moderately resistant at both the locations, Solapur and Hyderabad.
- Among the four entries that were identified promising during last year in UPN trial, entry, SF-10-4 was found moderately resistant at both locations, Solapur and DOR, Hyderabad.

Technology Recommended

- For Southern Telangana zone of Andhra Pradesh, foliar application of SAAF (Carbendazim + Mancozeb) @ 0.2% twice at 20 days interval is recommended to reduce Alternaria leaf spot disease with good benefit cost ratio.

DOR

वार्षिक प्रतिवेदन

Annual Report

2013-14

Institutional Activities

* Extension and other Activities
* Education and Training
* Awards and Recognitions
* On-going Research Projects
* Meetings and Events
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* Infrastructure Development
* Hindi Activities
* Visitors
* Appointments/Promotions/Transfers/Retirements
* Personnel

EXTENSION AND OTHER ACTIVITIES

Tribal Sub-Plan

Tribal sub-plan programme was implemented in 23 villages of Andhra Pradesh, 1 village of Rajasthan, 1 village of Karnataka and 12 villages of Tamil Nadu for castor; 4 villages of Andhra Pradesh, 2 villages of Karnataka and 24 villages of West Bengal for sunflower and 5 villages of Andhra Pradesh for safflower with the objective of alleviating poverty among the schedule tribe population and creation of productive assets for them. Under this programme, 1238 demonstrations of improved varieties/hybrids of DOR mandate crops (Castor- 778, Sunflower- 310 and Safflower-150) were conducted in association with NGOs such as, Research in Environment, Education and Development Society, Viksit Bharat Foundation and Agri-Biotech Foundation and AICRP centres such as Raichur, Nimpith, Yethapur, Hiryur, Palem, Mandor and Tandur. In West Bengal the tribal farmers earned profit of ₹12,000/acre through cultivation of sunflower. The average profit due to cultivation of castor in Rajasthan was ₹10,500/ acre, whereas in Andhra Pradesh it was varying from ₹6,500 to ₹10,000/acre. The farmers of Andhra Pradesh got the net income of ₹12,000 to ₹20,000 by growing castor in *rabi* season. They were given agricultural implements *viz.,* secateurs, bullock drawn seed drills, weeder, local iron *gorru* power sprayers, castor sheller, motor operated thresher, rotavator, MB plough, diesel pumpset and irrigation pipes, etc. as assets. The TSP on safflower was executed on 100 acres of Ranga Reddy Dt., Andhra Pradesh.

Sunflower hybrid DRSH-1 grown by tribal farmers in Chakdhobakure village, Bankura Dt., West Bengal

Expansion of safflower to non-traditional areas

Andhra Pradesh: During the year under report 500 acres of safflower was cultivated in Anantapur Mahaboobnagar, Kurnool and Prakasam districts.

Karnataka: In Bellary district, 60 acres of safflower cultivation was taken up in Chellagurki village.

Gujarat: Safflower cultivation was initiated in 50 acres in Bhuj district.

Maharashtra: Safflower cultivation was taken up in 25 acres in Latur district.

The expansion of safflower was undertaken on a PPP mode. In this regard, necessary arrangements were worked out with the industry with a buy back arrangement to ensure remunerative price to the farmers.

Farm Innovators' Day

A Farm Innovators' Day was organized at the Directorate on February 28, 2014. Twelve innovative farmers from Maharashtra, Karnataka, Andhra Pradesh and West Bengal participated in the programme and presented innovative methods of cultivating the oilseed crops and innovations made in fabricating some of the implements. They were felicitated in the function. The Venkata Sheshadri water supply system with one motor – two borewells for irrigating the crop of two acres by Shri Pulla Reddy, Mukundapuram village, AP, an engine which can be coupled to an irrigation pump and can conveniently be utilized for drawing water from a deep water source developed by

Shri. Kadivendi Mahipal Chari, Seetharamapuram village, A.P., Sri Tailam – a herbal remedy as anti-mosquito, pain reliever and wound healer developed by Shri Galla Chandrasekhar, Srikalhasti, AP and Mahipal semi-automatic cultivator are noteworthy.

Radio Talks

Scientist	Topic	Date of broadcast
Dr. M. Padmaiah	Rythughosti - interactions with the farmers	July 16, 2013
	Implementation of Tribal-Sub-Plan by DOR	August 1, 2013
	Rabi Amudam sagu melakuvalu	September 3, 2013
Dr. G. Suresh	*Proddutirigudu lo melayina yaajamaanya paddatulu*	August 2, 2013
Dr. I.Y.L.N. Murthy	*Nuneginjalalo gandhakam pramukhyata*	July 29, 2013

Television Programme

Scientist	Topic	Media	Date of telecast
Dr. M. Padmaiah	Castor cultivation in *kharif*	CVR News	June 6, 2013
	Plant protection measures and fertilizer management in castor	CVR News	July 31, 2013
	Plant protection measures in *kharif* castor	CVR News	September 8, 2013
	Castor cultivation in *rabi*	ETV 2	September 14, 2013
	Plant protection measures in *rabi* castor	CVR News	January 4, 2014
	Castor field day at Hazinathanda Web-Telecast at Krishi Vasant, Nagpur to clarify the queries raised by farmers of Andhra Pradesh	CVR News	January 15, 2014 February 12, 2014
Dr. G.D. Satish Kumar	Phone-In Programme (Live) on sunflower cultivation : Problems and Prospects	V6 News	January 29, 2014
Dr. P. Padmavathi	Safflower package of practices	CVR News	January 6, 2014
Dr. G. Suresh	Improved management practices for attaining higher yields in sunflower	Gemini TV	August 25, 2013

Documentary Film

A documentary film entitled "A successful castor farmer of Chenchu community in Mahabubnagar district" (3.45 minutes) was developed for the benefit of researchers, farmers and department officials.

Sunflower Germplasm Field Day

The sunflower Germplasm Field day was organized at ORS, Latur under Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra during February 5-6, 2014. The two day programme included visit to sunflower

germplasm of Latur centre; DOR, Hyderabad, NCP crosses, CMS lines, R lines, inbreds, restorers, private sector hybrids, F2 progenies and wild *Helianthus* species. Besides, NBPGR, New Delhi also had contributed 1092 lines for multiplication and characterization. All the materials were evaluated during *rabi* 2013 and the visit coincided with flowering stage. The layout, crop growth and expression were very good and all the participating AICRP sunflower breeders from across the country and other invitees made good evaluation and selections of the material. Further, a specialized downy mildew evaluation sick plot facility was also shown to the delegates.

Dr. B. Venkateswarlu, Hon. Vice Chancellor, MAU, Parbhani visited the sunflower germplasm plots, downy mildew screening and inaugurated the newly installed fogger system for downy mildew sick plot. Later he participated in the interaction meeting held in College of Biotechnology, MAU, Latur. Dr Nerkar, Former Vice Chancellor, MAU; Dr Tyagi, NBPGR, New Delhi; Dr D.P. Waskar, Director of Research, MAU; Mr K.N. Deshmukh, Joint Director of Agriculture; Dr. K.S. Varaprasad, Project Director, DOR and Dr. M.K. Ghodke, Senior Sunflower Breeder and Officer I/c ORS, Latur and all the sunflower scientists, breeders of other crops *viz*., cotton, sorghum, pulses and soybean of MAU participated in the field day. A technical bulletin in Marathi on 'Technology for Higher Sunflower Production' was released.

Sunflower and Safflower Field Day-cum-Training Programme on Seed Production

A Field Day-cum-Training Programme on seed production of sunflower and safflower was organized by DOR at DOR-ICRISAT Farm on March 15, 2014. About 100 sunflower and safflower farmers from the nearby villages have participated in the training programme.

Castor and Sunflower Field Day-cum-Training Programme in Seed Production

A Field Day-cum-Training Programme in seed production of castor and sunflower was organized by DOR at DOR-Narkhoda Farm on March 28, 2014. About 150 castor and sunflower growing farmers from the nearby villages have participated in the training programme.

Safflower Field day organized at Anantapur district of Andhra Pradesh

A field day on safflower was organized by DOR at Veligonda Village of Anantapur district on January 4, 2014. One hundred and fifty farmers from Veligonda, Vajrakarrur, Vurvakonda villages have participated in this field day. This was conducted to bring awareness about safflower cultivation among the farmers.

Castor Germplasm-cum Breeders' Field Days

Conducted castor germplasm-cum breeders' field day from 25 to 26 October 2013, in which 17 researchers participated. Around 123 accessions comprising 14 wilt resistant, 2 root rot resistant, 2 leafhopper resistant, 1 leaf hopper and wilt resistant, 3 putative drought resistant, 10 early,1 dwarf plant type, 19 high yielding and 60 high yield traits were indented by participants. Nineteen of these were commonly indented by participants which included accessions possessing wilt resistance (4), leaf hopper resistance (1), early maturity (4), high yield (5) and high yield contributing traits (5).

Training Programmes to Farmers

Pre- and post- demonstration training programmes were conducted for the farmers cultivating DOR mandate crops during *kharif* and *rabi* seasons at Chitlampalli and Kalyandurge of Anantpur district, Chenchugudem, Ambagiri, Vatavarlapalli, Sarlapalli, Kudichintabayalu, Hazipalli of Mahabubnagar district, HazinaTanda, Kurmaguda of Ranga Reddy district during 2013-14.

Hands on Training on "Microbial Agents of Major Insect Pests and Diseases of Crops"

A hands-on training on "Microbial Agents of Major Insect Pests and Diseases of Crops" was organized during 4-13 March, 2014 at the Directorate. The training was attended by 8 participants - six from private sector and 2 from SAUs. The participants were trained on isolation, identification, mass production, formulation, quality control and registration of microbial agents with specific reference to the plant disease antagonists *Trichoderma* spp., and *Pseudomonas fluorescens*, entomocidal bacterium *Bacillus thuringiensis*, entomopathogenic fungi like *Beauveria bassiana*, *Metarhizium anisopliae*, *Nomuraea rileyi*, *Paecilomyces fumosoroseus* and *Verticillum lecanii*, baculoviruses of *Helicoverpa armigera* and *Spodoptera litura* and Entomopathogenic nematodes. Identification of fungi through molecular techniques as well as identification of bacteria through PCR techniques including Cry gene profiling for *Bt* were taught to the participants.

Training on *Beauveria bassiana* Mass Production and Formulation to staff from the Licensee firm M/s Ambika Biotech, New Delhi

A hands-on training on "Mass production of *Beauveria bassiana* and formulation" was given to Mr. Saurabh Singh Tomer, CEO, Ambika Biotech & Agro Services, Mandsaur, M.P. from 5-7 September, 2013. The training covered mass production of *B. bassiana* (isolate ITCC-4513) on solid substrate, harvesting of pure dry conidia, formulation of conidia into a suspension concentrate, identification, storage and maintenance of *B. bassiana* cultures, quality control, generation of analytical test report and efficacy testing against host insect *Helicoverpa armigera* through larval bioassays.

Parthenium Awareness Day

The Parthenium Awareness Day was organized at DOR, Hyderabad on August 22, 2013 as a part of "Parthenium Awareness Week" observed from 16-22 August, 2013. All the Principal Scientists, scientists, staff and students of the Directorate attended the awareness progrramme. Owing to rapid and gregarious growth of Parthenium, its ill effects on human, livestock and all crops including oilseed crops are evident necessitating organizing such awareness programmes. Scientists of DOR elaborated the problems associated with Parthenium especially in reducing crop yields of oilseeds, spreading viral diseases like sunflower SND, efforts to control the weed through various methods and successful control of Parthenium through biological control. The harmful effects of this weed and its successful control were explained to farm staff and labourers through charts/posters and other exhibits and a mass campaign was taken up for uprooting the weed at Rajendranagar farm.

Vigilance Awareness Week

The vigilance awareness week was observed at DOR from October 28 to November 2, 2013. This year the main focus of observing Vigilance Awareness Period was for "Promoting Good Governance – Positive Contribution of Vigilance".

On October 28, 2013 the vigilance pledge in Hindi and English was administered to all the scientists, officers and staff. On November 1, 2013, Shri Anil Behari, Senior Administrative Officer, DOR, gave a talk on the theme of the subject. The banners made in bi-lingual, was displayed at the main office throughout the week. During the occasion of observance of Vigilance Awareness Week, posters of slogans against corruption were displayed at DOR main building. Besides, a permanent notice regarding the complaints on vigilance matters was prominently displayed in the

Annexe (administrative) building to draw the attention of everyone visiting DOR.

Shri Anil Behari, Sr. Administrative Officer, DOR delivering the talk

Orientation workshop on implementation of National Mission on Oilseeds and Oil Palm (NMOOP)

To facilitate the implementation of NMOOP an orientation workshop was organised from 13-14 March, 2014 at the Directorate under the Chairmanship of Addl. Secretary (looking after Oilseeds), DAC. Joint Secretary (Oilseeds), Joint Secretary (Trade and M&T) and other senior officials of DAC attended the meeting. More than 100 representatives from State Department of Agriculture/Horticulture, Scientists of ICAR and other Central Agencies like NOVOD Board, NSC, SFCI, KRIBHCO, HIL and R&D associated with TBOs participated in the workshop.

EDUCATION AND TRAINING

Details of Ph.D students

Name of the student	Title of thesis	Discipline	University/Date of registration
Major advisor: **Dr. M. Sujatha**			
N. Rajasekhar Reddy	Identification of molecular markers linked to Fusarium wilt resistance genes in castor	Genetics and Plant Breeding	JNTU, Hyderabad 15.7.2005
Vijay Sheri	Development of tissue culture and transformation protocols in sunflower as a prelude for development of transgenics against sunflower necrosis disease (completed)	Genetics	OU, Hyderabad 15.4.2008
M. Tarakeswari	Development of transgenic castor for resistance to lepidopteran pests through deployment of *Cry1 Aabc*F gene	Genetics	OU, Hyderabad 19.2.2009
Vasavi Singa Reddy	Development of tissue culture and transformation protocols in sunflower for SND resistance	Genetics	OU, Hyderabad 9.3.2009
K. Prathap Reddy	Mapping gene(s) for male fertility restoration (ARG cytoplasm) and resistance to powdery mildew (*Golovinomyces cichoracearum*) in sunflower (*Helianthus annuus* L.)	Plant Sciences	UoH, Hyderabad 6.7.2009
D. Sandeep Kumar	Tissue culture studies and genetic transformation in castor (*Ricinus communis* L.) by deploying *Cry1 Aabc* gene for resistance to lepidopteran pests	Genetics	OU, Hyderabad 24.2.2011
Major advisor: **Dr. V. Dinesh Kumar**			
K.B. Durga Bhavani	Development of transgenic castor tolerant to *Botrytis ricini* using defense regulatory genes	Plant Sciences	UoH, Hyderabad 04.09.2006
K. Aravind Kumar	Development of transgenic castor with tolerance to *Botrytis* using antifungal genes	Plant Sciences	UoH, Hyderabad 20.09.2007
B. Madhu	Development of transgenic fertility restorer lines in safflower (*Carthamus tinctorius* L.).	Plant Sciences	UoH, Hyderabad 18.08.2008
S. Velu Mani	Assessment of viral vectors for expression of gene cassettes for possible applications in castor	Plant Sciences	UoH, Hyderabad 19.08.2010
Ch. Anil Kumar	Genetic transformation of safflower (*Carthamus tinctorius* L.) and Arabidopsis for increased oil content	Genetics	OU, Hyderabad 21.3.2011
G. Lakshmi Devi	Strategies to develop transgenic castor (*Ricinus communis* L.) tolerant to necrotropic fungi	Biotechnology	ANGRAU, Hyderabad 1.8.2012

Name of the student	Title of thesis	Discipline	University/Date of registration
Major advisor: **Dr. P. S. Vimala Devi**			
Prashanth P. Hari	Development of combination formulations of Bt and entomopathogenic fungi for the management of *Helicoverpa armigera* and *Spodoptera litura*	Zoology	OU, Hyderabad 15.12.2006
A. Ravi Charan	Identification and molecular characterization of a local Bt isolate effective against *Helicoverpa armigera* and *Spodoptera litura*	Biotechnology	JNTU, Hyderabad 8.10.2007
V. Vineela	Development, characterization and evaluation of nanocarrier embedded toxin of *Bacillus thuringiensis* var. *kurstaki* for management of insect pests	Microbiology	OU, Hyderabad 6.2.2013
Major advisor: **Dr. R.D. Prasad**			
Nageswar Rao Namburi	Study of cultural, morphological, molecular and pathogenic variability in *Fusarium oxysporum* f.sp. *carthami* isolates of safflower in India and development of specific markers for detection	Genetics	OU, Hyderabad 26.02.2009
T. Navaneetha	Development of suitable formulations of potential bioagents for management of important diseases in castor, sunflower and safflower	Microbiology	OU, Hyderabad 2.4.2009
P. Sowmya	Study of molecular mechanisms involved in high temperature stress tolerance in *Trichoderma* species	Biotechnology	JNTU, Hyderabad 17.7.2009
Venkatesham Muthkani	Cultural, morphological, pathogenic and molecular characterization of *Macrophomina phaseolina* of different oilseeds and other cultivated crops	Genetics	OU, Hyderabad 24.02.2011
Major advisor: **Dr. M. Santhalakshmi Prasad**			
K. Sujatha	Study of resistance mechanism and management of Alternaria leaf blight in sunflower	Genetics	OU, Hyderabad 21.03.2011
D. Usha	Variation in fungicide sensitivity, toxin production in *Alternaria helianthi* isolates and studies on induced systemic resistance in sunflower against leaf blight	Microbiology	OU, Hyderabad 30.03.2011
N. Naresh	Diversity analysis of Alternaria leaf blight in sunflower based on morphological, pathogenic and molecular characters	Biotechnology	JNTU, Hyderabad 3.10.2011
E. Bharathi	Variability in pathogen population of castor wilt fungus and its management	Microbiology	OU, Hyderabad 12.02.2013

Name of the student	Title of thesis	Discipline	University/Date of registration
Major advisor: **Dr. S. Senthilvel**			
J. Poornima Kumari	Genetic and molecular analysis of nematode resistance in castor (*Ricinus communis* L.)	Genetics	OU, Hyderabad 05.03.2013
Ranjan Kumar Shaw	Molecular mapping of Botrytis resistance in castor (*Ricinus communis* L.)	Genetics	OU, Hyderabad 05.03.2013

National and International Training Programmes Organized

Programme	Period	Participants	Sponsor
Beauveria bassiana Mass Production and Formulation	September 5-7, 2013	Shri S.S. Tomar CEO of M/s Ambika Biotech, New Delhi	DOR, Hyderabad
Safflower Production Technology	September 27-28, 2013	Farmers from Andhra Pradesh, and Karnataka	DOR, Hyderabad
Safflower Production Technology	October 2-4, 2013	Farmers from Maharashtra	DOR, Hyderabad
Safflower Production Technology	October 9-10, 2013	Farmers from Gujarat	DOR, Hyderabad
Protection of Plant Varieties and Farmers Rights	December 19, 2013	Farmers from Nalgonda Dt., AP	DOR, Hyderabad
Molecular and Tissue Culture Techniques	One month during February, 2014	Ms. Sillma Rampasdarath, Ph.D. Student University of Mauritius	Govt. of Mauritius
Castor Breeding	February 25-26, 2014	Junior Breeders from AICRP (Castor) centres at Hiriyur, Jagdalpur and Kanpur	DOR, Hyderabad
Microbial Agents of Major Insect Pests and Diseases of Crops	March 4-13, 2014	Research personnel from SAUs and Private sector	DOR, Hyderabad
Technologies for Increasing Oilseed Production	January 1-4, 2014	Farmers of Navada District, Bihar	ATMA, Naveda, Bihar
Oriantation-cum-Training Programme on "Breeding Stategies and Methodologies for Sunflower Improvement"	October 9-10, 2013	Breeders from AICRP (Sunflower)	DOR, Hyderabad

AWARDS AND RECOGNITIONS

Best Worker Awards

The Best Worker Awards in different categories of DOR staff were awarded to the following staff on the occasion of DOR Foundation Day held on August 1, 2013.

Name/Designation	Category
Shri B. Sambaiah and Shri V. Sarath Babu	Technical
Shri K. Ramulu	Skilled supporting
Shri D. Mallesh, Smt P. Venkatamma and Smt. G. Pentamma	Temporary status labour

Best Research Paper Award

Dr. S. Chander Rao, Shri K. Prathap Reddy, Dr. P.B. Kirti and Dr. M. Sujatha received the Best Research Paper Award for the research paper entitled "Development of a Scoring Scale for Powdery mildew Disease and Identification of Resistant Sources in Cultivated and Wild Sunflower" Euphytica, 190 (385-399).

Recognitions

Dr. K.S. Varaprasad, Project Director is nominated as Member of Board of Management, University of Agricultural Sciences, Raichur, Karnataka for a period of three years from July 10, 2013.

Dr. M. Sujatha, Principal Scientist & Head (Crop Improvement), has been elected as Fellow of the National Academy of Sciences, Allahabad, India (NASI).

Dr. M. Padmaiah, Principal Scientist & Head (Social Sciences), DOR has been felicitated as Best Extension Scientist by Rythu Bandhu - an Agricultural Monthly Magazine on 3rd June, 2013 and by Rythu Nestham - an Agricultural Monthly Magazine on 23rd August, 2013.

Dr. V. Dinesh Kumar, Principal Scientist is a DBT nominee on the IBSC of JK Seeds and ICRISAT, Hyderabad and an External Expert on IBSC of Directorate of Poultry Research and ANGRAU, Hyderabad.

Ms. S. Vasavi, Ph.D scholar of the Directorate working under the supervision of Dr. M. Sujatha has received the K.V. Rao Scientific Society Award in Agricultural Sciences for the year 2013 for the Ph.D. work on sunflower.

ON-GOING RESEARCH PROJECTS

Institute Projects

Project code	Project title	Project leader
101-1	Augmentation, characterisation, maintenance, evaluation and utilization of sunflower germplasm	Dr. Mangesh Y. Dudhe
101-2	Introgression of resistance to *Alternaria helianthi*, sunflower necrosis disease and powdery mildew in sunflower	Dr. M. Sujatha
101-4	Development of sunflower hybrids suited to different growing situations	Dr. A.J. Prabakaran
102-1	Collection, characterization, maintenance , evaluation and utilization of safflower germplasm	Dr. N. Mukta
102-2	Development of improved varieties and hybrids in safflower	Dr. K. Anjani
102-6	Improvement of oil content in safflower	Dr. P. Kadirvel
103-1	Collection, evaluation, characterization, maintenance and utilization of castor germplasm	Dr. K. Anjani
103-2	Diversification of pistillate base and development of high yielding varieties and hybrids resistant to fusarium wilt, Botrytis, leafhopper and drought	Dr. C. Lavanya
103-4	Development of elite parental lines in castor through prebreeding	Dr. A.J. Prabakaran
103-6	Genetic enhancement through biotechnological approaches in castor	Dr. V. Dinesh Kumar
103-7	QTL mapping for Fusarium wilt resistance in castor	Mrs. B. Usha Kiran
103-10	Identification of molecular markers associated with disease resistance in castor	Dr. Senthilvel Senapathy
103-11	Elucidating the molecular mechanisms governing sex expression in castor	Dr. Sujatha, T.P
104-2	Sustainability of sunflower-based cropping system with reference to input management in Alfisols	Dr. S.N. Sudhakara Babu
104-4	Sustainability of safflower-based cropping system with reference to input management	Dr. P. Padmavathi
104-6	Studies on drought tolerance and water use efficiency in sunflower	Dr. Lakshmi Prayaga
104-7	Studies on drought tolerance, water use efficiency and source – sink relationships in castor	Dr. P. Lakshmamma
104-8	Studies on phosphorus acquisition in sunflower genotypes	Dr. Md. A. Aziz Qureshi
104-10	Nutrient interaction and use efficiency studies in sunflower and safflower	Dr. I.Y.L.N. Murthy
104-11	Enhancing resource use efficiency in castor based cropping systems	Dr. G. Suresh

104-12	Sustainability of oilseed-based cropping systems with reference to conservation agricultural practices in Vertisols	Dr. P. Padmavathi
105-1	Studies on entomopathogenic fungi and *Bacillus thuringiensis* (Bt) for the management of lepidopteran pests	Dr. P.S. Vimala Devi
105-2	Management of insect pests of castor	Dr. M. Lakshminarayana
105-3	Management of diseases of castor	Dr. M. Santha Lakshmi Prasad
105-4	Insect pests of safflower and their management	Dr. P.S. Srinivas
105-5	Management of diseases of safflower	Dr. R.D. Prasad
105-6	Management of insect- pests of sunflower	Dr. H. Basappa
105-7	Management of diseases of sunflower	Dr. S. Chander Rao
105-9	Management of root-knot and reniform nematodes of castor and sunflower	Dr. P. Giribabu
105-10	Development of semio-chemical based monitoring and management methods against major insect pests of castor	Dr. P. Duraimurugan
106-1	Biochemical characterization of sunflower, safflower and castor for potential value addition	Dr. Praduman
107-2	Impact of frontline demonstrations and improved technologies with special reference to technology adoption, constraints and socio-economic factors	Dr. M. Padmaiah
107-3	Interactive information Kiosk for dissemination of sunflower, safflower and castor technologies	Mrs. P. Madhuri
107-7	Development of pedigree information system for mandate crops	Dr. K. Alivelu
107-11	Supply chain scenario in oilseeds	Dr. S.V. Ramana Rao
107-12	Development of safflower germplasm core collection based on different descriptors	Dr. K. Alivelu
107-14	*In-silico* mining of castor draft genome	Dr. Ch. Sarada
107-15	Developing mobile phone-based knowledge modules for sunflower and castor growers	Dr. G.D. Satish Kumar
108-1	Development of stable cytoplasmic genetic male sterile system in sesame through wide hybridization	Dr. J. Jawahar Lal

Externally Funded Projects

Sponsor	Project title	Principal Investigator	Total outlay (₹ in lakhs)
ICAR-NPTC	Development of transgenic castor for resistance to lepidopteran pests	Dr. M. Sujatha	79.70
AMAAS	Development of practicable technologies for field level exploitation of consortia of microbial agents as ameliorators of biotic and abiotic stresses in crops	Dr. R.D. Prasad	72.74
ICAR Network	*Phytophthora, Fusarium* and Ralstonia diseases of horticulture and agricultural crops	Dr. R.D. Prasad	64.70
ICAR Network	Diagnosis and management of leaf spot diseases of field and horticultural crops – Alternaria leaf blight of sunflower	Dr. M. Santhalakshmi Prasad	40.69
ICAR Network	Seed production in agricultural crops	Dr M. Lakshminarayana	5.00
NAIP	Effect of abiotic stresses on natural enemies of crop pests: *Trichogramma, Chrysoperla*, *Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses	Dr. R.D. Prasad	165.00
DBT-BIRAC	Discovery of genome-wide SNPs and its use in developing a reference linkage map and association analysis in castor	Dr. Senthilvel Senapathy DOR Dr.Sanjay K. Shahi, Xcelris Genomics Ltd.,	278.44 (DOR: 135.14)
National Fund	Deciphering the molecular mechanism of induction of biotic stress tolerance induced by *Trichoderma* spp. in castor (*Ricinus communis* L.) Collaborating institutes: DOR and UoH, Hyderabad	Dr. V. Dinesh Kumar, DOR Dr. R. Makandar, UoH	200.09 DOR:144.00
DST	Crop management options to make safflower cultivation profitable for small farmers through enhanced utilization of petals	Dr. P. Padmavathi	18.08
DST	Molecular tagging and mapping of powdery mildew resistance in sunflower (*Helianthus annuus* L.)	Dr. M. Sujatha	44.84
Central Sector Project	Protection of Plant Varieties and Farmers Rights Authority	Dr. N. Mukta	8.00 (Annual)

MEETINGS AND EVENTS

Annual Group Meeting on Sunflower, Sesame and Niger

The Annual Group Meeting of Sunflower, Sesame and Niger was held at ANGRAU, Hyderabad during April 8-10, 2013. The meeting was attended by the scientists working under AICRP sunflower, sesame and niger, officials of central and state department of agriculture, public and private seed entrepreneurs and the host university. Dr. R. Sudhakara Rao, Director of Research, ANGRAU welcomed the gathering. The session was presided over by Dr. A. Padma Raju, Vice Chancellor, ANGRAU. Dr. K.S. Varaprasad, Project Director, DOR presented the research highlights of AICRP sunflower for the year 2012-13. He informed that Eastern India, particularly, West Bengal, Odisha and Bihar are the potential states for expanding sunflower area. He pointed out that with higher minimum support price, sunflower area may be on an increasing trend.

Dr. A.R.G. Ranganatha, Project Coordinator (Sesame & Niger), JNKVV, Jabalpur presented the research highlights of AICRP sesame and niger for 2012-13. He remarked that sesame has a potential because of its high market price. He also pointed that lines with low oxalic acid (<1%) content have been identified, which has high export potential. The chief guest, Dr. S. K. Datta, Deputy Director General (CS), ICAR, New Delhi in his speech expressed his concern about continuous decline in sunflower area and production and indicated that the barriers for achieving breakthrough in oilseeds production are suboptimal basic research, funding and manpower. He emphasized the need to characterize the production environment to identify best crop situation for crop cultivation. Dr. A. Padma Raju in his presidential remarks indicated that sunflower is suitable for different cropping systems due to its short duration. The competitive ability of sunflower with rainfed cotton, maize and chickpea can be increased only if the productivity is increased beyond 1.5 t/ha. He emphasized that niger is an important crop for high altitude tribal areas of Andhra Pradesh and the need for co-operative centers in tribal zones for niger and sesame.

Annual Group Meeting on Castor

The Annual Group Meeting on Castor was held at Agricultural Research Station, Swamy Keshwanand Rajasthan Agricultural University, Mandor, Rajasthan during May 16-18, 2013 to review the results of research conducted during 2012-13 and formulate the technical programmes of castor for the year 2013-14. The meeting was attended by the scientists working under AICRP (Castor), officials of central and state departments of agriculture, public and private seed entrepreneurs. The session was chaired by Dr. A.K. Dahama, Hon'ble Vice Chancellor, SKRAU, Bikaner. Dr. A.S. Faroda, former Chairman, ASRB, New Delhi was the chief guest. Dr. G.N. Parihar, Zonal Director Research ARS, Mandor welcomed the gathering and elaborated on important areas of research carried out by ARS, Mandor. Dr. Govind Singh, Director of Research, SKRAU, Bikaner highlighted importance of castor crop which has great commercial potential having high quantities of ricinoleic acid. Dr. K.S. Varaprasad, Project Director, DOR presented the research

highlights of AICRP Castor during 2012-13. He highlighted the growing importance of castor crop in Indian economy and stated that the productivity of castor crop in India is highest in the world and complimented the scientists for their contributions. Dr. Faroda highlighted the importance of the crop to the region in view of higher economic returns. He suggested to initiate the research to develop frost resistant hybrids and the technology for diversified uses of castor. He appealed to the scientists to work hard to reduce the input cost of the cultivation and improve the economic conditions of the marginal farmers growing this crop. Dr. Dahama in his remarks highlighted the need of developing short duration hybrids to fit the existing cropping system. While appreciating the ICAR in giving financial support to the AICRP castor center at Mandor, he also stressed the need of strengthening the castor research in Rajasthan through AICRP.

Institute Research Committee

IRC meeting was held from May 30 to June 1 and on June 19, 2013 under the chairmanship of Dr. K.S. Varaprasad, PD, DOR. Results of the 39 Institute projects and 9 externally funded projects were reviewed and technical programme for 2013-14 was finalised.

Quinquennial Review Team

Quinquennial Review Team (QRT) submitted the report for the period 2007-12 on 23rd May, 2013 to the DG, ICAR in the presence of DDG (CS). The recommendations made by the QRT under the Chairmanship of Dr. J.H. Kulkarni, Former Vice-Chancellor, UAS, Dharwad were based on visits to DOR, Hyderabad and various AICRP centres on Sunflower, safflower, castor, sesame, niger and linseed, critical review of presentations made by the scientists and discussions with Project Director, DOR and the Project Coordinators of Sesame & Niger and Linseed as well as with the scientists. The committee appreciated the excellent work done at DOR and many of the AICRP centres. However, they reported a wide gap in knowledge among scientists of DOR and AICRP centres which has reflected in the low and poor quality of research activities and publications by various centres. Effective co-ordination between the DOR/PC Units scientists and constant upgradation of the skills and knowledge of the staff at the centres were suggested. The QRT made a number of recommendations to improve the performance of DOR and the AICRP centres.

Annual Group Meeting on Safflower and Linseed

The Annual Group Meeting on Safflower and Linseed was held at Nimbkar Agricultural Research Institute, Phaltan, Maharashtra during August 29-31, 2013 to review the results of research conducted during 2012-13 and formulate the technical programmes of Safflower and Linseed for the year 2013-14. The meeting was attended by the scientists working under AICRP (Safflower and Linseed), officials of central and state department of agriculture, public and private seed entrepreneurs. Dr. A.K. Rajvanshi, Director, NARI welcomed the delegates and expressed his gratitude for ICAR in conducting the first AICRP group meeting at Phaltan. He informed the gathering about the importance of developing farm equipment for small holder farmers.

Dr. K.S. Varaprasad, PD, DOR presented the research highlights of safflower for 2012-13. He explained the reasons for the continuous decrease in area and production of safflower in India: low

seed replacement, non-availability of quality seed, yield gap/outreach of technologies and crop management vs. production environment interactions. He presented the discipline-wise highlights of the research achievements during 2012-13. Dr. Karam Hussain, Principal Scientist, AICRP (Linseed) presented the research highlights of linseed for 2012-13. He explained the reasons for decreasing area of linseed due to shifting of cropping pattern, shrinking of cultivable area due to indiscriminate urbanization and socio-economic compulsions. The Chief Guest, Dr. B.B. Singh, ADG (O&P) complimented NARI for holding the workshop and informed the gathering that India is importing oil worth ₹ 60,000 crores annually and is meeting only 45% of the oil demand domestically. He pointed out the concern of doubling the production of oilseeds from within the existing availability of land which is a great challenge to the oilseeds researchers across the country. In her chairperson's address, Dr. N. Nimbkar, President, NARI emphasized to learn lessons from other countries and other crops, which can be applied to safflower. She informed the gathering that in Nebraska, USA, safflower production steadily decreased due to decrease in yield of subsequent crops grown after safflower (Safflower roots being deeper enhanced soil erosion and soil water depletion) incidence of disease and insect pests and low seedling vigour. She reminded the success of system of rice intensification (SRI) and urged the scientists to explore the system of crop intensification

Research Advisory Committee

A new Research Advisory Committee consisting of Dr. E.A. Siddiq, Hon. Chair Professor, ANGRAU & Former DDG (CS), Hyderabad as Chairman was constituted from 2013-14. The other members are Dr. V. Muralidharan, Retd. Professor, TNAU, Coimbatore, Tamil Nadu; Dr. N. Seetharama, Ex-Director, DSR, New Delhi; Dr. S.P. Singh, Former Director, NBAII, Chandigarh (UT); Dr. H.S. Sen, Former Director, CRIJAF, Kolkata; Dr. R.B.N. Prasad, Chief Scientist & Head (LST), IICT, Hyderabad; Dr. M.N. Reddy, Ex-Director, MANAGE, Hyderabad; Sri Vishnupant Narayan Rao Mahale, Digraj Kd, Akola, Maharashtra; Dr. B.B. Singh, Asst. Director General (O&P), ICAR, New Delhi and Sri P. Gopal Reddy, East Kodipalli, Anantapur, AP. Dr. K.S. Varaprasad, PD, DOR, Hyderabad and Dr. G. Suresh, Principal Scientist, DOR, Hyderabad are as Ex-Officio Member and Member-Secretary, respectively. In the 27th meeting of RAC held on 28-29 May, 2014, Dr. K.S. Varaprasad, welcomed the Chairman and Members of RAC and made a presentation entitled "An Overview of Oilseed Scenario in India" and the new research initiatives undertaken by DOR during the year. It was followed by the presentation of action taken report on the recommendations of 26th RAC meeting by Member-Secretary. The scientists of the Directorate presented the status, targets and approaches of different research projects. The committee also visited different laboratories at DOR. The committee suggested action points as per the emerging issues.

Institute Management Committee

The 31st to 34th meetings of the Institute Management Committee were held on August 2, 2013; December 2, 2013; February 20, 2014 and April 10, 2014 under the Chairmanship of Dr. K.S. Varaprasad, PD, DOR, respectively. The Chairman welcomed the Management Committee Members and presented the research achievements of the Directorate for each quarter. The Member-Secretary apprised the committee about the action taken report on the proceedings of the preceding IMC meeting. The committee appreciated the work being carried out at the Directorate. The revenue generated and expenditure incurred in each quarter were also presented to the committee. The proposals on replacement of staff car, equipments listed in XII plan to be purchased in 2013-14 and 2014-15 and renovation of glass house were approved by the committee.

Visit of Shri Sharad Pawar, Hon'ble Union Minister for Agriculture and food processing industries, Govt. of India Directorate of Oilseeds Research (ICAR), Hyderabad.

Shri Sharad Pawarji, Hon'ble Minister for Agriculture and Food Processing Industries, Govt. of India, reviewed the status on each of the annual oilseed crops, palm oil and other secondary sources of vegetable oils on April 20, 2013. He expressed concern over the high import bill of over ₹50000 crores on vegetable oils. Dr K.S. Varaprasad, Project Director, DOR, presented an overview of oilseeds scenario in the country highlighting the status, achievements, problems and strategies for increasing oilseeds production, imports and exports and needed policy initiatives. Project Director, DOR highlighted the export of oilseed commodities to the tune of ₹24000 crores and the positive compound growth rates of oilseeds achieved in comparison to rice and wheat was commendable despite oilseeds cultivation under rainfed conditions by small and marginal farmers. The very high production growth rate achieved in cotton was acknowledged due to the *Bt* technology. The comfortable status of growth and expansion of soybean and castor; and the potential of oilpalm were convincing. The reasons for the declining area, especially of groundnut and sunflower despite increase in MSP were of serious concern. Shri Pawarji acknowledged the very high demand for vegetable oils due to the increase in population and increase in standard of living necessitating imports. The limitations for expansion of oilpalm in the country with the limitations of germplasm, planting material, long gestation period, supportive irrigation and infrastructure support, relatively higher production cost of domestic production for the crop were discussed. Soybean, groundnut, mustard and castor crops would provide major momentum of growth while oilpalm expansion is to be pursued with infrastructure backing. Shri Pawar also acknowledged the strength of biotechnological interventions for achieving quantum jump in oilseeds production in the country. Dr. S. Ayyappan, DG, ICAR indicated the high nutritive value of linseed while Dr. S.K. Datta, DDG (CS), ICAR discussed on the potential of tobacco seed oil. Mr. Atanu Purkayastha, Joint Secretary, TMOP indicated the enhanced role of technology mission on oilseeds considering various issues and prioritization for achieving self-sufficiency in vegetable oils. The Project Directors of Groundnut, Rapeseed-Mustard and Oilpalm participated in the meeting.

Visit of Shri Tariq Anwar, Hon'ble Minister of State for Agriculture and food processing industries, Govt. of India Directorate of Oilseeds Research (ICAR), Hyderabad.

Shri Tariq Anwarji, Hon'ble Minister of State for Agriculture and Food Processing Industries, Govt. of India, reviewed the status on each of the annual oilseed crops, palm oil and other secondary sources of vegetable oils July 8, 2013. Dr. K.S. Varaprasad, Project Director, DOR, presented an overview of oilseeds scenario in the country highlighting the status, achievements, problems and strategies for increasing oilseeds production, imports and exports and needed policy initiatives. Project Director, DOR highlighted the export of oilseed commodities to the tune of ₹24,000 crores and the positive compound growth rates of oilseeds achieved in comparison to rice and wheat was

commendable despite oilseeds cultivation under rainfed conditions by small and marginal farmers. Shri Tariq Anwar acknowledged the strength of biotechnological interventions for achieving quantum jump in oilseeds production in the country. On this occasion he also released two publications of DOR *viz.*, "Kusum" – *Utpadaan badaneke samagra sifarisay*" and Frontline Demonstrations Annual Report 2011-12.

Earlier, Hon'ble minister visited the Biotechnology, Pathology and other laboratories and was briefed by the scientists about the research activities, technologies developed and their extension to the farmers through frontline demonstrations and audio-visual aids by DOR in sunflower, safflower and castor crops. Shri Tariq Anwar expressed his happiness and said that DOR could continue to do the good research work and meet the challenges in the oilseed sector. Directors of the ICAR institutes located in Hyderabad and

Dr. A. Padma Raju, Vice-Chancellor, ANGRAU, Hyderabad have participated in the meeting.

Foundation Day Celebrations

The 36th Foundation Day of the Directorate was celebrated on August 1, 2013 at DOR, Hyderabad. Dr. A. Padma Raju, Hon'ble Vice-Chancellor, ANGRAU was the Chief Guest. Dr. M.V.Rao, Former Special Director General, ICAR and Ex.Vice-Chancellor, ANGRAU also graced the occasion. In his address, Dr. A. Padma Raju complimented the staff of Directorate for excellent progress and advised to find the technologies for increasing the production in rainfed situations. Dr. V. Chockalingam, Professor Emeritus, Dept. of Cardiology, Dr. MGR Medical University, Chennai delivered the lecture on "Healthy Heart for Hearty Health". In his presentation, he advised the staff to get rid of negative thinking and opined that positive mind, ideal eating and adequate exercise are the most important factors for maintaining healthy life. Seven staff members of the Directorate were awarded for their significant contribution in their respective field in 2012. Twenty nine staff were also felicitated in recognition of their 25 years of service at the Directorate. On this occasion, four digitalized CDs *viz.*, DOR Annual Reports and Annual Progress Reports of AICRP on Sunflower, Safflower and Castor of previous years were released. The afternoon session was chaired by Dr. E.A. Siddiq, former Dy. Director General (CS), ICAR in which Dr. A.K. Pradhan, Professor, Dept. of Genetics, Centre for Genetic Manipulation of Crop Plants, University of Delhi (South Campus), New Delhi delivered the Foundation Day lecture on "Breeding through Doubled Haploids : A Geneticist's View". The former Directors Dr. V. Ranga Rao, Dr. M.V.R.

Prasad and Dr. D.M.Hegde and retired staff members of DOR and representatives from local Institutes also graced the occasion.

Visit of Dr. R.S. Paroda to the Directorate

Dr. R.S. Paroda, Chairman, TAAS and former Director General, ICAR visited Directorate of Oilseeds Research on August 24, 2013. He visited the research farm at Narkhoda and discussed with the scientists on the various experiments conducted. He later interacted with all the scientists of the Directorate and the Directors from the other oilseed research institutes *viz*., DGR, DRMR, DSR and DOPR. He urged the scientists to work as a team and to cut across different institutions and disciplines with greater accountability keeping the national goal in view. He suggested that younger scientists should be encouraged.

HUMAN RESOURCE DEVELOPMENT

Trainings undergone by DOR personnel

Name	Programme	Venue	Date
Shri V. Sambasiva Rao	Database Management System	IASRI, New Delhi	April 8-12, 2013
Smt. Ch. V. Haripriya Shri B. Krishna Shri V. Sambasiva Rao	Competency Enhancement for Technical Officers	NAARM, Hyderabad	May 13-22, 2013
Dr. Mangesh Y. Dudhe	Managing IP under PVP	DSR, Hyderabad and PGR	May 15- 24, 2013
Dr. Md. A. Aziz Qureshi	Summer school on Soil Health Assessment Techniques	IARI, New Delhi	June 4 - 24, 2013
Dr. Mangesh Y. Dudhe	Advances in Statistical Genetics	IASRI, New Delhi	July 2 - 22, 2013
Mrs. B. Usha Kiran Dr. Sujatha, T.P.	Management Development programme on Biotechnology and Intellectual Property Rights	NAARM, Hyderabad	July 8 - 12, 2013
Mrs. B. Usha Kiran	Modern genomics for crop improvement	ICRISAT, Hyderabad	July 29 to August 9, 2013
Dr. H. Basappa Dr. M. Santhalakshmi Prasad	Pest Risk Analysis	NIPHM, Hyderabad	September 2-6, 2013
Dr. Jawaharlal Jatothu	Management of Plant Genetic Resources	NBPGR, New Delhi	September 16-25, 2013
Dr. M. Sujatha	Next generation sequencing	CCMB, Hyderabad	November 18-27, 2013
Dr. H. Basappa	Management Development Programme on Leadership Development	NAARM, Hyderabad	November 26 to December 7, 2013
Dr. Mangesh Y. Dudhe	Frontier Technologies in the Area of Biotechnology on Gene Isolation, Characterization and Breeding with reference to abiotic stress related genes	NRCPB, New Delhi	December 10-30, 2013
Mr. P. Ashok	Capacity Building Programme for Technical Personnel	IIPA, New Delhi	February 10-21, 2014
Dr. Sujatha, T.P.	Computational aspects for NGS Data Analysis: A Sojourn from Lab to Field	AAU, Gujarat	March 4-13, 2014

International Training

Name	Programme	Venue	Date
Dr. G.D. Satish Kumar	Media Design for Social Change	Centre for Development Innovation, Wageningen UR, Netherlands	May 27 to June 7, 2013

Participation in Conference / Seminars / Workshops / Meetings

Name	Programme	Venue	Date
Dr. R.D. Prasad Dr. M. Santhalakshmi Prasad Dr. K. Anjani	Annual Review Meeting of ICAR Outreach Project on "Phytofura"	CPRI, Shimla	April 9-11, 2013
Dr. M. Padmaiah Dr. G.D. Satish Kumar	Brainstorming session on Improving Research in Agricultural Extension:Issues and Way Forward	EEI, Hyderabad	April 26, 2013
Dr. I.Y.L.N. Murthy	Annual Group Meeting of AICRPDA	CRIDA, Hyderabad	June 12, 2013
Dr. I.Y.L.N. Murthy	Agri-Tech Investor's Meet	New Delhi	July 18-19, 2013
Dr. P.S. Srinivas	MDP Workshop on "PME"	NAARM, Hyderabad	June 18-22, 2013
Dr. S. Senthilvel Dr. Kadirvel Palchamy	Meet on Molecular Breeding	Tierra Seeds, Hyderabad	June 28, 2013
Dr. S.V. Ramana Rao Dr. P. Padmavathi Dr. P. Duraimurugan Mr. V. Sambasiva Rao	Agropedia 2.0: Capacity Building Workshop for New Partners	IASRI, New Delhi	July 15, 2013
Dr. G. Suresh	Zinc Day	ICRISAT, Hyderabad	August 1, 2013
Dr. Praduman	68th Annual Convention of Oil Technologists Association of India and International Conference on Emerging Trends in Oleochemicals & Lipids Expo - 2013	I ICT, Hyderabad	August 8-10, 2013
Dr. M. Santhalakshmi Prasad Dr. Md. A. Aziz Qureshi Dr. P. Duraimurugan	Awareness Building and Sensitization Workshop on National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA)	NAARM, Hyderabad	August 12-13, 2013

Name	Programme	Venue	Date
Dr. G. Suresh	Meeting on Standing Committee of Seed Producers	Commissioner & Director of Agriculture, Govt. of AP, Hyderabad	August 12, 2013
Dr. I.Y.L.N. Murthy	State level capacity building workshop on Economic Valuation of Bio Resources for Access and Benefit Sharing	Agro-Biodiversity Board, Hyderabad	August 22, 2013
Dr. M. Lakshmi-narayana	VIII Annual Review Meeting of ICAR Seed Project	New Delhi	August 26-27, 2013
Dr. M. Sujatha	South Asia Biosafety Conference	BCIL, New Delhi	September 18-20, 2013
Dr. I.Y.L.N. Murthy	Workshop for Appellate Authorities of RTI	ISTM, New Delhi	September 23, 2013
Dr. M. Sujatha	Tree Biotechnology 2013: Emerging Opportunities in Forestry and Tree Science	IFGTB, Coimbatore	September 23-24, 2013
Dr. K. Anjani Dr. N. Mukta	National Conference on Agro-biodiversity Management for Sustainable Rural Development	NAARM, Hyderabad	October 14-15, 2013
Dr. C. Sarada Dr. K. Alivelu	4th Installation training-cum-workshop of Nodal Officers of NAIP Project on "Strengthening Statistical Computing for NARS"	NAARM, Hyderabad	October 18-19, 2013
Dr. I.Y.L.N. Murthy	Raithu Mela	DRR, Hyderabad	October 20, 2013
Dr. Md. A. Aziz Qureshi	78th Annual Convention of Indian Society of Soil Science	CAZRI, Jodhpur	October 23-26, 2013
Dr. R.D. Prasad	Annual Review meeting of AMAAS Project	NBAIM, Mau	October 23-24, 2013
Dr. I.Y.L.N. Murthy	NBA and APSBD workshop	Hyderabad	October 24, 2013
Dr. S. Senthilvel	High performance computational facility for applications in Crop Genome Data analysis	NBPGR, New Delhi	October 23-25, 2013
Dr. I.Y.L.N. Murthy	NAIP workshop on e-Granth	ANGRAU, Hyderabad	October 25, 2013
Dr. S. V. Ramana Rao Mr. G. Raghunath Mr. V. Sambasiva Rao	KOHA Library Management Software		
Dr. M. Lakshminarayana	Plant Health Management for Food Security	DOR, Hyderabad	October 25-26 , 2013

Name	Programme	Venue	Date
Dr. I.Y.L.N. Murthy Dr. M. Padmaiah Dr. S.N. Sudhakara Babu Dr. G.D. Satish Kumar	World Agricultural Forum Congress & Agricultural Technical Trade Fair for re-shaping against for sustainable future focus on small holder	NIPHM, Hyderabad Hi-Tex, Hyderabad	October 28-31, 2013 November 4-7, 2013
Dr. R.D. Prasad	Consortium Advisory Committee meeting of the NAIP Project on "Study of the effect of abiotic stresses on the natural enemies of crop pests : *Trichogramma*, *Chrysoperla*, *Trichoderma* and *Pseudomonas*, and mechanism of tolerance to these stresses	NBAII, Bengaluru	November 8, 2013
Dr. Praduman	Advanced 'omics' techniques for improvement in plant and human health	IARI, New Delhi	November 15 to December 5, 2013
Dr. P. Duraimurugan	Fourth Biopesticide International Conference	CPRC, Palyamkottai, Tamilnadu	November 28-30, 2013
Dr. K. S. Varaprasad Dr. P. Giribabu	Nematodes: A friend and foe of Agri-Horticultural Crops	Solan, Himachal Pradesh	November 21-23, 2013
Dr. K. Anjani Dr. V. Dinesh Kumar	Safety Assessment of Genetically Modified Crops	ICRISAT, Hyderabad	November 23, 2013
Dr. V. Dinesh Kumar	NAIP National Training Workshop on Scientific Report Writing and Presentation	NAARM, Hyderabad	November 26-30, 2013
Dr. C. Sarada Dr. K. Alivelu	An Orientation to Data Management Platforms for Agricultural Research and Extension	ICRISAT, Hyderabad	December 5-6, 2013
Dr. I.Y.L.N. Murthy Dr. G. Suresh	Workshop on Ag. Balance	DRR, Hyderabad	December 9, 2013
Dr. I.Y.L.N. Murthy Dr. Md. A. Aziz Qureshi	Workshop on Balanced Fertilization in Crops with special reference to Potassium	ANGRAU, Hyderabad	December 16, 2013
Mr.G. Raghunath Mr.V. Sambasiva Rao	Emerging Technologies in Information Management'	S.V. Agricultural College, ANGRAU, Tirupati	January 4, 2014

Name	Programme	Venue	Date
Dr. S. Senthilvel Dr. Kadirvel Palchamy	Intensive Hindi Prabodh, Praveen and Pragya Training Course	Central Hindi Training Sub-Institute, Dept. of Official Language, Ministry of Home Affairs	January 6 to April 2, 2014
Dr. S.N. Sudhakara Babu Dr. V. Dinesh Kumar	Stakeholder Consultation Workshop on Performance Related Incentive Scheme for Promoting Basic Research	Administrative Staff College of India, Hyderabad	January 18-19, 2014
Dr. P.S.Vimala Devi	Emerging Trends in Eco-friendly Insect Pest Management	TNAU, Coimbatore	January 22-24, 2014
Dr. Md. A. Aziz Qureshi	Farmers Field School on "Integrated Nutrient Management for Sunflower"	Giddaluru Mandal, Prakasam Dt.	January 22-25, 2014
Dr. P. Duraimurugan	AICRP (AICSIP)	DOR, Hyderabad	January 23, 2014
Dr. I.Y.L.N. Murthy	Brainstorming Session on Soil Testing and Fertilizer Use	ANGRAU, Hyderabad	January 24, 2014
Dr. P. Duraimurugan	Agricultural and Horticultural Sciences (Agri-2014)	Hyderabad	February 3-5, 2014
Dr. K.S. Varaprasad Dr. I.Y.L.N. Murthy Dr. M. Padmaiah Dr. G. Suresh Dr. G.D. Satish Kumar Sri M. Bhaskara Reddy Sri B. Kistaiah	Krishi Vasant	CICR, Nagpur	February 8-13, 2014
Dr. R.D. Prasad Dr. S. Chander Rao Dr. V. Dinesh Kumar	NAIP Workshop on Cross Learning	DOR, Hyderabad	February 18, 2014
Dr. G. Suresh	SOYCON 2014 -International Soybean Research Conference	DSR, Indore	February 22-24, 2014
Dr. S.V. Ramana Rao Mr. G. Raghunath Mr. V. Sambasiva Rao	KOHA Professional Training	NAARM, Hyderabad	February 24-26, 2014
Dr. S. V. Ramana Rao	National Workshop on Sensitization on IPv 6	New Delhi	February 27, 2014
Dr. Mangesh Y Dudhe	DUS Annual Review Meeting	UAS, Dharwad	February 28 to March 1, 2014
Dr. S.N. Sudhakara Babu	National Workshop on Climate Change in Indian Agriculture	Vijayawada	March 1, 2014
Dr. M. Lakshmi-narayana	Breeder Seed Review Meeting	DAC, New Delhi	March 7, 2014

Name	Programme	Venue	Date
Dr. S.V. Ramana Rao	Final Workshop on ICAR as the Catalyzing Agent for Management of Change in the Indian NARS: Component -1	New Delhi	March 7-8, 2014
Dr. I.Y.L.N. Murthy Dr. M. Sujatha Dr. M. Padmaiah Dr. M. Lakshmi-narayana Dr. S.V. Ramana Rao Dr. G.D. Satish Kumar Dr. V. Dinesh Kumar	Orientation Workshop on National Mission on Oilseeds and Oil Palm	DOR, Hyderabad	March 13-14, 2014

PUBLICATIONS

Research Papers

Anjani, K. and Raoof, M.A. 2014. Analysis of mode of inheritance of Fusarium wilt resistance in castor (*Ricinus communis* L.). *Plant Breeding,* **133**: 101–107.

Anjani, K., Raoof, M.A. and Desai, A.G. 2014. Evaluation of world castor (*Ricinus communis* L.) germplasm for resistance to Fusarium wilt (*Fusarium oxysporum* f. sp. *ricini*). *European Journal of Plant Pathology,* DOI 10.1007/s10658-014-0413-x.

Archana, P., Jagan Mohan Reddy, M., Sreenivasa Rao, I. and Kumar, G.D.S. 2013. Constraint analysis of the farmers on climate variability in castor (*Ricinus communis* L.). *Journal of Oilseeds Research,* **30** (1):108-110.

Dinesh Kumar, V. and Nizampatnam, N.R. 2013. Rep-PCR identifies both inter- and intra-specific mitochondrial genome differences in *carthamus*. *Plant Molecular Biology Report,* **31**:1150–1156.

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Lavanya, C. and Varaprasad, K.S. 2012. Castor hybrids in India : A Success story. *Seed Times,* **5**(4): 111-117.

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Murthy, I.Y.L.N. and Mukta, N. 2013. Nutrient rich karanja (*Pongamia pinnata* L.) Pierre genotypes for diversified uses: An inventory. *Journal of Oilseeds Research,* **30**(1): 93-96.

Murthy, I.Y.L.N., Haripriya, Ch.V. and Padmavathi, P. 2013. Establishment of critical boron limits for castor (*Ricinus communis* L.) in red sandy loam soils with various boron extractants. *Indian Journal of Agricultural Sciences,* **83**(11): 1247-9.

Murthy, I.Y.L.N., Sudhakara Babu, S.N., Haripriya, Ch.V. and Bhaskara Reddy, M. 2013. Effect of calcium and boron on sunflower (*Helianthus annuus* L.) seed yield in Alfisols. *Journal of Oilseeds Research,* **30**(2):177-179.

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Presentations in Conference / Symposia

Name of the Scientist(s)	Title / Conference / Place / Date(s)
Anjani, K.	Conservation and sustainable use of native diversity in castor (*Ricinus communis* L.) in adapting to climate and anthropogenic changes: suggested measures" presented during National Conference on Agro-biodiversity Management for Sustainable Rural Development organized by NAARM, Hyderabad, 14-15 October, 2013.
Dinesh Kumar, V.	Invited lecture on "Genetic Purity Testing of Hybrids and GMO Testing " on 3-10-2013 at Secunderabad during the seminar on "Seed Quality" organized by Seedsmen Association.
Dinesh Kumar, V.	Invited lecture on "Molecular Genetics: Basic Concepts" and "Gene identification and Characterization in Crop Plants" on 07.01.14 and 21.01.2014 respectively to participants of the Winter School conducted by Directorate of Sorghum Research, Hyderabad held during 6-26, January 2014.
Dinesh Kumar, V.	Keynote lecture on "Genetic Engineering of Male Sterility and Fertility Restoration Systems" on 29.6.2013 during the UGC Sponsored National Seminar on "Transgenic Crops - Technology of the Millennium" held at Sri Y N College (A), Narsapur, Andhra Pradesh
Dinesh Kumar, V.	Lecture on "Transgenic Approaches in Development of Male sterility and Fertility Restoration System with Special Reference to Horticultural Crops" during one-day Interactive Meeting organized by Society for Promotion of Horticulture on "Male Sterility Systems in Horticultural Crops- Present Status and Future Strategies" at IIHR, Bengaluru on 24.01.2014
Dinesh Kumar, V.	"Genetic Purity Testing of Hybrids and GMO Testing " to the participants of the National Training programme on "Quality Seed Production" at Seed Technology Division of ANGRAU on 31.01.2014
Dinesh Kumar, V.	Lecture on "Genetic Purity Assessment of Hybrids" to participants of the National Training Programmes at ANGRAU, Hyderabad.
Duraimurugan, P., Srinivas, P.S.	Evaluation of pheromone trapping for monitoring of seasonal activity of Spodoptera litura in castor (Ricinus communis). In: Proceedings of 2nd International Conference on Agricultural & Horticultural Sciences, 03-05 February 2014, Hyderabad, India. pp. 239.
Giribabu, P.	Survey of plant parasitic nematode fauna associated with Castor (*Ricinus communis*) in selected districts of Andhra Pradesh (Poster presentation) In: National conference on "Nematodes - A Friend and Foe of Agri-Horticultural Crops," Y.S.Parmar University of Horticulture & Forestry, Solan, H.P. 21 - 23 November, 2013

Lakshminarayana, M.	'Integrated Pest Management in Oilseed Crops with special reference to castor' during the training programme on' Integrated Crop Management in Oilseeds' for Agricultural Extension Officers conducted by SAMETI, Malakpet, Hyderabad during February 10-14, 2014.
Lakshminarayana, M. Duraimurugan, P. and Vimala Devi, P.S.	Efficacy of microbial and botanical formulations for the management of lepidopteran pests infesting castor. In: Proceedings of Fourth Biopesticide International Conference, 28-30 November 2013, Crop Protection Research Centre, St. Xavier's College, Palayamkottai, Tamil Nadu. Pp. 248 -249.
Mangesh Dudhe, Y.	Invited lecture on "*In silico* development of microsatellite markers by using microsatellite identification tools available in public domain" during the National Symposium on Current Trends in Biotechnology held organized by Dept. of Botany, Osmania University, Hyderabad during December 7-8, 2013.
Murthy, I.Y.L.N. and Aziz Qureshi, Md. A.	Oral presentation on "Balanced fertilization in oilseed and pulse cops with special reference to potassium". Delivered during one-day workshop on Balanced fertilization in crops with special reference to potassium organized by International Institute of Potassium, Indian Potash Institute, ANGRAU, Hyderabad.
Satish Kumar, G.D.	Oral presentation on "Evaluation of mobile phone based agro-advisories on sunflower: Implications for scaling up" at the third International conference on "Extension Educational Strategies for Sustainable Agricultural Development – A Global Perspective" held at University of Agricultural Sciences, Bangalore from 05-08th December 2013. In: International Conference 2013-Abstracts. 217.
Satish Kumar, G.D.	Oral presentation on "Farmers Adaptability to Climate Change in Mahabubnagar district of Andhra Pradesh" by P. Archana, M. Jagan Mohan Reddy, I Sreenivasa Rao and G.D.S. Kumar at the third International conference on "Extension Educational Strategies for Sustainable Agricultural Development – A Global Perspective" held at University of Agricultural Sciences, Bengaluru from December 5-8, 2013. In: International Conference 2013-Abstracts. 312.
Satish Kumar, G.D.	Oral presentation on "A study on factors responsible for influencing farmers' adaptation to climate variability in castor" by M. Jagan Mohan Reddy, P. Archana, I Sreenivasa Rao and G.D.S. Kumar at the third International conference on "Extension Educational Strategies for Sustainable Agricultural Development – A Global Perspective" held at University of Agricultural Sciences, Bengaluru from December 5-8, 2013. In: International Conference 2013-Abstracts. 312-313.
Sujatha, M.	Lecture on Genetic diversity studies in Jatropha during the National Seminar on Tree Biotechnology 2013: Emerging Opportunities in Forestry and Tree Science organized by ICFRE at Coimbatore from 23-24 September 2013. Madhumita Dasgupta, Rekha R Warrier and R. Yashoda (Eds). pp. 115-117.
Sujatha, M.	Invited lecture on Advancements in Jatropha Biotechnology at the TSB 2013 and Jatropha Updates 2013 at Bangkok, Thailand from 16-19 October 2013.

Suresh, G.	Response of Oilseed crops to Zn. Paper presented during "ICRISAT-Sabanci University Zn Day" organized at ICRISAT, Patancheru 1st August, 2013.
Suresh, G., Sudhakara Babu, S.N. and Aziz Qureshi Md. A.	Performance of soybean-sunflower cropping system under varied nutrient management practices in Vertisols. In: Mitigating productivity constraints in soybean for sustainable agriculture. Proceedings of SOYCON 2014: International Soybean Research Conference. Society for Soybean Research and Development, Directorate of Soybean Research, Indore (India) held during February 22-24, 2014. Pp.173
Varaprasad, K.S.	A presentation on Bio-diversity Act to the students of Acharya Nagarjuna University, Guntur on 15.11.2013.
Varaprasad, K.S. and Giribabu, P.	Emerging nematode pest challenges in vegetable oilseeds production in India (Lead talk) In: National conference on "Nematodes - A Friend and Foe of Agri-Horticultural Crops," Y.S.Parmar University of Horticulture & Forestry, Solan, H.P. 21-23 November, 2013
Vimala Devi, P.S.	Microbial Pesticides: R & D to Commercialization" at the National Symposium on "Emerging Trends in Eco-friendly Insect Pest Management" (22-24 January, 2014) at TNAU, Coimbatore, Tamil Nadu, India

INFRASTRUCTURE DEVELOPMENT

Library and documentation

An amount of ₹ 15,05,246 lakhs has been spent to acquire books, periodicals, database and subscription for scientific journals. A total of 153 publications were received *on gratis*, besides newsletters and annual reports from different ICAR institutes. New records of books were added to the computerized library catalogue database. A total of 8500 records was imported in KOHA (Integrated Library Management) Software and patron list prepared for DOR. Current oilseeds literature alerts and online article delivering systems are being issued fortnightly to all the scientists of DOR. DOR newsletters were circulated to all scientists working at DOR and AICRP (Sunflower, Safflower and Castor) centres and other organizations dealing with oilseeds across the country. An amount of ₹ 6550/- was generated through the sale of 91 DOR publications. Literature search service to the students and researchers was provided with the help of in-house database, crop science database, AGRIS and AGRICOLA. A total of 156 requests received for document delivery services from State Agricultural Universities and other institutions were attended.

Development of a field screening facility for gray rot of castor

A field poly house (500 sq.m) facility for creating artificial epiphytotics of gray rot has been developed with temperature and humidity controls paving the way for identification of gray rot resistant lines of castor and their utilization in breeding programmes.

Other Civil Works

- The architectural drawings of Master Plan / Lay out Plan of the campus have been prepared, showing existing building complex, 12th Plan proposals as well as future requirements.
- Existing lower capacity H.T transformer has been replaced with 315 KVA transformer to cope up with the enhanced demand of power supply.
- Renovation of flooring in the committee room has been carried out.
- Renovation works has been taken up in Soil Science Laboratory.
- The agronomy lab has been renovated and modified as per the requirement of Biotechnology lab.
- Renovation of Museum has been taken up for enhanced showcasing of exhibits / information.
- Store room for castor breeding unit at Narkhoda farm has been constructed for providing additional storage facility.
- The repairs and maintenance of DOR residential quarters have been carried out.
- The colouring and painting of 10 rooms in ground floor of Jyothi hostel has been carried out as a part of periodical maintenance and better ambience to the hostellers.
- The colouring & painting including minor repairs of scooter / vehicle / store sheds, etc., has been taken up as a part of periodical maintenance.

हिन्दी गतिविधियाँ

हिन्दी पखवाडा समारोह

निदेशालय में 01&14 सितंबर, 2013 तक हिन्दी पखवाडा मनाया गया. इसका समापन समारोह 13 सितंबर, 2013 को आयोजित किया गया. इस पखवाडे के दौरान विभिन्न प्रतियोगिताओं का आयोजन किया गया. जिनमें वैज्ञानिक, अधिकारी व कर्मचारियों ने उत्साह से भाग लिया. पखवाडे के दौरान एक कार्यशाला का आयोजन भी किया गया.जिसमें श्रीमती नरेशबाला, सहा. निदेशक (राजभाषा) हिन्दी शिक्षण योजना ने हिन्दी के व्याकरण तथा आलेखन टिप्पण पर कक्षा चलाई.

पखवाडे का समापन समारोह डॉ. के. एस. वरप्रसाद, परियोजना निदेशक की अध्यक्षता में हुआ. कार्यक्रम का आरंभ श्री प्रदीप सिंह, सहा. निदेशक (राजभाषा) के स्वागत एवं मुख्य अतिथि परिचय से हुआ. इसक पश्चात प्रभारी राजभाषा डॉ. एन. मुक्ता ने राजभाषा की प्रमुख गतिविधियों पर प्रकाश डाला. इसके बाद प्रोत्साहन योजना के अंतर्गत वर्ष 2012 -13 के दौरान हिन्दी में कार्यालयीन कार्य करने वाले अधिकारी व कर्मचारियों को नगद पुरस्कार मुख्य अतिथि डॉ.घनश्याम, रीडर, बी.जे.आर. कॉलेज, हैदराबाद द्वारा वितरित किए गये. इसी क्रम में पखवाडे के दौरान आयोजित विभिन्न प्रतियोगिताओं के विजेताओं में पुरस्कारों का वितरण किया गया. डॉ.आई.वाई.एल.एन. मूर्ति प्रधान वैज्ञानिक ने प्रोत्साहन पुरस्कार वितरित किए.

अपने मुख्य अतिथि संबोधन में डॉ.घनश्यामजी ने भाषा और संस्कृति के बारे में बताते हुए कहा कि भाषा के बिना संस्कृति को जीवित रखना मुश्किल है. आज हिन्दी ही नहीं सभी भारतीय भाषाओं का अस्तित्व खतरे में है. पाश्चात्य संस्कृति का अंधा अनुकरण कर आज की युवा पीढी धीरे-धीरे भाषा और संस्कृति दोनों से ही दूर होती जा रही है.

अपने अध्यक्षीय संबोधन में डॉ. के.एस. वरप्रसाद, परियोजना निदेशक ने हिन्दी से जुडे अपने अनुभवों से सभा को अवगत कराया. प्रारंभ में केवल वे ही फाइलों में टिप्पणी हिन्दी में करते थे. इनसे प्रेरित हो कुछ अन्य वैज्ञानिक, अधिकारी व कर्मचारी भी फाइलों में हिन्दी में आलेखन टिप्पण कर रहे हैं.

डॉ. एच. बसप्पा, प्रधान वैज्ञानिक के धन्यवाद ज्ञापन से कार्यक्रम का समापन हुआ.

राजभाषा कार्यशाला

निदेशालय में वर्ष के दौरान चार कार्यशालाओं का आयोजन किया गया. यह कार्यशालाएं 20/6/2013, 11/9/2013, 21/12/2013 तथा 22/3/2014 को आयोजित की गयी. इन कार्यशालाओं में संस्थान के सभी कर्मचारियों ने भाग लिया.

तिलहन अनुसंधान निदेशालय राजभाषा पुरस्कार से सम्मानित

नगर राजभाषा कार्यान्वयन समिति, केन्द्र सरकार के कार्यालय, हैदराबाद की 49 वीं बैठक क्रीडा के निदेशक तथा समिति के अध्यक्ष डॉ. बी. वेंकटेश्वर्लु की अध्यक्षता में केंद्रीय युनानी चिकित्सा अनुसंधान संस्थान, हैदराबाद में आयोजित की गयी इस बैठक में केंद्र सरकार के कार्यालयों के 175 से भी अधिक प्रतिनिधियों ने भाग लिया.

तिलहन अनुसंधान निदेशालय को हैदराबाद स्थित केंद्रीय कार्यालयों में जनवरी-जून, 2013 के दौरान संघ की राजभाषा

नीति के कार्यान्वयन में सर्वोत्तम निष्पादन हेतु वैज्ञानिक अनुसंधान एवं विकास संगठनों की श्रेणी में तृतीय पुरस्कार स्वरूप शील्ड प्रदान की गयी. इसे निदेशालय के प्रभारी निदेशक डॉ. आई वाई एल एन. मूर्ति एवं सहा. निदेशक, राजभाषा, श्री. प्रदीप सिंह ने प्राप्त किया.

नराकास की ओर से शब्द स्मृति ज्ञान प्रतियोगिता का आयोजन

निदेशालय में 18 दिसंबर, 2013 को नगर राजभाषा कार्यान्वयन समिति, केंद्र सरकार की ओर से केंद्र सरकार के कर्मचारियों हेतु शब्द स्मृति ज्ञान प्रतियोगिता का आयोजन किया गया. प्रतियोगिता डॉ. आई वाई एल एन. मूर्ति, प्रभारी निदेशक के नेतृत्व में आयोजित की गयी. प्रतियोगिता का शुभारंभ सचिव, नराकास के स्वागत भाषण से हुआ. डॉ. मूर्ति ने अपने भाषण में इस तरह की प्रतियोगिताओं के आयोजन पर प्रकाश डालते हुए कर्मचारियों से अधिक संख्या में भाग लेने का आग्रह किया. इस प्रतियोगिता में केंद्रीय सरकारी कार्यालयों के अधिकारी/कर्मचारियों ने उत्साह से भाग लिया. श्री प्रदीप सिंह, सहा. निदेशक, राजभाषा, ने इस प्रतियोगिता के आयोजन का अवसर प्रदान करने हेतु सचिव, नराकास तथा हैदराबाद स्थित विभिन्न कार्यालयों से आए प्रतिभागियों को धन्यवाद दिया.

VISITORS

Visitor	Designation/Institute/Place	Date
Shri Sharad Pawar	Honourable Minister for Agriculture and Food Processing Industries, GOI	20.04.2013
Dr. A.K. Vasist	ADG (PIM), ICAR, New Delhi	29.06.2013
Shri Devendra Kumar	Director (Finance), ICAR, New Delhi	29.06.2013
Shri Tariq Anwar	Honourable Minister of State for Agriculture and Food Processing Industries, GOI	08.07.2013
Dr. R.S. Paroda	Chairman, TAAS & Former Director General, ICAR, New Delhi	24.08.2013

During the year under report, about 1475 visitors including farmers from various states like Chhatishgarh, Karnataka, Tamil Nadu, Andhra Pradesh, agricultural students from various Agricultural Universities across country, delegates of other countries, trainee participants and school children.

APPOINTMENTS / PROMOTIONS / TRANSFERS / RETIREMENTS

Promotions

Name	Post held	Promoted to post	Date of promotion
Dr. Ch. Sarada	Senior Scientist	Principal Scientist	December 6, 2012
Shri N. Prabhakara Rao	Asst. Chief Technical Officer	Chief Technical Officer T-9	January 5, 2012
Shri G. Srinivas Yadav	Junior Stenographer	Personal Assistant Grade II	October 26, 2013
Shri P. Srinivas	Temporary Status Labour	Skilled Support Staff	March 12, 2014
Shri Pradeep Singh	AD (OL)	Second financial up- gradation under MACP	September 11, 2008

Superannuation

Name	Post held	Date of Retirement
Shri B. Sambaiah	Sr. Technical Assistant T-4	July 31, 2013
Shri B. Rajarathnam	Technical Officer T-5	February 28, 2014

Voluntary Retirement

Name	Post held	Date of Retirement
Shri B. Hari Kumar	Personal Assistant	July 1, 2013 (FN)

Demise

Name	Post held	Date of Retirement
Shri J. Maheshwar	Skilled Support Staff	14.04.2013
Shri C.V.L. Narayana	Technical Assistant	03.11.2013
Shri V. Ram Mohan	Technical Assistant	09.03.2014

PERSONNEL

(as on March 31, 2014)

Dr. K.S. Varaprasad Project Director

Project Director's Cell

Dr. D. Pati	T-9 (Chief Technical Officer)
Mr. G. Chandraiah	Personal Secretary
Mr. P. Srinivasa Rao	Personal Assistant

Research Sections

Crop Improvement

Dr. M. Sujatha	Head & Pr. Scientist (Gen. & Cyto.)
Dr. K. Anjani	Pr. Scientist (Pl. Breeding)
Dr. A.J. Prabakaran	Pr. Scientist (Pl. Breeding)
Dr. V. Dinesh Kumar	Pr. Scientist (Biotechnology)
Dr. N. Mukta	Pr. Scientist (Eco. Botany)
Dr. C. Lavanya	Pr. Scientist (Pl. Breeding)
Dr. N.V.P.R. Ganga Rao	Sr. Scientist (Pl. Breeding) (deputation with ICRISAT)
Dr. Senthilvel Senapathy	Sr. Scientist (Pl. Breeding)
Dr. Kadirvel Palchamy	Sr. Scientist (Genetics)
Mr. H.H. Kumaraswamy	Scientist (Biotechnology) (on study leave)
Dr. Mangesh Y. Dudhe	Scientist (Pl. Breeding)
Mrs. B. Usha Kiran	Scientist (Biotechnology)
Dr. Hari Prakash Meena	Scientist (Pl. Breeding)
Dr. Sujatha, T.P.	Scientist (Biotechnology)
Dr. Jawaharlal Jatothu	Scientist (Pl. Breeding)
Mr. G. Balakishan	T-7-8 (Assistant Chief Technical officer)
Mr. K. Sayendra	T-5 (Technical Officer) (F/F)
Mr. P. Gopinathan	T-5 (Technical Officer) (F/F)
Mr. N. Veeraiah	T-5 (Technical Officer) (F/F)
Mr. D. Mallesh	T-4 (Sr. Technical Assistant) (F/F)
Mr. P. Sunil Kumar	T-4 (Sr. Technical Assistant) (Lab Tech.)
Mr. G. Srinivasa Rao	T-3 (Technical Assistant) (F/F)
Mr. S. Jagadishwar	T-3 (Technical Assistant) (F/F)

Crop Production

Dr. I.Y.L.N. Murthy	Head & Pr. Scientist (Ag. Chemistry)
Dr. S.N. Sudhakara Babu	Pr. Scientist (Agronomy)
Dr. G. Suresh	Pr. Scientist (Agronomy)
Dr. P. Lakshmamma	Pr. Scientist (Pl. Physiology)
Dr. Lakshmi Prayaga	Pr. Scientist (Pl. Physiology)
Dr. P. Padmavathi	Sr. Scientist (Agronomy)
Dr. Md. A. Aziz Qureshi	Sr. Scientist (Soil Science)
Dr. Praduman	Scientist (Biochemistry)
Mrs. Ch.V. Haripriya	T-6 (Senior Technical Officer)
Mr. P. Ashok	T-4 (Sr. Technical Assistant) (F/F)
Mr. L. Krupakar	T-4 (Sr. Technical Assistant) (F/F)
Mr. S. Narasimha	T-4 (Sr. Technical Assistant) Lab. Tech.)

Crop Protection

Dr. P.S. Vimala Devi	Pr. Scientist (Ag. Entomology)
Dr. H. Basappa	Pr. Scientist (Ag. Entomology)
Dr. R. Durga Prasad	Pr. Scientist (Pl. Pathology)
Dr. M. Lakshminarayana	Pr. Scientist (Ag. Entomology)
Dr. S. Chander Rao	Pr Scientist (Pl. Pathology)
Dr. M. Santhalakshmi Prasad	Pr. Scientist (Pl. Pathology)
Dr. P.S. Srinivas	Sr. Scientist (Ag. Entomology)
Dr. P. Duraimurugan	Sr. Scientist (Ag. Entomology)
Dr. P. Giribabu	Scientist (Nematology)
Mr. G. Keshauloo	T-5 (Technical Officer)
Mr. Shaik Shoukat Ali	T-4 (Sr. Technical Assistant) (Lab. Tech.)
Mr. J. Balram	T-2 (Sr. Technician) (F/F)
Mr. Ch. Anjaiah	T-1 (Technician) (F/F)
Mr. S. Saida Reddy	T-1 (Technician) (Lab. Asstt.)

Social Sciences

Dr. M. Padmaiah	Head & Pr. Scientist (Ag. Extension)
Dr. S.V. Ramana Rao	Pr. Scientist (Ag. Economics)
Dr. Ch. Sarada	Pr. Scientist (Ag. Statistics)
Dr. G.D. Satish Kumar	Sr. Scientist (Ag. Extension)
Dr. K. Alivelu	Sr. Scientist (Ag. Statistics)
Mrs. P. Madhuri	Scientist (SS) (Comp. Applications)
Mr. B. Krishna	T-6 (Senior Technical Officer)
Mr. B. Kistaiah	T-5 (Technical Officer)

Support Services

AKMU Cell

Mr. P. Srinivasa Rao	T-5 (Technical Officer)

Technical Coordination Cell

Mrs. R. Raji	Personal Assistant
Mr. G. Srinivas Yadav	Personal Assistant

Library and Documentation

Mr. G. Raghunath	T-6 (Senior Technical Officer)
Mr. V. Sambasiva Rao	T-6 (Senior Technical Officer)

Art & Photography

Mr. B.V. Rao	T-6 (Senior Technical Officer)
Mr. B.V. Noble	T-4 (Senior Technical Assistant)

Farm Section

Mr. N. Prabhakara Rao	T- 9 (Chief Technical Officer)
Mr. M. Bhaskara Reddy	T-7-8 (Assistant Chief Technical Officer)
Mr. Y. Ramagovinda Reddy	T-6 (Senior Technical Officer)
Mr. M. Panduranga Rao	T-5 (Technical Officer)
Mr. G.Y. Prabhakar	T-4 (Senior Technical Assistant)
Mr. T. Veeraiah	T-3 (Technical Assistant)
Mr. Surender Prasad	T-4 (Senior Technical Assistant)
Mr. V. Sharath Babu	T-3 (Technical Assistant)
Mr. A. Srinivasa Raju	T-3 (Technical Assistant)
Mr. N. Vasanth	T-3 (Technical Assistant)
Mr. K. Srinivas	T-3 (Technical Assistant)
Mr. M. Indrasena Reddy	T-3 (Driver)
Mr. Y. Venkateshwara Rao	T-3 (Tractor Driver)
Mr. B. Giri	UDC

Seed Section

Mr. M. Ramulu	T-5 (Technical Officer)
Mr. T. Veeraiah	T-4 (F/F)

Administration

Mr. Anil Behari	Senior Administrative Officer
Mr. Pradeep Singh	Assistant Director (OL)
Mr. S. Shamdas	Assistant Administrative Officer
Dr. G. Annapurna	T-5 (Technical Officer)
Ms. J. Vijayalakshmi	Assistant
Mrs. G. Kalavathi	Assistant
Mrs. R.A. Nalini	Assistant
Mrs. C. Lalitha	Personal Assistant
Mr. P.R.Varaprasada Rao	Assistant
Mr. T. Bitchanna	UDC
Mr. C. Prabhudas	Duplicating Machine Operator

Stores

Mr. G. Srinivasa Rao	Assistant
Mrs. S. Swaroopa Rani	Assistant
Mr. G. Rakesh	Assistant
Mrs. V. Kalpana	UDC

Audit & Accounts

Mr. H. Ganesha	Finance & Accounts Officer
Mr. A. Prem Kumar	Junior Accounts Officer
Mr. E.V.R.K.N. Prasad	Assistant
Mr. G.B.N. Prasad	UDC
Mrs. B. Gyaneshwari	UDC

Drivers

Mr. V.Y. Swamy	T-3 (Technical Assistant) (Driver)
Mr. G. Ramulu	T-3 (Technical Assistant) (Driver)
Mr. G. Parthasaradhi	T-3 (Technical Assistant) (Driver)
Mr. E. Ravi Kumar	T-2 (Technical Assistant) (Driver)

Skilled Supporting Service

Mr. G. Rajamouli	Skilled Supporting Staff (Beldar)
Mr. G. Yadaiah	Skilled Supporting Staff (Beldar)
Mr. G. Mallesh	Skilled Supporting Staff (Peon)
Mr. D. Narsimha	Skilled Supporting Staff (Cleaner)
Mr. K. Ramulu	Skilled Supporting Staff (Farash)
Mr. M. Venkatesh	Skilled Supporting Staff (Peon)
Mr. A. Rambabu	Skilled Supporting Staff (Peon)
Mr. M. Ramulu	Skilled Supporting Staff (Mali)
Mr. P. Krishna	Skilled Supporting Staff (Peon)
Mr. D. Balaiah	Skilled Supporting Staff (Beldar)
Mr. B. Narsimha	Skilled Supporting Staff (Mali)
Mrs. P. Mary	Skilled Supporting Staff (Beldar)
Mrs. M.H. Elizabeth	Skilled Supporting Staff (Beldar)
Mrs. P. Narsamma	Skilled Supporting Staff (Beldar)
Mrs. B. Kistamma	Skilled Supporting Staff (Beldar)
Mr. K. Sanjeeva	Skilled Supporting Staff (Beldar)
Mr. Ch. Balaiah	Skilled Supporting Staff (Beldar)
Mr. J. Narsimha	Skilled Supporting Staff (Beldar)
Mr. B. Vishnu	Skilled Supporting Staff (Cattleman)
Mrs. G. Bharathamma	Skilled Supporting Staff (Beldar)
Mr. Narasimha	Skilled Supporting Staff
Mr. B. Gyaneshwar	Skilled Supporting Staff
Mr. P. Srinivas	Skilled Supporting Staff

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