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वार्षिक प्रतिवेदन
Annual Report
2014-15

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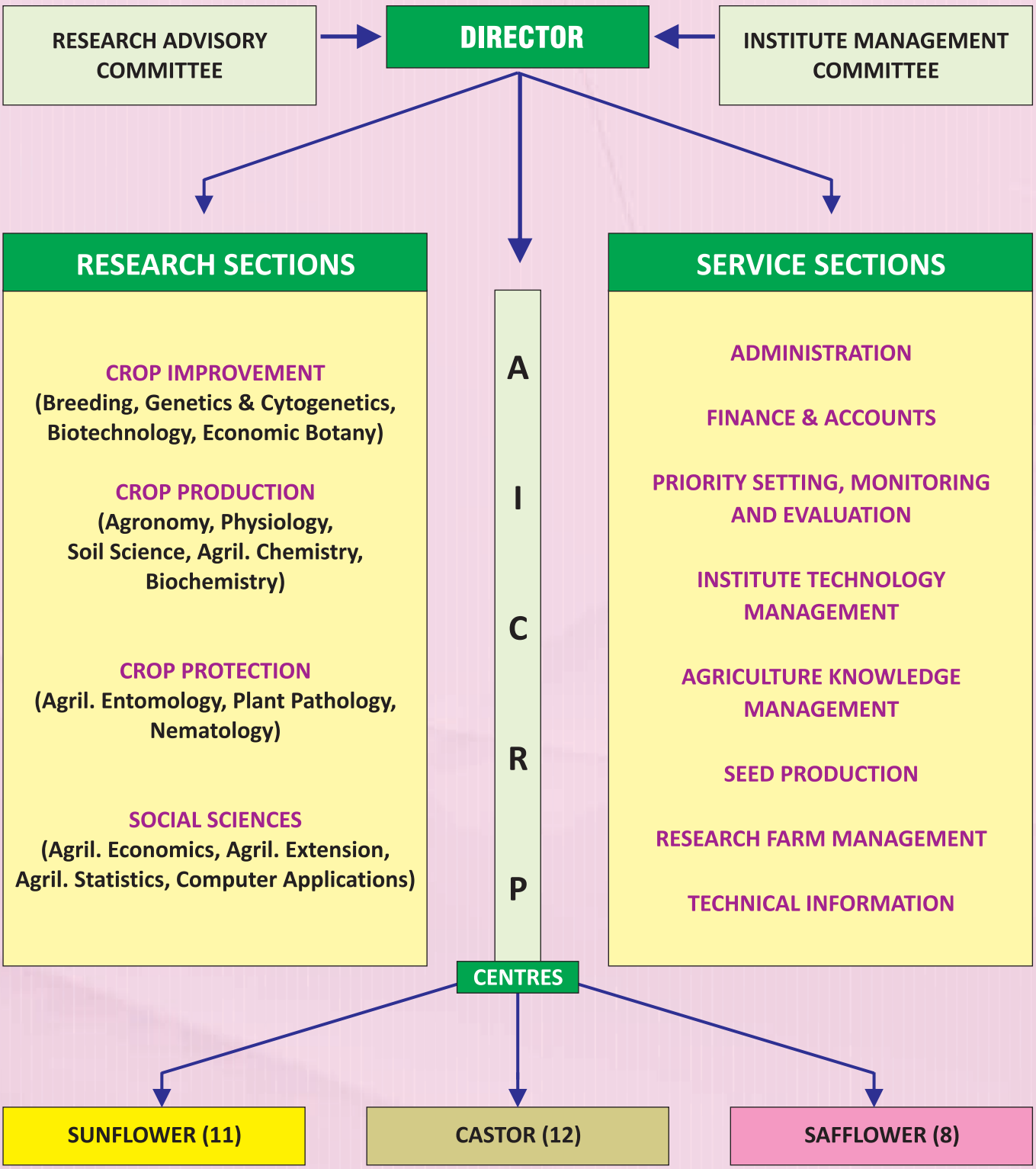
भातिअसं
IIOR

भाकृअनुप–भारतीय तिलहन अनुसंधान संस्थान
ICAR-Indian Institute of Oilseeds Research

राजेंद्रनगर, हैदराबाद/ Rajendranagar, Hyderabad-500 030

Organogram

ICAR-INDIAN INSTITUTE OF OILSEEDS RESEARCH



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ICAR-IIOR Annual Report

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PREFACE

It gives me immense pleasure in presenting the Annual Report 2014-15, highlighting the significant research achievements and activities of Indian Institute of Oilseeds Research (formerly Directorate of Oilseeds Research). The salient achievements in All India Coordinated Research Project on Castor, Sunflower and Safflower as well as other activities of the Institute are also documented in this report. It is noteworthy to mention that the Institute has been certified as ISO 9001: 2008 organisation.

During the period under report, new initiatives have been taken up which include, finalisation of programme for sunflower area expansion in West Bengal in association with Sundarban Development Board, identification of collaborative areas through an interactive meeting on networking oilseed Institutes, enhancement of collaboration with DAC by organizing National Seminar on "Strategies for Enhancing Oilseeds Production through NMOOP", facilitated transfer of male sterile system technology and material developed by IIOR to CRIJAF, Berrackpore.

Some of the significant research highlights for the year 2014-15 are: Release and recommendation of one hybrid (NARI- H-23) and one variety (NARI-57) in safflower for the states of Maharashtra, Karnataka, Madhya Pradesh and West Bengal; registered a Macrophomina resistant castor germplasm selection; RG-2822 (IC0346626) and GMU 4983/IC 13884 were registered with PGRC, New Delhi for resistance to Fusarium wilt in safflower; validation of A 5K SNP genotyping array (Illumina) for castor for its technical performance by genotyping 318 diverse castor accessions, seed treatment with *T. harzianum* Th4d and *Pseudomonas fluorescens* Pf2 recorded significantly less wilt disease incidence in castor and standardisation of a reliable new screening method for aphid resistance through artificial releases.

I place on record my sincere gratitude to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR for upgrading the Directorate to Institute; Dr. S.K. Datta, former Deputy Director General (CS) and Dr. J.S. Sandhu, DDG (CS); Dr. B.B. Singh, Assistant Director General (OP), ICAR for their unstinted guidance and support in executing the mandate of the Institute. I also express my gratefulness to the Chairman and all the members of the Research Advisory Committee 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 Institute for their efforts and cooperation in bringing out the publication.The contribution of Sri P. Srinivasa Rao, PA for editorial assistance, proof reading and final page setting is acknowledged.

(K.S. VARAPRASAD)
Director

IIOR, Hyderabad
June 29, 2015

CONTENTS

IIOR

वार्षिक प्रतिवेदन

Annual Report

2014-15

Executive Summary

EXECUTIVE SUMMARY

The salient findings of the research activities executed during 2014-15 at the Indian Institute of Oilseeds Research are presented crop wise.

CASTOR

Thirty two accessions possessing various agronomically important traits were augmented in germplasm unit from the explorations made in the Chhindwara region of Madhya Pradesh and Warud region of Maharashtra. One hundred and eighty new accessions collected from Rajasthan and Gujarat (S.K. Nagar) during 2013-14 were characterized and passport information, morphological descriptors and data on quantitative traits were generated. Three accessions RG-3832, RG-3839 and RG-3831 recorded high test weight (50-52 g) when compared to the check GCH-7 (31 g). Likewise, the seed yield recorded in RG-3850, RG-3880, RG-3938 and RG-3860 was 11% more than the check GCH-7 (3074 g/5.4 sq.m.). Total drymatter at harvest was more in RG-2797, RG-1437 but seed yield and harvest index were significantly higher in RG-298 and RG-1826 indicating better performance of these genotypes in rainfed conditions. Three hundred castor genotypes evaluated for ricinoleic acid content showed maximum ricinoleic acid content in RG-3728 (91.31%) and minimum in RG-2787 (79.12%). DUS testing of two hybrids and four inbred parental lines were conducted. The selection RG-226 contains 92% ricinoleic acid while the six leading cultivars contain 86-88%. Wilt and leaf hopper resistant cultivars were identified and their diversity was studied based on morphological traits. The germplasm RG-2822 (IC-0346626; INGRI-4028) was registered as resistant germplasm for *Macrophomina* root rot by Plant Germplasm Registration Committee.

The pedigree method of selection in the segregating generations for development of diverse male combiners was continued. One male line, DCS-121 (PVT-II-12-2), was high yielder (146 g/plant) and it also exhibited physiological superiority in terms of TDM (439.7 g/plant) and HI (33.3%) when compared to the check, DCS-9. Fourteen selections from 12 different crosses involving diverse male lines were found promising for yield components. Eleven advanced lines of less and high branching types with long primary spikes were multiplied for evaluation in rice fallows. Pedigree method of selection continued in 11 crosses from BCF_8 to BCF_{11} exhibiting uniform pistillate expression in majority of the plant progenies.

Two hybrids ICH-66 and ICH-68 were found superior over the check under common evaluation hybrid trial at Anand (Irrigated) and IIOR (Rainfed) and are being evaluated under Initial Hybrid Trial of AICRP (Castor) during 2014-2015. In a common evaluation hybrid trial, CEH-137 (73%) and CEH-216 (69%) with significant increase over the best check, GCH-7 (2818 kg/ha) under irrigated conditions at Anand; and five high yielding hybrids *viz.*, CEH-193 (57%), CEH-192 (52%), CEH-185 (26%), CEH-152 (26%) and CEH-172 (22%) under rainfed conditions, compared to DCH-177 (1099 kg/ha) were found promising.

A 5K SNP genotyping array (Illumina) for castor was validated for its technical performance by genotyping 318 diverse castor accessions. A total of 4,098 high quality SNPs were called with a call rate that ranged from 80 to 100 per cent with an average of 98 per cent and reproducibility of 100 per cent across biological and technical replicates. Three castor mapping populations of over 200 recombinant inbred lines (RIL) segregating for resistance to gray mold, Fusarium wilt and reniform nematode were developed. The castor association mapping panel (over 300 genotypes consisting of the core sub-set, trait specific germplasm, elite inbreds, released varieties and parental lines of hybrids) was evaluated for Fusarium wilt resistance and other agronomic traits.

In the seed imbibition method of transformation, highest GUS expression (94%) was found 10 days after co-cultivation when 2-day-old germinating seedlings were injured at the embryonic axis region with needle

and cocultivated for 1 h with 1.0 OD bacterial titer containing 200 μM acetosyringone. A modified *in planta* transformation method using different gene constructs for incorporating grey mold resistance was carried out with 1550 seedlings of castor cultivar, 48-1 and T_1 seeds from 470 T_0 plants harvested. GUS analysis indicated a few positive T_1 plants.

For studies on deciphering the molecular mechanisms of induced systemic resistance by Trichoderma, presence of Trichoderma as colony forming units within the roots of castor after 75 days post inoculation demonstrated longer association of Th4d strain with the castor variety DCS-107. Induced systemic resistance (ISR) effected by Th4d strain was confirmed using standard enzyme assays such as peroxidase and phenylalanine ammonia lyase, RT-PCR with selected signature genes of ISR, and disease bioassays. Transcriptome studies carried out with different time points and the genes differentially expressed due to ISR identified. Pot experiments confirmed the ameliorative effect of Trichoderma (Th4d) towards resistance of JI-35 genotype against *Fusarium* infection.

Application of FYM along with 100% NPK recorded highest seed yield of sorghum (3501 kg/ha) and castor (361 kg/ha) compared to either N alone or NP or without FYM. The performance of drip irrigated *rabi* castor 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. The significantly highest seed yield was recorded in DCH-519 (2921 kg/ha) which out yielded all other genotypes tried.

Two castor cultivars GCH-4 and GCH 7 were resistant to *Phytophthora* leaf blight with less than 10% disease severity over two consecutive years. For artificial inoculation of wilt disease, 4 g of sorghum inoculum per kg soil was found to be ideal as the concentration caused 100% mortality in susceptible variety, JI-35. Seed treatment with *Trichoderma* isolate *T. harzianum* Th4d and *Pseudomonas fluorescens* Pf2 recorded significantly less wilt disease incidence in castor. Soil solarization brought down *Fusarium* inoculum load in the soil very effectively by almost 20 times. In solarized plot, *Trichoderma harzianum* Th4d seed treatment as well as seed and soil application recorded low wilt incidence and high seed yield compared to pathogen check (90.3%). A detached leaf technique has been standardized to screen castor lines against gray mold.

Three isolates of *Bacillus thuringiensis* var. *kurstaki* from IIOR collection (127, 154 and 172) were effective at high temperatures against *Spodoptera litura*, *Helicoverpa armigera* and *Achaea janata*. Oil based SC formulations of DOR Bt-127 @ 3.5 ml/l and combination of DOR Bt-127 + *Nomuraea rileyi* @ 3.0 ml/l were found most effective against *Spodoptera litura*. A protocol for mass production of Bt in polypropylene bags was developed for high toxin production.

Eleven parental lines (DPC-21, 23 and 25; DCS-94, 109, 110, 114 and 118; M-571, 574 and collection for Porbandar) and 10 advanced lines (PHT-14-4, 23, 31, 33, 38, 53, 54; PVT-12-64, 76 and PVT-11-85) of castor were found resistant to leafhopper. Six selections from mutant DPC-9 (Rb-2011-213, 214, 217, 231, 244 and DPC-23) were found consistently resistant to leafhopper. Two genotypes *viz*., RG-2800 and RG-2774 were found less susceptible to capsule borer under both net and open field conditions. Btk (Delfin), DOR Bt-1, Novaluron, Flubendiamide and Chlorantraniliprole were found safer to the parasitoids *viz*., *Trichogramma chilonis* and *Snellenius maculipennis* in laboratory bioassays. Wheat bran + sugarcane jaggery + chlorpyriphos 20EC based poison bait was effective against *S. litura* in castor. Significant positive correlation was found between egg masses of *S. litura* in castor and current and previous week pheromone trap catches.

SUNFLOWER

Two hundred and eighty five accessions that including 31 CMS lines, 90 B lines, 97 restorer lines and 38 inbreds and accessions of *H. niveus* were obtained from USDA-ARS. From the germplasm available at IIOR, two genotypes, GMU-156 and GMU-53, were identified as non-dormant and can be sown within 10 days after harvest. Evaluation of promising germplasm

resulted in confirmation of 29 accessions for high seed yield per plant (40-46 g/plant), 28 accessions for high oil content (40-42%) and seven accessions for high test weight (9-10 g/ 100 seeds). DUS testing trial was conducted for 26 candidate entries (6 A-lines, 8 R lines and 12 hybrids) with 13 reference entries and data for 26 DUS traits was recorded. Final consolidated report was submitted to PPV&FRA for 23 candidates comprising three hybrids (two new and one VCK), 15 new A, B and inbred parental lines and five R lines of sunflower.

For mapping powdery mildew resistance, RILs involving crosses PS2023B x TX16R (123), Morden x EC537925 (190) and TX16R x ID-25 (162) were generation advanced (F_7/F_7/F_4, respectively). With regard to interspecific crosses involving cultivated sunflower and *H. praecox*, F_1s showed resistance to powdery mildew. Morphological and molecular analysis of powdery mildew isolates from all sunflower growing regions confirmed that powdery mildew infecting sunflower in different parts of India is *G. cichoracearum*.

The limit of detection of the transgene in sunflower event No 481 harbouring the TSV-CP gene was done and expression of the transgene was detected up to 0.01% in case of both the TSV-CP and *npt*II genes.

Population improvement for increasing the autogamy in ARM243A/B pair resulted in increase of seed yield from 9 g/plant in the base material to 20 g/plant and 25 g/plant seed yield, respectively in first and second cycles of selfing and selection.

Diversification of CMS and restorer base, gene pools for maintainer and restorer lines were initiated among high yielding maintainer (B) and multi and mono-headed restorer (R) lines with good combining ability and individual plant selections were made in both the gene pools in random mating cycle-3.

For prebreeding, a total of 54 accessions of six diploid annual species were established. Evaluation of 12 interspecific cross combinations was done for cytomorphological characters and hybridity was confirmed using sunflower specific SSR markers. Sunflower advanced hybrids (IOSH-14-102 and IOSH-14-05) were found promising for seed yield coupled with zero incidence of downy mildew compared to public (KBSH-44 and DRSH-1) and private (SB-202 and Kaveri Champ) hybrids.

Supplementation of 5 t FYM/ha with RDF to *kharif* sorghum followed by growing sunflower with its recommended NPK gave higher sunflower seed yield (1231 kg/ha) compared to 150% NPK (1057 kg/ha) to both the crops in the system. Seed yield was significantly higher (1573 kg/ha) with NPK + FYM (sorghum) – NPK (sunflower) that was at par with NPK - NPK + B (1 kg/ha) NPK + S (25 kg/ha) + B + Zn (5 kg/ha) application compared to 150% NPK application (1460 kg/ha).

Significant differences among genotypes were observed for harvest index (HI) but stress did not affect HI. DRSH-1 recorded highest HI both in control and stress followed by KBSH-44. Genotypes HoHAL-17 and HoHAL-22 produced superior root volume (28 and 20 cc/plant, respectively) under P stress situation.

Total antioxidant capacity of sunflower parental lines ranged from 18.24 to 36.47 DPPH (TEAC mm/g), reducing power varied from 11.53 to 24.43 (GAE mg/g), while total phenol content ranged from 49.66 to 72.43 gallic acid equivalent mg/100 g dry weight.

Seed priming with Carbendazim @ 2g/kg + Thiamethoxam @ 4 g/kg followed by foliar spray of Propiconazole @ 0.1% and Thiamethoxam @ 0.04% twice at 30 and 45 days after sowing recorded significantly low incidence of SND, leaf blight and powdery mildew with highest yield of 1432 kg/ha and B:C ratio of 2.6.

Oil based SC formulations of DOR Bt-127 @ 2.0 ml/l and combination of DOR Bt-127 + *Nomuraea rileyi* @ 3.0 ml/l were found most effective against *Helicoverpa armigera* in sunflower.

Three germplasm lines (GMU-1, 243, 504) and three wild *Helianthus* accessions (DEC-1887, HIR-03, TUB-07) showed resistant reaction to leafhopper.

SAFFLOWER

Twenty trait specific safflower germplasm accessions for high oil content (34.1 to 36.7%) were identified from a set of 215 accessions evaluated. Variability was

recorded for seed yield (2.1-63.6 g/plant), 100-seed weight (2.4-8.3 g) and oil content (18.3-33.7%) among 148 accessions of IIOR safflower core subset. Among 40 exotic accessions from USDA, variability was recorded for number of branches (8-16) and capitula (19-44/plant), 100-seed weight (2.5-4.7g) and oil content (25.3-40%). A set of 30 accessions from Mexico recorded variability for plant height (95-124cm), number of branches (5-11) and capitula (16-27), seeds/capitula (14-46), 100-seed weight (2.9-4.4g) and oil content (31.3-38.6%).

Parental line improvement through introgressive breeding and conventional breeding resulted in identification of interspecific derivatives and inbreds with Alternaria tolerance (20% incidence as against 100% in check), tolerance to Fusarium wilt (0-5% as against > 80% in Nira), high yield coupled with *Alternaria* resistance, high oil (34 to 39%) and short duration (60-65 days against 85 days in A-1).

The experimental hybrids, DSH-299, DSH-290, DSH-289, DSH-302 and DSH-301 recorded 33-50% higher (3562-4027 g/13.5 sq.m.) than the check hybrid, NARI-H-15 (2645-2671 g/13.5 sq.m.) under minimal irrigation (one irrigation) condition.

In demonstration trials of DSH-185 *vs*. variety A-1 in farmers' fields in Chhattisgarh and Maharashtra, DSH-185 yielded 17.5 q/ha and 21 q/ha against the yield of 5 q/ha and 18 q/ha in the check A-1 under rainfed and irrigated conditions, respectively.

Marker-assisted selection (MAS) assay (based on an indel marker derived from FAD2-1 gene) for high oleic trait has been developed and validated in F_2 /backcross populations derived from the cross: Bhima x Motnola-2000 (EC-736515) in safflower. Marker-assisted backcrossing (MABC) has been initiated to improve Bhima for high oleic trait.

Five Mexican cultivars with one check (NARI-57) of high oil entry were evaluated under three levels of fertilizer input *viz*., 100% NPK, 150% NPK and STCR based fertilizer (SSNM). Among the cultivars, the check NARI-57 recorded the highest seed yield which was statistically similar to Mexican entry CCC-B2. Accumulation of oil content, tocopherols and fatty acid profiling was done during various stages of seed development in safflower high and low oleic acid genotypes. Oil content increased up to 36 days after flowering (DAF) and thereafter stabilized in all the genotypes till maturity. Gradual increase in oleic acid and decrease in linoleic acid was observed during maturity in high oleic types (CCC-B1 and Ciano-OL) while no significant difference was observed during maturity in low oleic types (Ciano-Lin and A-1). Maximum α-tocopherol content was reached at 21 DAF that decreased with maturity in all the genotypes.

An initiative was taken, to link the farmers and the industry though Public Private Partnership (PPP) mode for safflower cultivation, and the study was taken up in three villages of Uruvakonda mandal, Anantapur district. The initiative paid rich dividends to the safflower farmers who could get ₹ 14,263 net returns/ha as against ₹ 9,463 for the competing chickpea crop. The output marketing through PPP also made a significant impression in minimizing the drudgery of farmers in marketing their produce. The farmers could sell their produce for ₹ 3050/q in PPP mode as against ₹ 2550-2800/q in traditional mode besides gaining through reduced incidental costs and transportation costs.

Crop information system for safflower was developed which includes sub modules on various cultivars, crop management practices like land preparation, sowing, seed treatment, intercultural operations, etc. The pest and diseases modules includes the details of the various pests and diseases attacking the crop at various crop growth stages and their control measures, management practices, etc.

Seed treatment with Cymoxanil 8% + Mancozeb 64% @ 0.2% and *Trichoderma harzianum* Th4d SC @ 2ml/kg were found to be the most effective as they recorded significantly low Fusarium wilt incidence (10.3 and 11.3% respectively) as compared to control (21.9%). Eleven safflower breeding lines *viz*., SAF-1203-2(R), SSF-GMU-6878, PBNS-116, PBNS-123, PBNS-114, SAF-1205-(W), DSI-101, DSF-2014, DSI-118, SSF-GMU- 4912 and Manjeera were found promising with

less than 25% disease severity of Phytophthora leaf blight.

A new screening method for aphid resistance through artificial releases was found consistent and reliable. Stem elongation stage was found to be the most vulnerable stage to aphids. Fourteen accessions (GMU-184, 219, 332, 668, 904, 948, 958, 1101, 1102, 1301, 2252, 5131, 6299, 6401) were found moderately resistant to aphids. Studies on inheritance suggested the possibility of two recessive genes involved in resistance to aphid.

SESAME

Interspecific hybridization of TKG-22 and GT-10 (male parents) was carried out with sesame wild species (*S. malabaricum*, *S. mulayanum S. laciniatum S. alatum* and *S. radiatum*) of which the crosses with only *S. malabaricum* were successful. Pollen sterility ranged from 81.0% (*S. malabaricum* x GT-10) to 84.5% (*S. malabaricum* x TKG-22) in the F_1 plants. Under the national crossing programme, sixty experimental hybrids were evaluated in which the hybrids DS-5 x JLS-9707-2 and DS-5 x TKG-22 performed better with 20% and 17% standard heterosis, respectively over the best check, GT-10.

Frontline demonstrations (FLDs) on oilseeds and Tribal Sub Plan (TSP)

A total of 4915 demonstrations covering 2040.5 ha were conducted under National Mission on Oilseeds and Oil Palm. The number of demonstrations conducted across nine oilseed and oilseed based cropping system are as follows: castor-500, sunflower-600, safflower-600, sesame-490, niger-220, linseed-500, rapeseed and mustard-500, groundnut-670, soybean-700, farming systems- 85, STCR technologies-50. Average seed yield in eight castor demonstrations under rainfed was 509 kg/ha as against castor equivalent (398 kg/ha). The additional net returns accrued was ₹ 4540/ha with a BCR of 2.2 in improved technolog (IT) and 1.8 in farmers' practice (FP). In case of protective irrigation, the yield in IT was 1023 kg/ha as against 857 kg/ha in FP (castor equivalent yield). The mean yield of 14 FLDs in IT was 729 kg/ ha as against 595 kg/ha in FP. The additional net returns was ₹ 4540/ha with BCR of 2.2 in IT and 1.8 in FP.

Fifty sunflower FLDs were conducted on whole package, five demonstrations each on soil test based fertilizer application, soil application of sulphur and foliar spray of boron at 45 DAS during *rabi* 2014-15 in five villages of Prakasam district, Andhra Pradesh. Demonstrations on soil test based fertilizer application increased the seed yield by 19% as compared to FP of applying urea and DAP. The additional net returns accrued were ₹ 13,000/ha with IT. The B:C ratio was 2.86 and 2.24 with IT and FP, respectively. Simple practice of application of boron @ 2 ml/l as directed spray on capitulum at 55 DAS resulted in 12% increase in seed yield in IT as compared to FP. An additional net returns of ₹ 4,813/ha was accrued with IT. The B:C ratio was 2.13 and 1.98 with IT and FP, respectively. Soil application of sulphur @ 25 kg/ha increased the seed yield by 13% in IT plot as compared to FP. The additional net returns accrued were ₹ 6,063/ ha with IT. The B: C ratio was 2.49 and 2.24 with IT and FP, respectively.

Tribal sub-plan programme was implemented in 48 villages of 10 districts spanning over seven state *viz.*,Andhra Pradesh, Rajasthan, Karnataka, Tamil Nadu, Telangana, West Bengal and Chattisgarh with the objective of reducing poverty among the schedule tribe population and creation of productive assets for them. Under this programme, 908 demonstrations of latest released varieties/hybrids of castor, sunflower and safflower along with improved technologies were conducted in association with NGOs such as, Viksit Rythu Sankshema Samastha and Agri-Biotech Foundation and AICRP centres such as Nimpith, Yethapur, Hiryur, Palem, Mandor, Raipur and Tandur. The farmers of these villages were growing a less remunerative crops. These farmers were trained about the improved cultural practices to cultivate castor, sunflower and safflower crops. The farmers were given all the inputs such as seed, fertilizer and pesticides. Periodically, the scientists of IIOR visited the fields and monitored the programmes. They were also given different agricultural implements. In West Bengal the tribal farmers got the profit of ₹ 9000 to10,000/acre

through cultivation of sunflower. The average profit due to cultivation of castor in Rajasthan was ₹ 11938/ acre, where as in Telangana, it was varying from ₹ 7000 to 10,000. The farmers of Andhra Pradesh got net income of ₹ 9385/acre by growing castor and the net profit of growing castor in Tamil Nadu was ₹ 8074/ acre. The net profit due to cultivation of safflower in Telangana State was ₹ 8225/acre.

Under consortium mode approach in Adilabad, six on-farm trials on groundnut with castor (11:1) were conducted where farm pond water irrigation facility is available and farmers' could get 7 q groundnut and 2 q castor per acre.

The oilseeds crop management advisories were disseminated through ICT. Sixty nine text messages were developed and more than three lakh text messages were disseminated through farmers SMS portal to 4850 oilseed farmers mobile telephones. Voice advisories on sunflower (70) and castor (50) and text messages (95) in regional language were developed for mobile phone based dissemination. Videos of critical interventions influencing the yield of sunflower and castor were developed in Telugu (14 nos), Hindi (13 nos) and English (3 nos).

IIOR

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The Institute

- Mandate
- Staff Position
- Financial Statement

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Scope: Sustained growth of production and productivity of castor, sesame, sunflower, safflower, linseed and niger by conducting research to generate, refine, validate and disseminate technologies through capacity building of stakeholders.

EA/NACE	: 34 - 73.10	Initial issue date	: 31.03.2015
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H. Narasimhaiah
Director

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THE INSTITUTE

The establishment of All India Coordinated Research Project on Oilseeds (AICORPO) in April, 1967 based on the recommendations of a sub-committee appointed by the Government of India was the most significant event in the history of oilseeds research in India. The project had its beginning with one Project Coordinator to coordinate and monitor the research programmes of groundnut, rapeseed-mustard, sesame, linseed and castor operating at 32 research centres. Later during 1972, safflower, sunflower and niger were brought under the umbrella of AICORPO and the number of research centres increased to 40. Realizing the need for one national institute for oilseeds, the AICORPO was elevated to the status of Directorate of Oilseeds Research on August 1, 1977 with 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. DOR has been entrusted with the responsibility to plan, coordinate and execute the research programmes to augment the production and productivity of sunflower, safflower and castor crops in the country through All India Coordinated Research Project on oilseeds (AICRP) operating at 31 locations spanning over 14 states. With the addition of Sesame, Niger and linseed to the mandate crops, the Directorate of Oilseeds Research is upgraded to Indian Institute of Oilseeds Research (IIOR) w.e.f. February 3, 2015 as per the approval of XII plan EFC.

Mandate (DOR)

- 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, safflower and castor.

Mandate (IIOR)

- Basic and strategic research to augment the productivity of castor, sunflower, safflower, sesame, niger and linseed.
- Networking of all Oilseed Directorates on the Research and Technology Dissemination to develop national strategy to enhance oilseeds productivity.
- Planning, Coordinating and Monitoring of applied research on the issues related to national as well as regional importance through All India Coordinated Research Project on Oilseeds.

Staff position as on March 31, 2015

Category	Sanctioned	Filled	Vacant
Scientific	43*	40*	3
Technical	51	42	9
Administration	29	23	6
Skilled supporting	33**	22	11
Total	**156**	**127**	**29**

* including one RMP
** including additional 8 posts sanctioned by the Council for which administrative approval awaited.

Financial Statement

Allocation and Expenditure

Head of Account	Allocation (₹ in lakhs)				Expenditure (₹ in lakhs)			
	DOR Plan	AICRP (OS)*	Non Plan	Total	DOR Plan	AICRP (OS)*	Non Plan	Total
A. GRANT IN AID - CAPITAL								
1. Equipment	60.00	0.00	6.75	66.75	60.00	0.00	6.75	66.75
2. Library	10.00	0.00	6.00	16.00	10.00	0.00	6.00	16.00
3. Furniture	0.00	0.00	3.25	3.25	0.00	0.00	3.25	3.25
B. GRANT IN AID - SALARIES								
Establishment Charges	0.00	1566.80	1184.65	2751.45	0.00	1566.80	1176.77	2743.57
Overtime Allowance	0.00	0.00	0.25	0.25	0.00	0.00	0.08	0.08
Pension	0.00	0.00	78.00	78.00	0.00	0.00	78.00	78.00
Wages	0.00	0.00	256.10	256.10	0.00	0.00	256.10	256.10
C. GRANT IN AID - GENERAL								
TA	23.00	37.70	10.00	70.70	23.00	37.70	9.98	70.68
Res. & Operational Expenses	167.00	179.00	75.00	421.00	167.00	179.00	74.99	420.99
Administrative Expenses	31.00	0.00	186.00	217.00	31.00	0.00	184.98	215.98
Miscellaneous Expenses	4.00	0.00	12.00	16.00	4.00	0.00	12.00	16.00
Need Based Research	0.00	40.50	0.00	40.50	0.00	40.50	0.00	40.50
Tribal Sub-plan	50.00	58.00	0.00	108.00	50.00	58.00	0.00	108.00
Total	**345.00**	**1882.00**	**1818.00**	**4045.00**	**345.00**	**1882.00**	**1808.90**	**4035.90**

* include sunflower, castor, safflower, sesame & niger and linseed

AICRP on Sunflower, Safflower & Castor

	Allocation (₹)	Expenditure (₹)
Grants for Capital	0	0
Grants for Salaries	66230000	66230000
Grants for General	10370000	10370000
TSP	4000000	4000000
Total	**80600000**	**80600000**

AICRP on Sesame & Niger

	Allocation (₹)	Expenditure (₹)
Grants for Capital	0	0
Grants for Salaries	40775000	40775000
Grants for General	8725000	8725000
TSP	800000	800000
Total	**5030000**	**5030000**

AICRP on Linseed

	Allocation (₹)	Expenditure (₹)
Grants for Capital	0	0
Grants for Salaries	49600000	49600000
Grants for General	6700000	6700000
TSP	1000000	1000000
Total	**57300000**	**57300000**

Resource Generation

Particulars	Amount (₹ in lakhs)
Sale of Farm Produce	5.09
Sale of Old Vehicles & Machine Tools	0.42
Sale of IIOR Publications & Tender forms	0.05
Rent	7.10
License Fee	1.61
Interest earned on Loans & Advances	8.37
Leave Salary & Pension Contribution	0
Analytical testing charges	2.71
Interest earned on STDR	51.01
Receipts from service rendered/Sale of Technology	11.57
Unspent balance of grants	0
Training	0.8
Miscellaneous receipts	9.35
Total	**98.08**

Funds Received for Externally Funded Projects

Particulars	Amount (₹ in lakhs)
DST Projects	19.48
Deposit Schemes	199.51
Total	**218.99**

IIOR

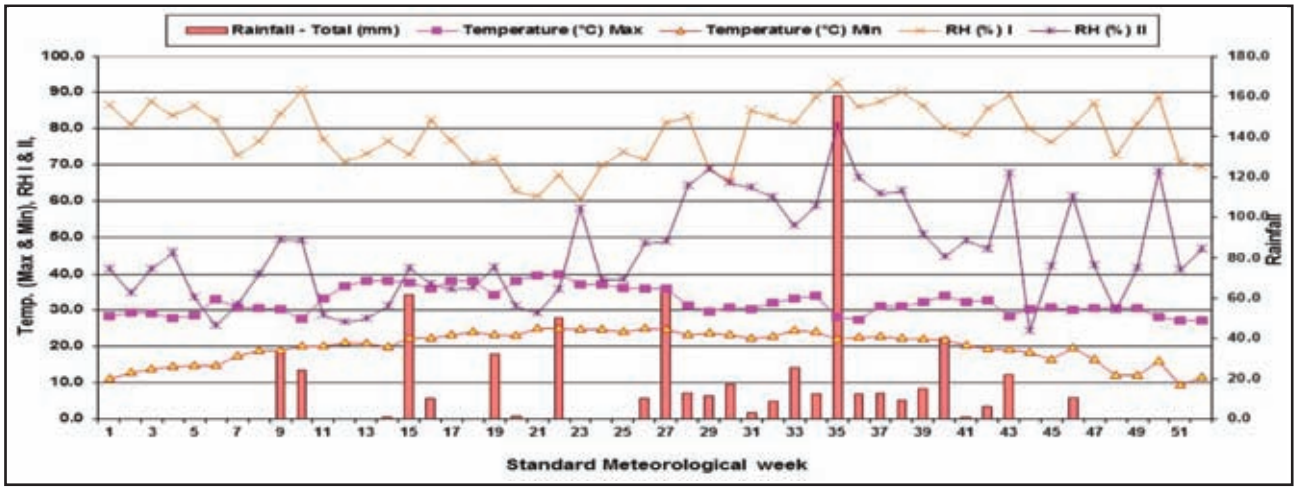
वार्षिक प्रतिवेदन

Annual Report

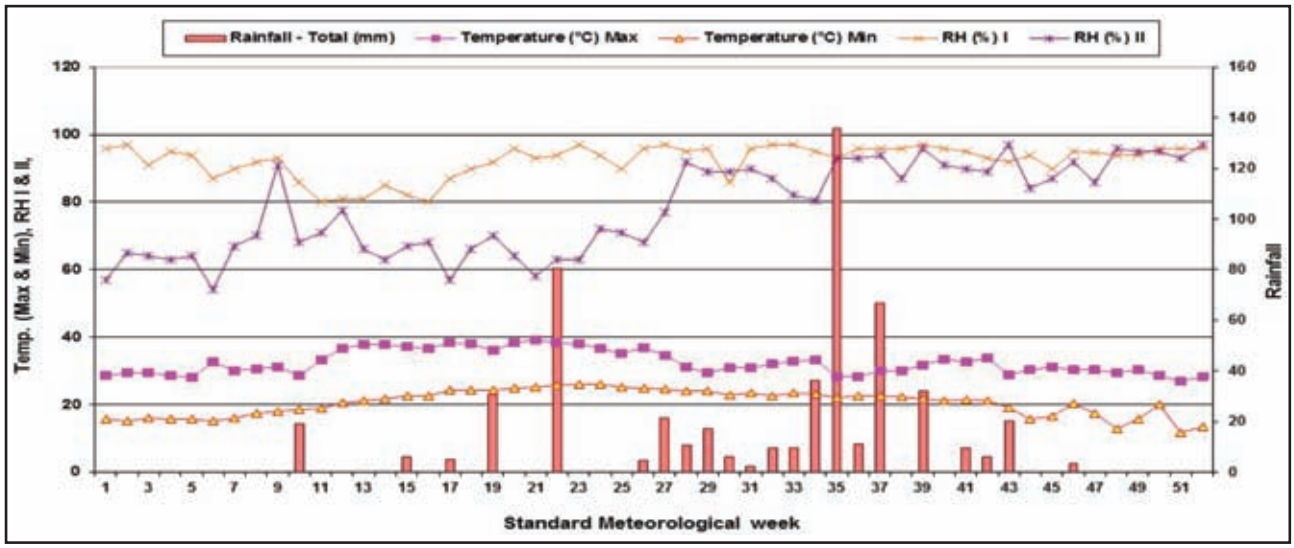
2014-15

Research Achievements

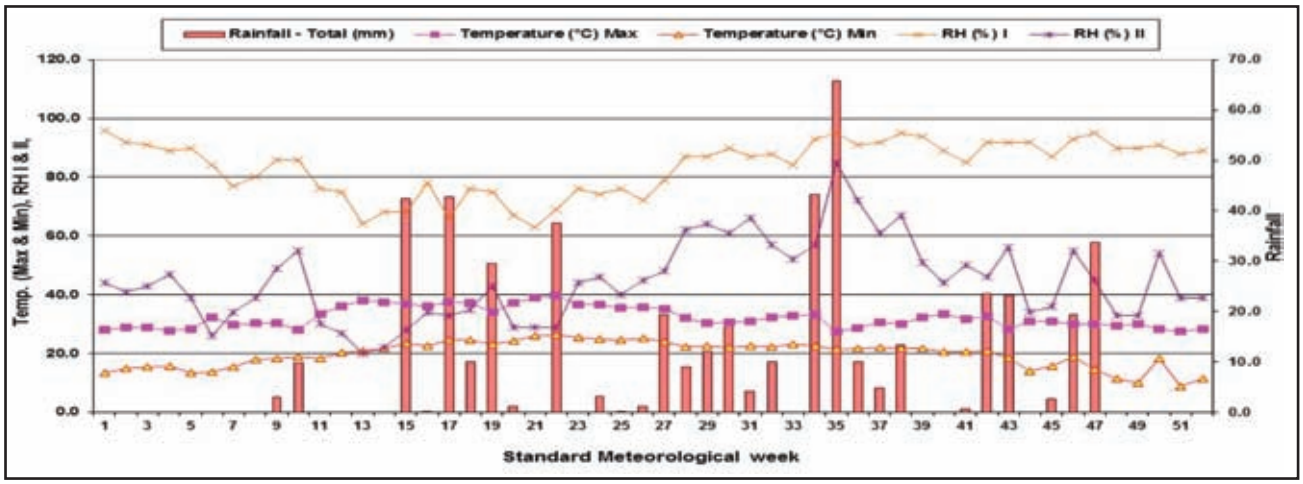
- Castor
- Sunflower
- Safflower
- Sesame
- Other Scientific Activities
- AICRP



Weekly Weather Data at Rajendranagar Farm (2014)



Weekly Weather Data at Narkhoda Farm (2014)



Weekly Weather Data at ICRISAT Farm (2014)

CASTOR

CROP IMPROVEMENT

Genetic Resources

Augmentation: A castor germplasm exploration was conducted in Chhindwara region of Madhya Pradesh, and Warud region of Amaravati District, Maharashtra in collaboration with Zonal Agricultural Research Station, Chhindwara and collected 32 accessions of castor possessing many productive spikes, partially female raceme types, high yield (around 5-6 kg/plant), bold and non spiny capsules, white, red, dark brown and white seeded types, long secondary spikes, CO-1 type with white seeds and small leaves, and compact and long spike (70-80 cm), etc.

Castor germplasm collections possessing long productive spikes collected from farmers' fields in Chhindwara region of Madhya Pradesh

Characterization and evaluation of fresh collections: One hundred and eighty new accessions collected from Rajasthan and Gujarat (S.K. Nagar) during 2013-14 have been characterized for 23 descriptors and evaluated for 19 quantitative traits. Great diversity was observed with respect to morphological and quantitative traits and 22 accessions having desirable characters were selected. Three accessions (RG-3859,

RG-3946, RG-3963) exhibited low node number (7-9) while the best check, GCH-7 had 15 nodes up to primary spike. Higher 100-seed weight (50-53.2 g) than GCH-7 (31 g) was recorded in three accessions *viz.*, RG-3832 (53.2 g), RG-3839 (52.6 g), and RG-3831 (50 g). Seven accessions recorded higher seed yield than GCH-7 (431 g/5.4 sq.m.) at 150 days after planting (649-1256 g/5.4 sq.m.) and 180 DAP (612-998 g/5.4 sq.m.; GCH-7: 429 g/5.4 sq.m.); four have recorded higher seed yield (1821-2974 g/5.4 sq.m.) than GCH-7 (1530 g/5.4 sq.m.) at 210 DAP. RG-3859 having low node number (7) gave higher seed yield at 120 DAP (1256 g/5.4 sq.m.) and 180 DAP (998 g/5.4 sq.m.). Higher total seed yield than GCH-7 (3074 g/5.4 sq.m.) was realized from four accessions namely, RG-3850 (3589 g/5.4 sq.m.), RG-3880 (3453 g/5.4 sq.m.), RG-3938 (3413 g/5.4 sq.m.) and RG-3860 (3233 g/5.4 sq.m.). The 180 fresh accessions from Rajasthan and S.K. Nagar were grouped into four diverse groups by Wards' minimum variance method of cluster analysis.

DUS testing: DUS testing of two hybrids (one new; one VCK) and four inbred parental lines was conducted during *kharif* 2014 as two separate replicated trials. The hybrid trial comprised of two candidate entries and four reference hybrids; the inbred parental trial consisted of four candidates along with seven reference entries. Data for 30 DUS traits was recorded in accordance with the DUS test guidelines. Final consolidated report was submitted to PPV&FRA for two candidates (new) of castor including one hybrid and one variety based on DUS trial conducted during *kharif* 2013-14.

Yield evaluation, diversity analysis and confirmation of trait-specificity of promising germplasm selections

Agronomic yield and yield traits: Germplasm selection, RG-43 (IC-0584671), which is wilt and leafhopper resistant, has confirmed its early maturity (days to flowering: 53 days; check GCH-7: 67 days) in a multilocation evaluation trial. RG-3798 has exhibited long effective length of primary spike (68 cm; GCH-7: 60 cm) trait confirming its ability to produce long productive primary spike under varying environments. High yielding ability of four selections, RG-3491 (2740 g total yield/10.8 sq.m.; GCH-7: 2580 g total yield/ 10.8 sq.m.), RG-3160 (2626 g/10.8 sq.m.), RG-3798 (2682 g/10.8 sq.m.) and RG-3799 (2406 g/10.8 sq.m.), have been confirmed in a replicated multilocation evaluation trial under rainfed and irrigated situations. The high yielding ability of three germplasm selections *viz.*, RG-1647 (1827 g/10.8 sq.m.), RG-2375 (1968 g/ 10.8 sq.m.) and RG-3767 (2272 g/10.8 sq.m.) has been confirmed for second consecutive year at IIOR, Hyderabad in a preliminary evaluation trial while GCH-7 yielded 2121 g/net plot (CV:20%; $CD_{0.05}$: 142).

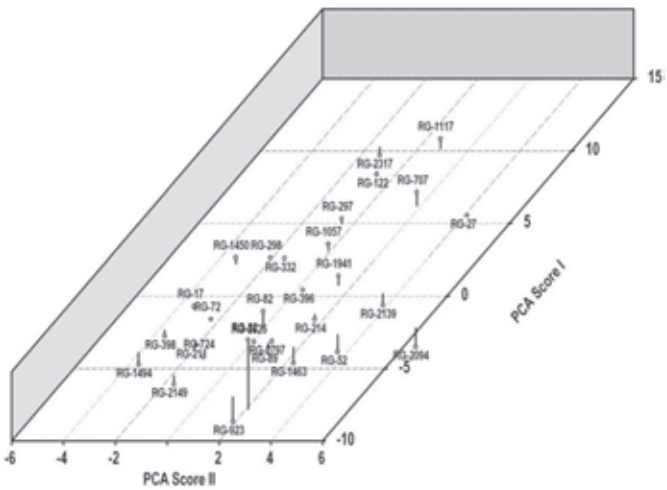
Biochemical studies

Three hundred castor genotypes were evaluated for ricinoleic acid content. Maximum ricinoleic acid content was observed in RG-3728 (91.31%) while minimum in RG-2787 (79.12%).

High ricinoleic acid: High ricinoleic acid content ranging from 90 to 92% has been confirmed in 14 germplasm selections in the second consecutive year in a multilocation evaluation trial conducted at four locations. The selection, RG-226 possessed the highest ricinoleic acid (92%) content while the checks, GCH-7, DCH-519, 48-1, DCS-106, DCS-9 and GC-3 had 86-88% ricinoleic acid content. Among the 14 high ricinoleic acid selections, 2 to 22% higher seed yield than the best check, GCH-7 (1979 g/10.8 sq.m.) have been realized from RG-3467 (2413 g/10.8 sq.m.), RG-311 (2231 g/10.8 sq.m.), RG-370 (2070 g/10.8 sq.m.) and RG-63 (2013 g/10.8 sq.m.).

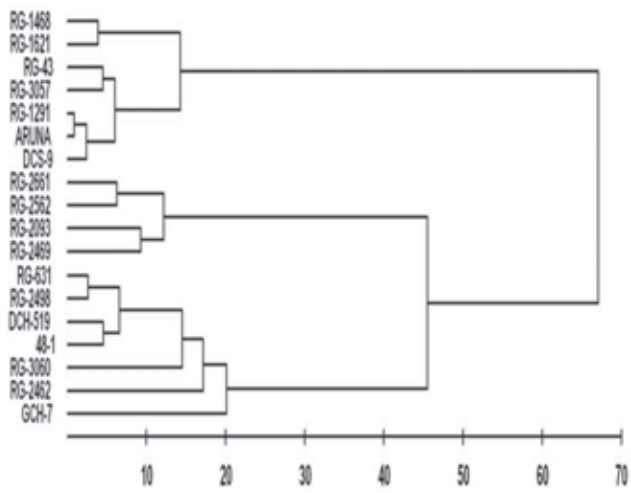
Drought resistant accessions: Higher seed yield than GCH-7 (4040 g/10.8 sq.m.; CV: 16%, $CD_{0.05}$: 137) was recorded in three putative drought tolerant accessions *viz.*, RG-707 (4102 g/10.8 sq.m.), RG-27 (4141 g/10.8 sq.m.) and RG-1117 (4937 g/10.8 sq.m.) at IIOR, Hyderabad. The principal component analysis of 30 putative drought tolerant accessions revealed wide diversity among the accessions based on 18 agro-morphological traits.

Wilt resistant selections: Among the 15 wilt resistant selections from germplasm (< 20% wilt incidence), two (RG-297, RG-3100) have yielded (3264-3301 g/10.8 sq.m.) at par with GCH-7 (3315 g/10.8 sq.m.; CV: 20%, CD 0.05 : 771) at IIOR, Hyderabad.



PCA plot showing wide diversity among 30 putative drought tolerant castor germplasm accessions

Leafhopper resistant selections: Two leafhopper resistant selections *viz.*, RG-2562 and RG-2661 have yielded (3045-3335 g/10.8 sq.m.) at par with the best check, DCH 519 (3015 g/10.8 sq.m.; CV: 16, $CD_{0.05}$: 845) in a replicated evaluation trial at IIOR, Hyderabad. The 14 leafhopper resistant selections, which confirmed resistance in the second consecutive year at multilocation under artificial epiphytotic conditions, have been grouped into seven distinct groups by Wards' minimum variance method of cluster analysis using 18 agro-morphological traits.



Dendrogram constructed by Ward's minimum variance method of cluster analysis using 18 agro-morphological traits of 14 leafhopper resistant castor germplasm selections

Development of heterotic groups

Thirty five accessions were found to be heterotic for short plant height, low node number, early maturity, long productive primary spike, high 100-seed weight and seed yield when crossed to non-TSP-10 R-based pistillate lines which were developed from germplasm accessions.

Prebreeding for inbred line development

Plant-progeny-wise selections and sib crossings were made among 15 trait specific selections from germplasm identified for high ricinoleic (90-92%), wilt resistance (<20% wilt incidence), leafhooper resistance (0 hopper burn), leaf miner resistance, extra-early maturity in order to develop inbreds possessing these traits.

Multiplication, documentation, supply and utilization of germplasm

Multiplied 329 accessions and passport information, morphological descriptors and data on quantitative traits of 180 fresh accessions were documented. Supplied 570 accessions to various AICRP (Castor) centres for multilocation yield evaluation and screening against diseases and insect pests besides 517 accessions were for utilization in the research programmes. Twenty one trait-specific accessions (early maturity, low node number, long productive spikes, high yield, compact spikes, wilt and root rot resistance) have been utilized in fresh crossing programmes by castor breeders at Hiriyur; IIOR, Hyderabad; Junagadh, Kanpur, Navasari and Palem centres.

Germplasm registration

The castor germplasm selection, RG-2822 (IC-0346626; INGR1-4028), proposed for resistance to *Macrophomina* root rot, was approved for registration by Plant Germplasm Registration Committee (PGRC) in its XXIX meeting held on May 5, 2014.

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

Development of diverse male combiners/varietal lines: Male line development continued through

pedigree method of selection in the segregating generations of three double cross hybrids, generated from wilt resistant, high yielding male lines *viz*., SKI-291, SKI-217, DCS-106, JI-226 and JI-227, a local germplasm collection *viz*., Narkhoda local with long spike and monoecious trait (60 cm with 30% maleness). Desirable single plants were selected from large segregating population of four F_2 (each 300-400 plants) and advanced through selfing individual plants. The F_2 of a triple cross involving a perennial Ethiopian local castor accession, as a male line, generated a large variation for sex expression *viz*., 0-100% maleness. Single plants with desirable male expression (5-10 male flowers in 1-2 whorls of flowers at the base of the primary spike) were selected and selfed.

Among 18 F_3 populations (60 plants each) evaluated for yield components and sex expression, 14 selections from 12 different crosses involving diverse male lines were promising for yield components like long spike (50-60 cm), good branching (≥ 10 spikes/plant); four populations for desirable male expression (10-15 male flowers in 1-2 whorls of flowers at the base of the primary spike).

Evaluation of advanced lines

In Preliminary varietal trial-I (PVT-I), among 240 advanced selections grown in single rows in an augmented randomized block design along with three checks replicated after every 10 entries, 43 selections were found promising based on spike length, capsule number on primary, branching and proportion of female to male flowers on the primary spike.

Preliminary varietal trial-PVT-II: Thirty one promising advanced lines, identified during 2013-14, were re-evaluated in three row plots with a spacing of 90 cm x 60 cm, replicated twice in a RBD under rainfed conditions. Among them, 16 entries were promising with significant yield increase (160-252%) over the best check, DCS-9 (578 g/plot). Among them, PVT-12-160, PVT-12-104, PVT-12-103, PVT-12-8 were late to 50% flowering (60-65 days) while other high yielding entries *viz*., PVT-12-4, PVT-12-98, PVT-12-3, PVT-12-2, PVT-12-7 were early to flowering (40-45 days). The lines like PVT-12-8, PVT-12-15, PVT-12-76, PVT-12-85, PVT-12-98, PVT-12-103, PVT-12-121, PVT-12-160, PVT-12-161 with ideal proportion of male flowers will be further identified as male lines based on the combining ability analysis.

Identification of new male lines: Two male lines *viz*., DCS-121, DCS-122, tolerant to *Botrytis* under severe natural incidence are under artificial screening. The line DCS-121 (PVT-II-12-2), is also high yielding (>100% over the best check DCS-9, 578 g/plot); physiologically efficient with high seed yield (146 g/plant), TDM at harvest (439.7 g/plant) and harvest index (33.3%) compared to the check, DCS-107 (87 g/plant, 433.6 g/plant, 20.1%) in a study to identify early vigour lines.

New male lines developed

Male line	Pedigree	Morphological character
DCS-121	DPC-9 x DCS-45	Red, triple bloom, spiny capsules, 12-14 N
DCS-122	DPC-17 x DCS-64	Red, double bloom, spiny capsules, 12-14 N

PVT-12-160 PVT-12-6 DCS-121

Multiplication of entries for specific traits: Eleven advanced lines of less and high branching types with long primary spikes were multiplied in five row plots for evaluation under rice fallows. In another set, 15 entries were multiplied in a six row plot in *kharif* season. The 15 lines included entries like PVT-11-2, 19, 34, 60 and 70 which confirmed their yielding

ability with >50% higher yield than the best check DCS-107 (300 g/plant).

Development of new pistillate lines: A programme on generation of diversity was initiated using the new pistillate source identified during *kharif* 2013. Pistillate selections from kh-13-154 with dwarf plant type, condensed nodes, cup shaped leaves, divergent branching angle, was used as the donor.

Pedigree method of selection continued in the breeding material involving two double cross F_2, 33 $F_{8 \text{ to }} F_{11}$ populations in *rabi* 2014. The material involved nearly 500 plants of two F_2 populations each, generated from two double crosses involving two pistillate sources *viz.*, DPC-9 and RG-404/B. Single plants with pistillate expression were selected in primary and secondary spike stages, irrespective of other morphological characters. Single plants with stable pistillate expression will be observed up to the fifth or sixth stages and will be selfed in the later spike orders.

Development of hybrids and preliminary evaluation of hybrids

Generation of new hybrids: Thirteen pistillate lines and 35 male lines were maintained the following sets of crosses were made to generate new hybrids.

Parents used in development of hybrids at IIOR, Hyderabad

Set	Female	Male
I	DPC-16, DPC-21, DPC-23, DPC-25	DCS-81, DCS-84, DCS-86, DCS-89, DCS-94, DCS-106, Haritha, DCS-78, Gandhi, PVT-12-2, JI-226, JI-227, JI-319, JI-322, JI-338, JI-340, JI-384, SKI-215, SKI-283, SKI-294, SKI-301, MCI-3, MCI-8, GC-3
II	DPC-18, DPC-19, DPC-20	DCS-9, 48-1, DCS-78, DCS-107, Haritha, GC-3
III	DPC-21, DPC-23, DPC-24, DPC-25, M-571, M-574	GP-101, GP-401, GP-407, GP-432, GP-487, GP-489, GP-493, GP-526, GP-537, GP-538, GP-568, GP-585, GP-640, GP-672, GP-674, GP-699, GP-712, GP-729, GP-737, GP-752, GP-753, GP-759, GP-764, GP-778, GP-783, GP-788, GP-789

Common evaluation hybrid trial: Among eight promising hybrids identified as promising in the common evaluation trials conducted at Anand (irrigated) and IIOR (rainfed), ICH-66 and ICH-68 were found to be significantly superior over the check, GCH-7 in the PHT conducted at Anand during *kharif* 2014. These two hybrids were also found to be resistant to wilt both at IIOR, Hyderabad and S.K. Nagar under wilt sick plots.

Preliminary hybrid trial-I: Thirty five hybrids were evaluated under rainfed conditions and the hybrids involving new pistillate line, DPC-25 had very long spikes (60-70 cm) with loose and high number of capsules. Thirteen hybrids recorded 10-100% significant yield increase over the best check, DCH-519 (1360 kg/ha). The hybrid, PHT-14-29 (DPC-25 x DCS-113) with 100% yield increase over the check, medium plant height (100 cm), 12 nodes to the primary spike recorded a desirable proportion of monoecious (4 cm) nature on a long primary spike (65 cm).

ICH-68, a promising early maturing hybrid suitable for both irrigated and rainfed cultivation

Hybrids contributed for coordinated multi-location trials: Three hybrids *viz.*, DCH-1642, PHT-14-44 and PHT-14-46, evaluated in national screening nursery for wilt (NSNW) were resistant to wilt with <20% wilt incidence at S.K. Nagar and IIOR, Hyderabad. The hybrid seed of PHT-14-44 was produced in isolation for including in the coordinated multilocation trials along with another early duration, wilt resistant hybrid PHT-12-3.

Among the 11 hybrids in IVHT, DCH-1720 with 2% yield increase over the best check, DCH-519 (3276 kg/ha) was promoted to AHT-I, based on the wilt resistance in all the three wilt sick plots at IIOR, Hyderabad; S.K. Nagar and Palem.

Induction of polyploidy

An attempt was made to induce polyploidy in castor using colchicine. Seeds of three castor genotypes *viz.*, 48-1, DCS-107 and RG-969 were treated with colchicine at four different concentrations (1%, 0.5%, 0.3% and 0.1%). The seeds were soaked at three different durations (12 h, 24 h and 48 h). A total of 600 treated plants from each genotype was sown in the field along with untreated control. Colchicine treatment at high concentration coupled with long duration impacted the germination with no germination noted in the treatment of 48 h at 1% concentration. Initial evaluation of guard cell size in 1,800 treated plants resulted in three putative polyploids, which are being confirmed by chromosome count.

Genetic variability for early vigour, total drymatter (TDM) and heavest index (HI)

Forty eight genotypes which included five hybrids along with their parents, 10 preliminary hybrids, 14 male lines and 10 pistillate lines with 48-1, DCH-519 as checks were evaluated for early vigour, TDM and HI. Among hybrids and parents, DCS-107 (male parent of DCH-1715) showed early vigour and TDM at 35 DAS. DCH-1715 and DCS-78 (male parent of DCH-519) recorded high seed yield, TDM and HI. Hybrid DCH-177 along with its parents DCS-9 and DPC-9 showed high seed yield (DPC-9:131, DCS-9:116, DCH-177: 123 g/plant) and HI (DPC 9:31.3, DCS 9:31.8, DCH 177: 39.7%) though the TDM is less (DPC 9:419, DCS 9:363, DCH 177: 309 g/plant).

Among male parents, DCS-81 and DCS-86 recorded early vigor and high TDM at 35 DAS. High seed yield and TDM at harvest was recorded by DCS-86, DCS-105, DCS-112 and PVT-1-12-2. PVT-1-12-2 also recorded high HI (33.3%). In female parents, early vigour was high in DPC-21, DPC-23, DPC-24 and DPC-25. Two pistillate lines, *viz.*, DPC-16 and DPC-23 recorded high seed yield and HI.

Evaluation of genetic stocks

During 2014-15, genetic stocks isolated for various combinations of stem and capsule colours were evaluated and several capsule colours could be stabilized as genetic stocks. Among the 10 genetic stocks constituted last year, 2 stocks which were unique showed stability for the stem colour. Hence, the seeds of these two stocks have been multiplied adequately for the purpose of registration. A new red stem colour genotype (GSC-008) was obtained from yellow stem mutant

GSC-008, a new stem colour genetic stock developed using yellow stem mutant

Generation of mapping populations

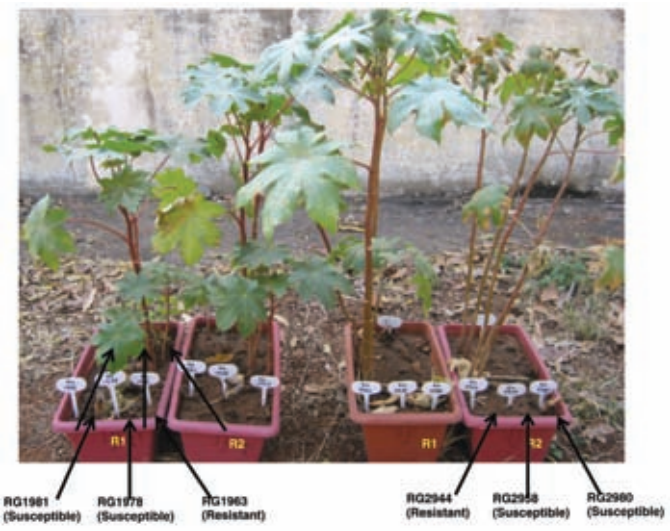
Three recombinant inbred line (RIL) populations (DCS-9 × RG-3216; DCS-9 × RG-1139; DCS-9 × RG-3309) consisting of over 200 progenies were developed for genetic analysis, mapping of gray mold resistance and

construction of high density linkage map in castor. From these populations, several inbreds were identified with good agronomic features as potential male lines for hybrid development. One population (JC-12 × 48-1) consisting of circa 240 progenies was advanced from F_3 to F_5 for developing a set of recombinant inbred lines for genetic analysis and mapping of *Fusarium* wilt and nematode resistance in castor.

Evaluation of castor association mapping panel for agronomic traits

The association mapping panel of 302 castor genotypes (consisting of the core sub-set, trait specific germplasm, elite inbreds, released varieties and parental lines of hybrids) was evaluated for *Fusarium* wilt resistance and other agronomic traits *viz*., plant height, stem colour, presence of bloom, capsule spineness, number of nodes, number of spikes, primary spike length and100-seed weight. Evaluation for *Fusarium* wilt resistance was done in pot culture using *Fusarium oxysporum* f.sp. *ricini* inoculum isolated from IIOR farm. The plants were observed for disease symptoms from the time of emergence. Chlorosis and discoloration of leaves, necrosis and ultimately death of seedlings were observed as the symptoms of pathogen infection. The susceptible check, JI-35 showed disease symptoms after 12-15 days of sowing and died within 25 days of sowing. The resistant check (48-1) showed disease symptoms after 25 days of sowing and survived even after 40 days of sowing. The test accessions exhibited a wide range of reaction for pathogen infection. Some of the accessions did not show any disease symptoms even after 90 days of sowing. The reactions of all accessions were consistent across replications.

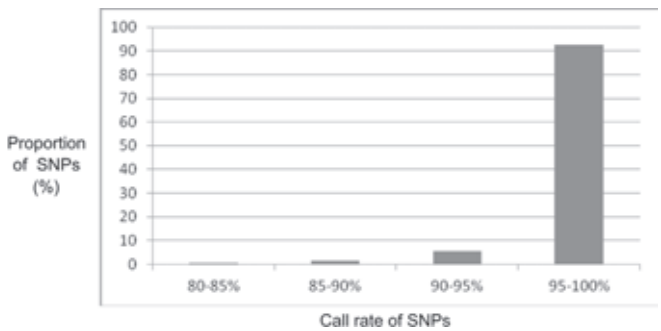
The reaction of a few accessions to pathogen infection in the artificial screening using pot culture is presented. Among 302 accessions tested, 185 accessions were considered as 'susceptible' (reaction similar to susceptible check, JI-35), 55 were rated as 'moderate' (reaction similar to resistant check, 48-1), and 62 were scored as 'highly resistant' (reaction better than 48-1). By and large, the results showed that this genotype panel represented good range of variability for useful agronomic traits and reaction to wilt pathogen hence; it can be ideally used for association mapping in castor.



Reaction of castor genotypes for *Fusarium* wilt resistance in sick pots

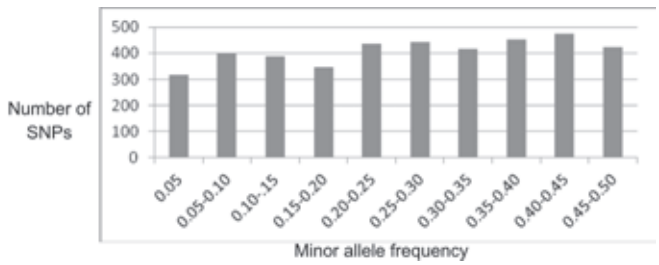
Validation of castor SNP genotyping array

A newly designed 5K SNP array was validated for its technical performance by genotyping 318 diverse castor accessions of the association mapping panel which fairly represented the genetic diversity available in castor germplasm. Out of 5,238 SNPs presented in the Infinium bead chip, high quality genotype calls were obtained for 5,038 SNPs (96.18%), while clear genotype clustering was not obtained for the remaining 200 SNPs. Out of 5,038 scorable SNP markers, 927 were monomorphic across samples (81% polymorphism) and 13 of them had missing data points of more than 20% in the panel of 318 accessions. Finally, a total of 4,098 SNPs was called successfully with high quality. The call rate of these SNPs ranged from 80 to 100% with an average of 98%. The reproducibility of all the 4,098 SNPs across biological and technical replicates was 100%.



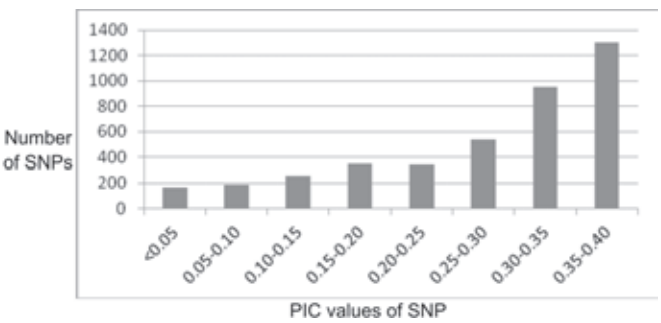
Distribution of call rate of SNPs across 318 castor accessions

The array performance in polymorphism detection was assessed using the diversity measures *viz*., minor allele frequency (MAF), polymorphic information content (PIC), observed heterozygosity and gene diversity. Of the 4,098 informative SNPs, 2,690 (65.64%) had MAF >0.2 and could be considered as markers with normal allele frequencies. About 18% of SNPs had a MAF of 0.1 - 0.2 and 291 SNPs had MAF of <0.05. In addition, 489 SNPs (12%) showed almost equal allele frequencies (with MAF close to 0.5) for two alternative alleles.



Distribution of minor allele frequency (MAF) of SNP markers

PIC measure suggests the usefulness of marker for diversity and linkage analyses and it ranges from 0 to 0.5 for a bi-allelic marker such as SNP. The PIC values for individual SNP in the array ranged from 0.003 to 0.375 with the peak distribution between 0.30 and 0.40 indicating that the SNPs in the array are highly polymorphic and useful.

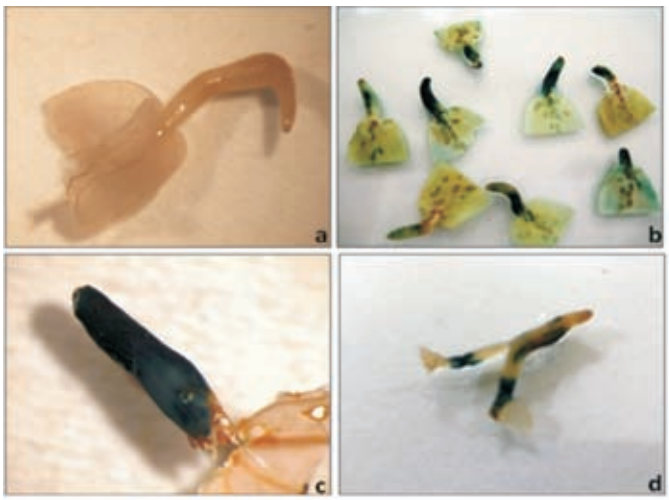


Frequency distribution of polymorphism information content (PIC) of SNP markers

The average observed heterozygosity across the castor accessions was 11%, which is within the expected range of residual heterozygosity in inbred lines of castor (being a highly cross pollinated crop). The gene diversity ranged from 0.003 to 0.500 with an average of 0.351 indicating a moderate level of genetic diversity in castor as reported by other marker systems such as SSR, ISSR and AFLP. Thus, the array developed is of superior quality in terms of performance, polymorphism and reliability, which could be readily used for any genome-wide research applications in castor.

Transgenic events for insect resistance: Transgenic events were developed through deployment of the *Cry1Aabc* and *Cry1abcF* genes and transgenic events harbouring the *Cry1Aa* and *Cry1Ec* genes were characterized for the protein levels. A total of 6800 embryos were subjected to *Agrobacterium*-mediated transformation with a transformation frequency of 0.05%. In Cry1Aa events (804, DTS-43 and AK1304-PB-1), concentration of Cry1Aa protein in T_4 generation plants ranged from 0.16-0.978 ng/mg of fresh leaf tissue and in Cry1Ec lines (AMT-1, NBRI-PB-1), protein concentration ranged from 0.192 to 2.4 ng/mg of fresh leaf tissue.

Optimization of tissue culture and transformation protocol: Seed imbibition and meristem-based protocols were optimized to obtain high frequency of transient expression (>90%) in castor. In this method, transformation of de-coated seeds of castor was done by *Agrobacterium tumefaciens* strain EHA 105 with binary vector *pCAMBIA* 1305.2 with double 35s promoter. Different variables such as age of seedlings (0, 1, 2 and 3 days), type of injury, bacterial density (0.5, 1.0 and 2.0 OD), co-cultivation time, acetosyringone concentration (50, 100, 150 and 200 μM), tobacco leaf extract and effect of surfactant (Triton x-100: 0.01, 0.1 and 1%) and vacuum infiltration (10, 15 and 30 min) were tested. A total of 3120 decoated seeds were tested using different variables. Highest *GUS* expression (94%) was found 10 days after co-cultivation when 2-day-old seedlings were injured with needle and 1 h co-cultivation time with 1.0 OD bacterial titer and 200 μM acetosyringone.



Seed imbibition and *GUS* expression in castor

a. Control; b&c: *gus* positive embryos 10 days after co-cultivation; d: *gus* expression in the sectioned seedlings

Development of strategies for obtaining *Botrytis* tolerant transgenic castor plants

Attempts are being made to validate the gene constructs developed to impart tolerance to grey mold disease in castor. Tobacco is being used as the model system for this purpose and simultaneously efforts are on to transform castor using different methods of transformation.

In planta transformation

A modified *in planta* transformation method was adopted with 1700 seedlings of castor cultivar 48-1 (Jwala) using different gene constructs (*gus*, *ERF1, AtEBP1, BIK1)* as individuals and *ERF1 + GUS, AtEBP1 + BIK1* as concoction. Totally about 470 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 in castor**

Construct used	No of seedlings co-cultivated	T_0 plants established
Multigene construct (*AtEBP1- BIK1- ERF1*)	300	120
pCAMBIA 2301 –*ERF1*	250	100
AtEBP1	300	100
*BIK1*250	100	
AtEBP1 + BIK1 (concoction)	200	50

Analysis of T_1 progeny castor *in planta* transformed plants

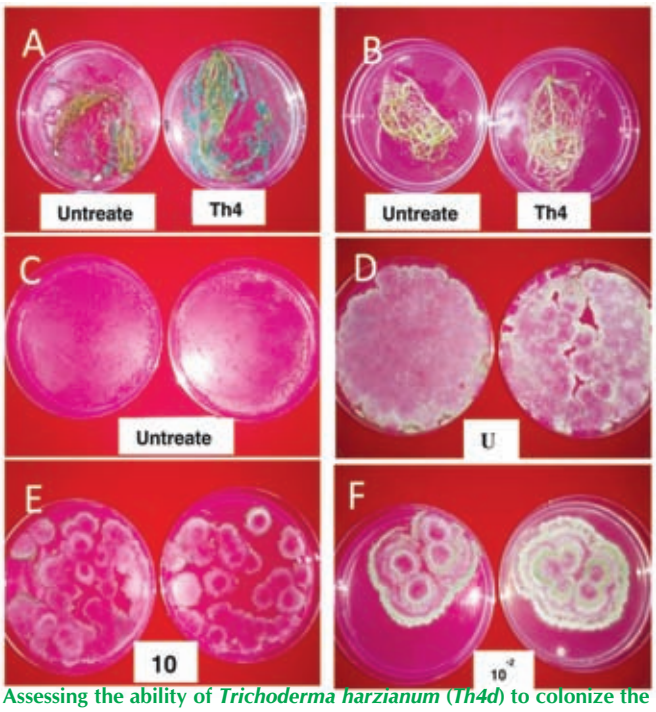
Initially 15000 T_1 seeds from 300 T_0 castor *in planta* transformed plants with different constructs [*ERF1 + GUS* (200), *GUS* (40), *AtEBP1* (60)] were raised in green house. Characterization of 1500 pooled samples of 10 plants each were done through PCR with gene specific primers. Only one T_1 plant showed presence of *ERF1* gene but the introduced gene cassette was not complete. Thus, the frequency of transformation was negligible.

In order to increase the efficiency of identification of positive plants, hygromycin selection was used to screen the T_1 plants initially and only the seedlings that survived selection were transferred to soil and subjected to PCR analysis. About 10000 T_1 seedlings (3-day-old) from 200 T_0 castor *in planta* transformed plants with different constructs were subjected to antibiotic screening (hygromycin- 40 mg/l). 600 plants that survived selection were subjected to PCR analysis with gene specific primers. Only one of the plants showed presence of *GUS* gene. Thus, the frequency of transformation was found to be extremely low with *in planta* method of transformation.

Deciphering Molecular Mechanism of Induction of Biotic Stress Tolerance by *Trichoderma* spp in Induced Systemic Resistance in Castor

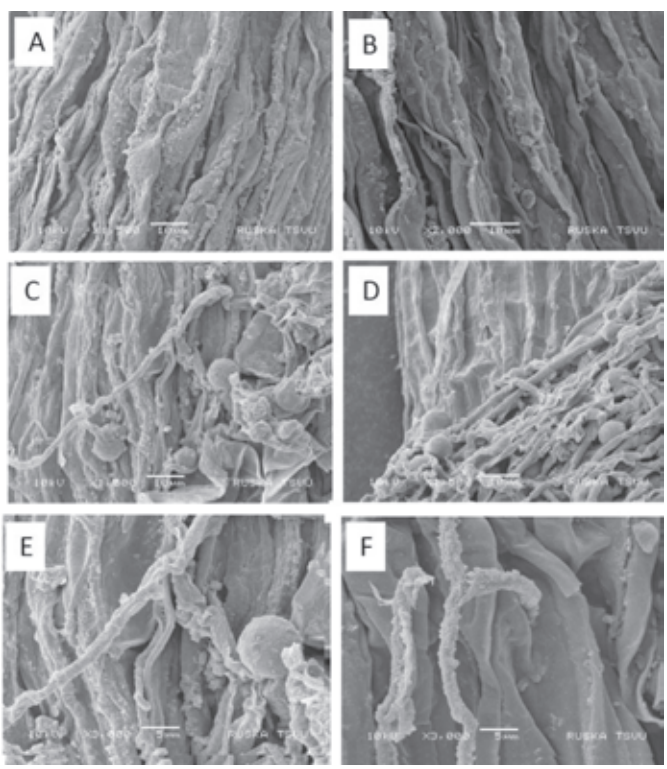
Assessing the colonizing ability of different isolates of *Trichoderma* spp in castor roots

Of the many strains tried for assessing the colonizing ability, *Th4d* strain was identified to be the best in colonizing castor roots. Root samples from 60-day-old seedlings of DCS-107 treated with *Th4d* as seed treatment were crushed under aseptic condition using phosphate buffer and plated in *Trichoderma* Selective Medium (TSM) for assessing colonization of castor roots by *Trichoderma*. Untreated castor seedlings were used as control. Five days after inoculation *Trichoderma* colonies appeared from surface sterilized *Trichoderma* treated roots, whereas no colonies appeared from untreated roots as represented. The presence of chlamydospores in the cortex region was observed in the transverse sections of the roots confirming the colonization by *Trichoderma*.



Assessing the ability of *Trichoderma harzianum* (*Th4d*) to colonize the root system of castor by plating technique. Filtrates of the crushed roots from 60-day-old seedlings were diluted and plated on TSM. Dilutions are indicated.

A. Unsterilized, B. Surface sterilized, C. Untreated, surface sterilized, D - F. *Th4d*-treated, Surface sterilized



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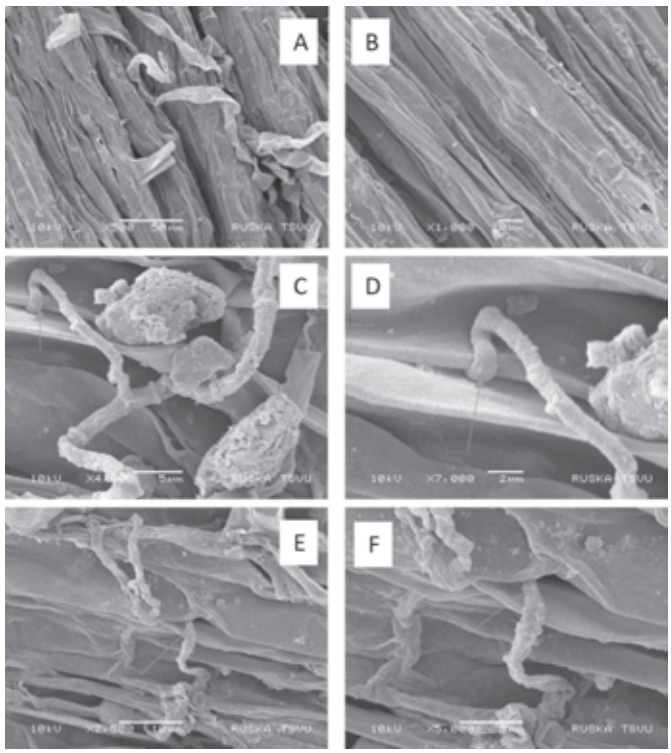


II

Scanning electron micrographs of *Th4d*-treated and untreated castor roots showing the entry points of *Trichoderma* into the roots.

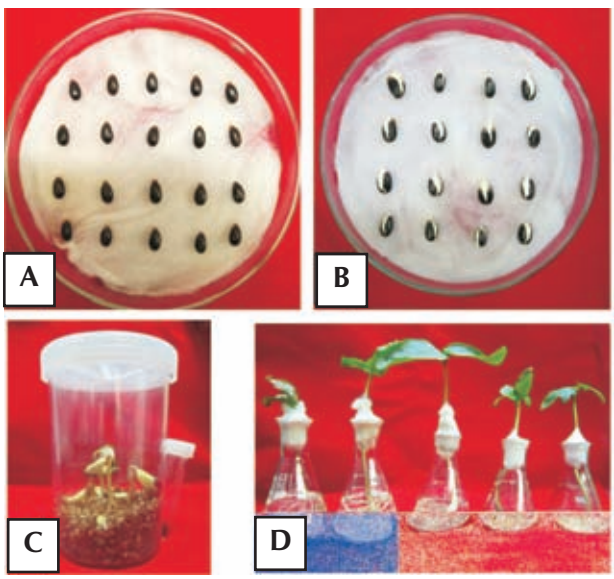
I. Seedlings grown in soil system. A, B. Epidermis cells of untreated roots (X500, X1000), C – E. Fungal hyphae and conidia of *Th4d* inoculum colonizing castor root surface (X1500, X1500, X3000), F. *Th4d* hyphal filament penetrating the root epidermis between adjacent cells (X3000)

II. Seedlings grown in hydroponics system. A, B. Epidermal cells of untreated roots (X500, X1000), C – F. *Th4d* hyphal filament penetrating the root epidermis between adjacent cells (X4000, X7000, X2500, X5000)

The penetration and colonization of roots of castor by *Trichoderma* was further validated through SEM analysis. Penetration process was analyzed using seedlings grown either in soil or in hydroponics. Seeds treated with *Trichoderma* were grown in soil for 12 days and then roots were taken for SEM studies or roots of 12-day-old seedlings grown in hydroponics were exposed to *Trichoderma* germlings and after 48 hours the roots were analyzed for penetration by *Trichoderma*. SEM analysis was indicative of the germination of *Trichoderma* spores on the castor roots and penetration of the hyphae into the root across the epidermal cell layers in both soil grown as well as hydroponic seedlings. This analysis also indicated that *Trichoderma* entered castor roots through the intercellular spaces.

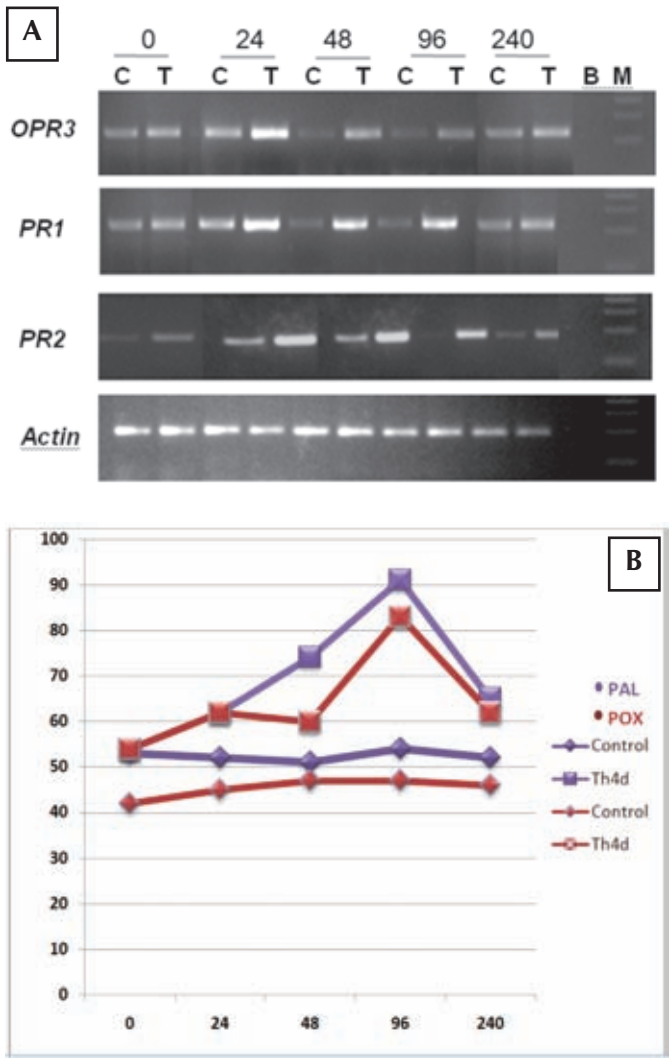
Molecular analysis of induction of systemic resistance

For studying the molecular networks underlying the interaction between castor and *Trichoderma* and further resistance of the plant against various pathogens, a hydroponic system was standardized. These hydroponic seedlings were inoculated with germlings of *Th4d* @ 10^5 germlings/ml. To study the early molecular events that occur during the interaction, genes implicated in various defense regulatory pathways that are shown to be modulated during ISR were studied through semi quantitative RT-PCR. RNA samples from cotyledonary leaves collected at regular intervals after treating the root system of hydroponically grown seedlings of castor with *Trichoderma* germlings were used for RT-PCR analysis. Among the various genes studied *PR1, PR2* from salicylic acid - pathway and *OPR3* from jasmonic acid - pathway were identified to show differential gene expression profiles at various time points i.e., 24, 48, 96 and 240 hpi. It was observed that the expression of genes increased from 24 to 96 hpi and gradually decreased until 240 hpi. In the same samples, elevated expression of enzymes PO and PAL were observed in the *Th4d* treated castor hydroponic seedlings indicative of early induction of systemic resistance due to *Trichoderma*.



Hydroponics system for studying interaction between castor and *Trichoderma*

A. Surface sterilized castor seeds, B. Germinated, 4-day old castor seeds, C. Elongated castor seedlings in vermiculite, D. 12 days old castor seedlings transferred to hydroponics medium and inoculation with *Trichoderma* germlings

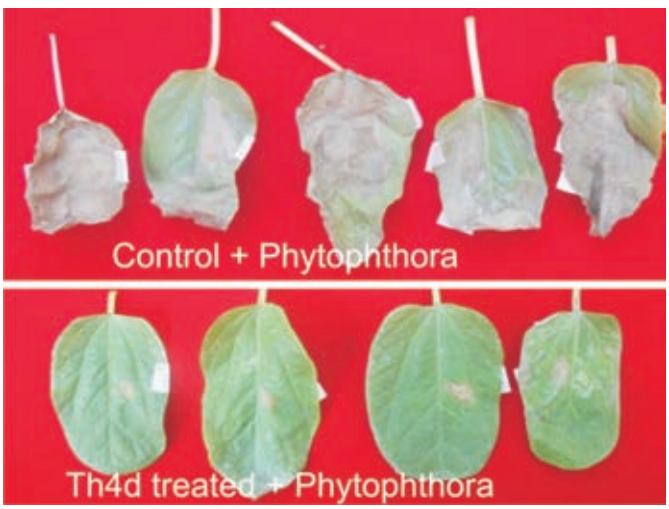


A. RT-PCR analysis indicated elevated expression of selected signature genes induced during systemic resistance. B. Elevated expression of defense related enzymes, phenyl ammonia lyase (PAL) and peroxidase (POX) in the cotyledons of *Trichoderma* treated seedlings taken at different time intervals post inoculation with *Trichoderma*. (X-axis: indicates the time intervals, hpi and Y-axis indicates the enzyme units

Effect of *Trichoderma*-mediated induced systemic resistance in castor against *Phytophthora parasitica* var *nicotianae*.

As previously reported, *Trichoderma*-mediated ISR had a beneficial effect in castor with reduced disease establishment in *Th4d* treated seedlings when the cotyledonary leaves of control and *Trichoderma* treated seedlings were plugged with *Phytophthora* fungus and the disease spread was recorded at regular intervals. Reduced lesion size of *Phytophthora* infection as well as the reduced cell death in *Th4d* treated seedlings as

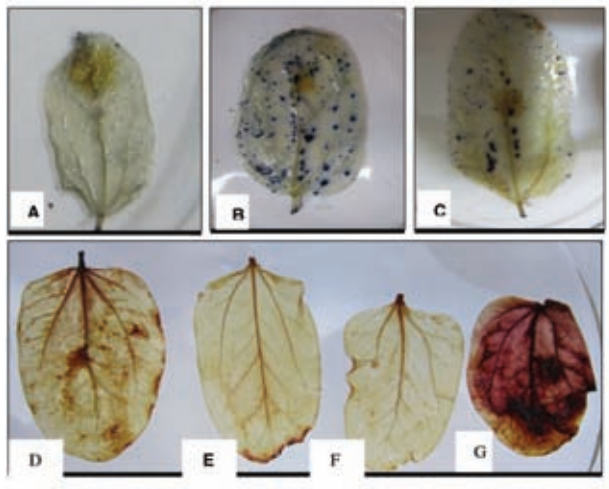
indicated by Trypan blue and DAB staining was observed. Further, biochemical analysis indicated that in the treated seedlings activities of defense related enzymes, phenylalanine ammonia lyase and peroxidase, were higher and that could be implicated in containment of the pathogen in treated seedlings compared to untreated seedlings. RT-PCR analysis indicated that expression of three genes *PR1, PR2* and *OPR3* was elevated in *Trichoderma* treated seedlings challenged with the pathogen *Phytophthora parasitica* var *nicotiana* compared to the untreated seedlings. Expression of these candidate genes was seen to be elevated even up to 96 hpi indicating the accentuated effect of ISR in the presence of the pathogen in *Th4d* treated seedlings. *Th4d* treated castor seedlings also showed resistance to *Fusarium* disease as demonstrated by not only reduced mortality of seedlings but also by elevated expression of defense related genes and increased PAL and POX activity.



Phytophthora lesions were reduced in *Trichoderma* treated seedlings compared to control

DNA fingerprinting of the castor varieties and parental lines of hybrids

Genomic DNA was isolated from varieties (48-1 and DCS-107) and the parents of hybrids DCH-177 (DPC-9 x DCS-9) and DCH-519 (M-574 x DCS-78). Hundred and two SSR markers were screened, out of which 56 microsatellite markers (54.9%) were polymorphic. A total of 132 alleles were amplified and number of



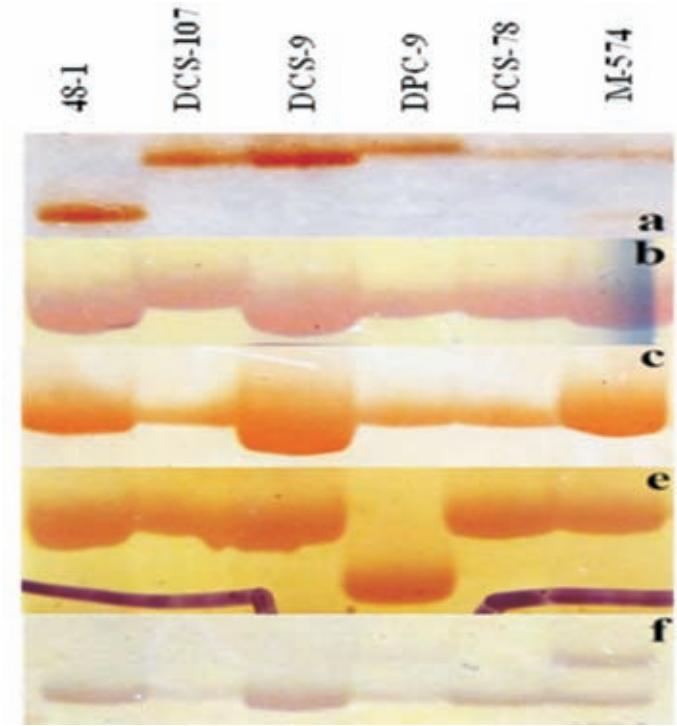
Estimation of cell damage, fungal proliferation and ROS production by Trypan blue and DAB staining techniques

I. Trypan blue staining – A: Un-inoculated, B: *Phytophthora* only, C: *Trichoderma* + *Phytophthora*
II. DAB staining – A: *Trichoderma* + *Phytophthora*, B: *Trichoderma* alone, C: Un-inoculated, D: *Phytophthora* alone

alleles per locus ranged from 2 to 5 with an average of 3. However, more than 3 alleles were amplified at 16 loci. Thirteen unique alleles (12.7%) were observed for the five parental lines 48-1, DCS-107, DCS-9, DPC-9 and M-574, while for DCS-78, no unique allele was observed. The allele frequency ranged from 0.33 to 0.83 with an average of 0.60. The average PIC value of each locus was 0.43, with the highest of 0.67.

Purity assessment of DCH-177 and DCH-519 hybrids

Twenty four markers showed polymorphism between DCS-9 and DPC-9, the parental lines of the hybrid DCH-177, and 13 markers between DCS-78 and M-574, the parental lines of hybrid, DCH-519. Combination of two (mRcDOR-103, mRcDOR-166) for DCH-177 and three markers (mRcDOR-49, mRcDOR-69, mRcDOR-206) for DCH-519 were used for assessing hybrid purity. For all the markers, parents showed single allele whereas hybrid showed both the parental alleles indicating the heterozygosity of the hybrid. The markers (mRcDOR-49, mRCDOR-69, mRcDOR-103, mRcDOR-166, mRcDOR-206) were further tested with DNA of 100 individual plants to assess their utility in hybrid purity assessment. All the individual hybrid plants showed both the alleles



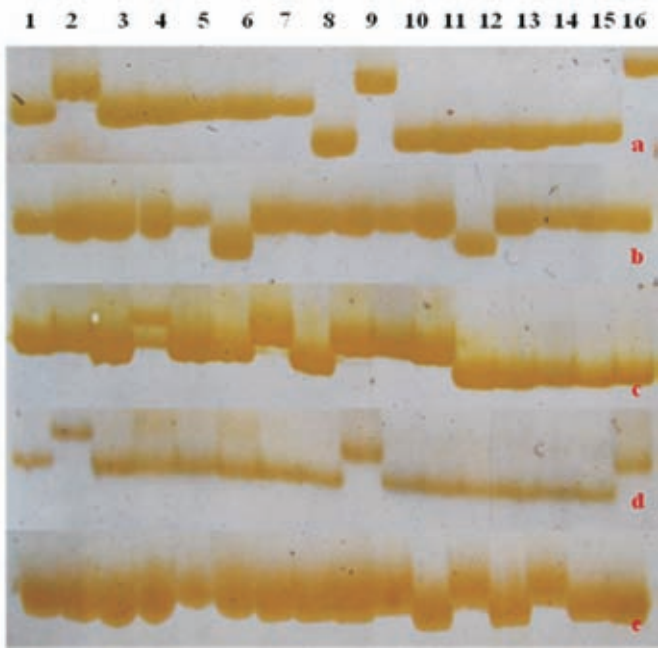
Unique alleles indentified for castor parental lines using SSR primer

(a) mRcDOR-24, (b) RCM-13315, (c) mRcDOR-151, (e) RCM-13405, (f) RCM-12532

specific to the parents except in few samples where parental band was observed indicating selfed plant. The results confirmed the utility of these markers in genetic purity assessment of the hybrids.

Screening of breeding lines of castor using SSR markers

Fifty primer pairs were selected to detect the SSR variation in 24 castor genotypes out of which 36 were polymorphic (72%) and 14 were monomorphic. A total of 92 SSR alleles were detected, and the number of alleles detected on a single locus ranged from 1 to 4, with an average of 2.5 alleles per locus. The highest number of alleles (4) was observed with RCM13335 and RCM13992 primer. The average PIC value of each locus was 0.30 with the highest of 0.56 for RCM12706 primer and the lowest of 0.11 for three markers RCM13360, RCM13405 and RCM13409. The major allelic frequencies ranged from 0.44 to 0.94, with an average of 0.76. The RCM12706 primer was highly informative and gave highest PIC of 0.56. The correlation coefficient ranged from 0.43 to 0.95. The analysis classified the set of parental lines into 4 clusters (I-IV).



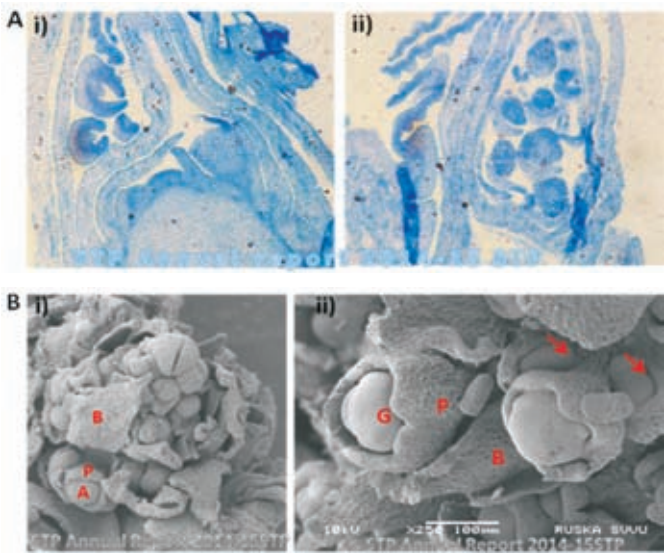
Genotyping of castor genotypes using SSR primer pairs

(a) RCM-12706, (b) RCM-12906, (c) RCM-13633, (d) RCM-13961, (e) RCM-13315

Molecular mechanisms governing sex expression

Variability in sex expression in castor and sex reversals to monoecism in pistillate lines of castor are complex mechanisms and an attempt has been made to understand the molecular mechanisms governing the phenomenon of sex expression in castor.

Inflorescence architecture of four parental lines was studied whorl-wise. In monoecious lines the whorl of transition from male to female flowers varied in two lines; the female flowers were seen in the first whorl itself to 19th whorl onwards. In ISF (Interspersed staminate flowers) line no transition to male was seen in flower bud stage and only female flowers were observed in all whorls like the pistillate lines. Study on spike developmental stages after differentiation in monoecious and pistillate lines was also carried out. Seven stages of differentiation were identified in monoecious line. Scanning Electron Microscopy (SEM) studies were carried out in two parental lines at two different stages.



Floral development in castor parental lines

A. Histological sections showing i) shoot apical meristem before differentiation and ii) after differentiation of shoot apical meristem to floral meristem with developing male flower buds. B. Scanning electron microscopy showing i) development of male flower buds in monoecious line. Bract is shown as B and tissue which later becomes become androecium (A) and petals (P) are indicated by red letters. ii) differentiation of female flower buds in pistillate line. Bract is indicated as B and tissue which later becomes becomes gynoecium (G), and petals (P) are indicated by red letters. Red arrows indicate the primordial tissue of young female flowers developing at the base (node) of the apical female flower

Epigenetic mechanisms play a major role in most of the developmental processes especially in floral development. To understand the effect of epigenetics on sex expression, seeds (120-140) of three parental lines of castor (2 monoecious lines and a pistillate line) were treated with four concentrations of epimutagen (2-deoxy 5-azacytidine) along with control plants and grown in pots in controlled conditions. Few seed treated plants were injected with epimutagen before and after primary inflorescence differentiation, along with control. Injection had an effect on stage of differentiation. In field grown plants of three parental lines, secondary or higher order spike buds, before and after differentiation were injected with four concentrations of epimutagen, in two sets. The variation in phenotype especially sex expression was monitored in the treated plants under controlled conditions (glasshouse) and in field. A seed treated and uninjected epimutant in a monoecious line exhibited stunting, rosette growth and completely male spike. Few plants of a monoecious line with 70-80% male flowers exhibited variation in sex expression such as reduced percentage of male flowers and the male flowers were stunted and small. However there was no significant effect of epimutagen seed treatment or injection on the monoecious line with two whorls (10-20%) of male flowers or the pistillate line grown under controlled conditions. The pollen from epimutagen treated plants did not show treatment-induced male sterility.

An epimutant of monoecious line showing stunting, rosette leaves and small spike with fully male flower buds

CROP PRODUCTION

Enhancing Resource Use Efficiency in Castor Based Cropping Systems

Moisture and nutrient utilization dynamics in castor-sorghum cropping system 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 in shallow Alfisols. The cropping season 2014 was late onset of monsoon with drought during initial stage and the total rainfall was short by about $<35\%$ of normal (730 mm) and both sorghum and castor crops suffered due to moisture stress. While sorghum received 15 mm rain after two days of sowing with 9 mm preceding rainfall event, castor crop did not receive any post-sowing rain for up to 18 days. Total cropping season rainfall received was 397 mm for sorghum and 365mm for castor, out of the total annual rainfall of 543mm. Plant stand of castor was

low with sole N or only NP application. The treatments NPK (60:40:30), NPK (60:40:30) + 5 t/ha FYM, as well as no manure or fertilizer application treatments recorded higher/optimal plant stand. Application of FYM along with 100% NPK recorded highest seed yield of sorghum (3501 kg/ha) and castor (361 kg/ha) compared to either N alone or NP or without FYM. No manure or application of either N alone or NP or 50% NPK recorded lowest seed yield (251 kg/ha). In general, crop growth and yield was higher with combination of NPK (60:40:30) + 5 t/ha FYM under the conditions of limiting soil moisture during 2014.

Agro-techniques for *rabi* castor

Number of days to 50% primary and secondary spike initiation of three castor genotypes differed due to four planting dates (15th Sept.; 1st Oct.; 15th Oct.; 1st Nov) sown during *rabi* season. Among different genotypes, number of days taken to 50% primary and secondary spike formation of DCH-519 hybrid was earlier by 2-7 days compared to GCH-7 and DCH-177 in September 15th planted crop.

The performance of drip irrigated *rabi* castor was evaluated in fixed plots with eight treatments in three replications in Alfisols with a soil pH of 7.86, organic carbon (0.39%) and low N (227 kg/ha), P (10.28 kg/ha) and K (200 kg/ha). Drip fertigation at 0.8 Epan + 100 % N and K application resulted in higher seed yield (3115 kg/ha) and consumed less water (20%) compared to check basin method in *rabi* castor. Ten (7 hybrids + 3 varieties) of public-sector released castor genotypes *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 in large plots 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. The significantly highest seed yield was recorded in DCH-519 (2921 kg/ha) out yielded all other genotypes.

Studies on Drought Tolerance, Water Use Efficiency and Source - Sink Relationships

Screening identified germplasm lines with drought tolerance

Six germplasm lines with known drought tolerance in previous experiments along with checks (48-1, DCH-519) were grown under rainfed conditions (no irrigation was given) during *kharif*, 2014 with four replications in RBD. All genotypes matured by 150 days. There were not many tertiaries produced. Crop was lanky due to continuous rain fall and more cloudy days during early stages of crop growth. Primary seed yield was significantly higher in RG-2797, RG-1494 which was on par with check DCH-519.

Seed yield of different spike orders, TDM and HI of different genotypes

	Seed yield (g/plant)				Total drymatter at harvest (g/plant)	Harvest index (%)
	Primary	Secondary	Tertiary	Total		
DCH-519	42.2	45.5	0	87.7	268.6	32.6
RG 111	16.3	47.2	0	63.5	195.3	32.3
RG 298	23.2	51.8	40.9	115.9	256.6	45.1
RG 1437	23.2	45.2	0	68.4	297.5	22.9
RG 1494	31.8	44.6	0	76.4	233.3	32.7
RG 1826	24.8	35.0	51.8	111.6	241.9	46.1
RG 2797	33.7	0.0	0	33.7	312.1	10.9
48-129.3	66.5	0	95.8	302.4	31.9	
Mean28.0	42		81.58	263.5	31.9	
SEm ±	3.2	4.2		4.45	12.23	1.39
C D (P=0.05)	9.6	12.8		13.48	37.1	4.23
C V(%)	19.6	17.4		9.44	8.04	7.58

There was no seed yield from secondaries in RG-2797. Secondary seed yield was more in RG-298 after the check variety 48-1. Tertiary seed yield was recorded only in RG-298 and RG-1826 and total seed yield was also significantly higher in these two genotypes. Total drymatter at harvest was more in RG-2797, RG-1437 but seed yield and harvest index were significantly higher in RG-298 and RG-1826 which indicated better performance of these genotypes in rainfed conditions though all other genotypes also showed drought tolerance in field during previous years of experimentation by withholding irrigation from 30-90 DAS.

Confirmation of drought tolerance of genotypes with good root traits

Ten genotypes (8 with good, 2 with poor root traits) along with checks (48-1, DCH-519) were sown in field during November, 2014 in three replications in split plot design with irrigated and water stress treatments and water stress was imposed from 30-90 DAS. Seedling vigor was more in RG-27, RG-72, RG-1645 and 48-1 and these genotypes also recorded more TDM at 30 DAS i.e., before imposing drought stress. Total drymatter (TDM) reduced significantly due to water stress. Chlorophyll content expressed as SPAD chlorophyll meter (SCMR) reading, relative water content (RWC), excised leaf water retention capacity expressed as excised leaf water loss percent (ELWL) increased, specific leaf area (SLA), and membrane stability index (MSI) decreased with drought stress.

***TDM and physiological parameters before relieving stress* (BRS)**

Parameter	Control	Stress
TDM (g/plant)	97.9	58.6
SCMR47.4	50.6	
SLA (dm2/g)	0.246	0.215
RWC (%)	67.5	68.4
MSI 72.5	71.4	
ELWL (%) After 4 hours	12.3	15.9

After relieving stress at 90 DAS, no irrigation was given to the crop till harvest. Primary seed yield reduction was significant with stress. RG-27, RG-89, RG-1826 and RG- 2439 recorded <16% reduction in seed yield of primary and secondary orders in stress compared to control with <0.85 DSI (Drought Susceptibility Index) and >84% DTE (Drought Tolerance Efficiency).

Only primary seed yield reduction was significant with stress. RG-27, RG-89, RG-1826 and RG-2439 recorded <16% reduction in seed yield in stress compared to control with <0.85 DSI and >84% DTE.

Seed yield of different spike orders, total seed yield and DSI

Treatment		Seed yield (g/plant)			Genotype	Total seed yield (g/plant)		Yield reduction (%)	DSI	DTE
		Primary	Secondary	Total		Control	Stress			
Control		47.7	40.3	88.0	48-1	87.9	78.4	10.8	0.58	89.2
Stress		37.7	33.9	71.6	RG-27	108.8	91.5	15.9	0.85	84.1
CD (P=0.05)					RG-72	83.5	65.6	21.5	1.15	78.5
Main plots		1.12	5.3	6.4	RG-89	72.5	70.3	3.2	0.17	96.8
Sub plots		7.7	7.1	11.5	RG-211	91.6	69.0	24.6	1.32	75.4
Interaction	1	10.9	NS	NS	RG-1117	93.7	54.0	42.4	2.27	57.6
	2	10.4			RG-1645	51.5	41.3	19.8	1.06	80.2
CV (%)	a	2.4	13.0	7.2	RG-1826	87.2	77.7	11.0	0.59	89.0
	b	15.5	16.3	12.3	RG-2439	90.6	80.4	11.2	0.60	88.8
					DCH-519	112.4	87.8	21.9	1.17	78.1

Seedling tolerance of castor genotypes with good root traits for drought and temperature

Under laboratory conditions nine genotypes were screened for drought tolerance (with PEG) and among the genotypes studied, RG-72 recorded 50% germination even at -0.6 M Pa stress. RG-72 and RG-2048 recorded good seedling growth up to -0.4 M Pa. Among the 10 genotypes studied for temperature tolerance with TIR (Temperature Induction Response) technique, RG-72, RG-1826, RG- 2048 and RG-2439 showed >90% seedling survival at induction and >80% survival even at lethal temperature. RG-72 and RG-2048 showed tolerance to drought and temperature during germination and seedling growth.

Studies on Source-Sink Relationships

Leaf fall quantification in castor

Three genotypes with differences in LAI (1-5), RG-2149, RG-2058, RG-387 along with variety 48-1 and hybrid DCH-519 as checks were sown in three replications with five rows each during *kharif,* 2014. In all genotypes, each leaf on 10 plants was tagged by using different colour ribbons. Data on fallen leaf number, leaf dry weight, seed yield of different order branches and TDM at harvest were recorded. Fallen leaf weight percent in total drymatter ranged from 15-27 with a mean of 20%. A factor for estimation of TDM with senescing/fallen leaf weight will be derived using regression equation and validation of regression model will be done and a correction factor for TDM and HI will be worked out using two years data.

Contribution of fallen leaf to total leaf in different castor genotypes (per plant)

Genotype	Total fallen leaf no.	Remaining leaf no. at harvest	Total leaves produced	Fallen leaf weight	Remaining leaf weight at harvest	Total leaf weight with fallen leaf	% fallen leaf weight
48-1	19	27	46	103.1	8.4	111.4	19.1
RG-2149	13	32	45	151.5	37.5	189.0	23.1
RG-2058	13	18	31	131.3	16.4	147.7	26.5
RG-387	21	42	63	61.1	15.4	76.5	15.2
DCH-519	18	28	46	96.6	16.1	112.7	18.2
Mean	17	29	46	109	19	127	20.4

Contribution of fallen leaf to total leaf in different castor genotypes (per plant)

Genotype	TDM at harvest (g/plant)		Seed yield (g/plant)				HI (%)	
	Without fallen leaf	With fallen leaf	Primary	Secondary	Tertiary	Total	Without fallen leaf	With fallen leaf
48-1	447.1	550.1	28.0	67.6	37.7	133.3	30.7	24.7
RG-2149	521.1	672.6	38.5	10.4	0.0	48.9	9.7	7.4
RG-2058	400.2	531.5	36.0	30.8	35.4	102.2	28.9	20.5
RG-387	349.2	410.3	21.6	57.0	37.2	115.8	33.5	28.4
DCH-519	436.6	533.2	46.5	41.8	40.9	129.1	30.3	24.7
Mean	430.8	539.5	34.1	41.5	30.2	105.9	26.6	21.1

Selection of castor parents with high harvest index

Three breeding lines with two checks were sown in four replications. Seedling vigour was more in K-12-86-2 followed by K-12-98-3. Primary, tertiary, total seed yield, TDM and HI did not differ among the breeding lines except secondary seed yield which was significantly higher in K-12-86-2 and K-12-98-3.

TDM, seed yield and HI of breeding lines

Genotype	Seedling vigour (g/plant)	Seed yield (g/plant)				TDM at harvest (g/plant)	HI (%)
		Primary	Secondary	Tertiary	Total		
DCH-519	0.52	35.6	35.3	27.2	98.1	523	18.9
K-12-86-2	1.17	23.5	69.2	53.6	146.3	443	33.7
K-12-91-2	0.69	21.2	59.6	51.1	131.9	475	27.7
K-12-98-3	0.88	29.8	72.0	45.6	147.4	487	30.4
48-1	0.74	32.5	80.2	60.9	173.6	557	31.3
Mean	0.80	28.5	63.2	47.7	139.4	497	28.39
SEm±	0.047	5.76	5.94	3.41	8.68	19.65	2.51
CD (P=0.05)	0.15	NS	19.4	11.1	28.3	64.08	8.19
CV(%)	10.10	35.0	16.3	12.4	10.8	6.9	15.31

None of these parental lines out yielded check variety 48-1. K-12-86-2 recorded 33.7% HI followed by 48-1 (31.3) and K-12-98-3 (30.4%).

CROP PROTECTION

Wilt

Identification of resistance sources against wilt

Eighty three parental and advanced breeding lines were evaluated against wilt in sick plot. Among them, three lines *viz*., PMC-40, DCS-86 and DCS-118 were highly resistant without disease. Thirty six entries (PMC-6, PMC-9, PMC-11, PMC-14, PMC-15, PMC-16, PMC-17, PMC-18, PMC-19, PMC-21, PMC-24, PMC-25, PMC-33, PMC-34, PMC-35, PMC-36, PMC-37, PMC-38, PMC-39, PMC-40, PMC-50, PMC-51, PMC-55, PMC-60, DCS-86, DCS-105, DCS-107, DCS-108, DCS-112, DCS-118, DCS-119, 48-1, collection from porbandar, DPC-23, DPC-21, M-571) were promising with <20% wilt incidence. The wilt incidence was 96% in susceptible check JI-35. In national screening nursery for wilt disease (NSN-W), among 48 entries evaluated in sick plot, 15 entries RCH-426, YRCH-1427, ICH-44, ICH-66, ICH-68, JHB-1006, JHB-1018, DCH-1642, PHT-14-44, PHT-14-46, DCS-109, DCS-119, JHB-1021, JHB-1025 and JHB-1027 were promising with <20% wilt incidence.

Haritha, 48-1 and DCH 519 showed resistant reaction with *Fusarium* isolates of Rajendranagar, Palem, S.K. Nagar. PCH-222 recorded susceptible reaction to Rajendranagar, S.K. Nagar isolates while resistant reaction to Palem isolate. DCS-9 recorded resistant reaction with *Fusarium* isolates of Rajendranagar, Palem isolates but susceptible to S.K. Nagar isolate.

For artificial inoculation of wilt disease, pathogen grown on sterilized sorghum grains for 10-14 days served as inoculum. To decide the quantity of inoculum required for high wilt incidence various concentrations starting from 0.5 to 4 g/kg soil were tested and 4 g of sorghum inoculum per kg soil was found to be ideal for wilt screening as it caused 100% mortality of susceptible variety JI- 35.

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

In pathogenic variability, many isolates caused 100% wilting in genotype JI-35 while low wilt was recorded in genotypes 48-1 and JI-258. All the isolates were able to cause moderate to high level wilt incidence in cultivars Kranthi and VP-1. *Fusarium* isolates For-12-16 (Hiriyur, Karnataka), For-13-33 (Junagadh, Gujarat), For-180 (Palem, Telangana), For-113 (Narkhoda, Telangana), For-112 (Narkhoda, Telangana) were

highly virulent causing more average wilt incidence (>75%) in seven tested castor cultivars. For-12-13, For-12-11, For-13-38, For-13-39 were less virulent and showed low wilt incidence. For identification of differentials of castor wilt disease, Tapoica, Jatropha were artificially inoculated with wilt pathogen and disease was not observed in the above plants which are non hosts for *F. oxysporum* f.sp. *ricini*.

Screening of *Trichoderma* isolates and *Pseudomonas fluorescens* against Fusarium wilt

Twenty *Trichoderma* isolates (Phytofura 1 to 15), *Trichoderma harzianum* Th4d, *T. asperellum* TaDOR7316, *T. asperellum* TaDOR673, *T. asperellum* Tv5, *T. asperellum* N13 and *Pseudomonas fluorescens* Pf2 were screened against wilt in castor. Among them, *T. harzianum* Th4d, Phytofura 3, 12, 13, 14 and Pf2 treatments recorded significantly less disease incidence (30.8%, 33.3%, 31.0%, 34.6%, 34.6 % and 32.0%, respectively) when compared to pathogen check (76.9%).

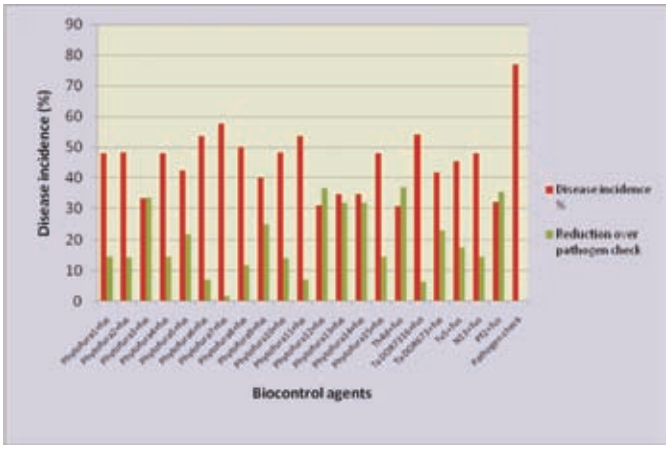
T. harzianum (Th4d) *P. fluorescens* (Pf2)

Trichoderma (Phytofura 12) Pathogen check

Efficacy of biocontrol agents against castor wilt

Management of wilt disease

A field trial was conducted for management of wilt disease in solarized and unsolarized plots. Solarization was done during peak summer (April to May) with polythene sheet. In unsolarized plot, plants were completely knocked down with wilt within a month



Efficacy of biocontrol agents against wilt incidence in castor

Solarized plot

Non-solarized plot

Management of castor wilt disease
a. Solarized plot b. Non solarized plot

after sowing. Soil solarization very effectively brought down Fusarium pathogen load in the soil by 20-fold and in solarized plot, *T. harzianum* Th4d seed treatment (55.3%) as well as seed and soil application (64.4%) recorded low wilt incidence and high seed yield compared to pathogen check (90.3%).

Gray mold

Detached leaf technique for screening against *Botryotinia* gray mold

A detached leaf technique has been standardized to screen castor lines against gray mold and a 5 mm agar disc of 7-day-old *Botryotinia ricini* culture was used for inoculation. Abaxial surface of castor leaf facing up was placed in a Petri dish lined with moist blotting paper and inoculum disc was placed on the detached leaves. The petiole of the leaf was inserted in moist cotton swab to maintain turgidity. The Petri plates containing inoculated leaves were incubated at 25°C and 90% RH with periodic wetting. The disease severity was recorded starting from 3 days after inoculation.

Gray mold development on detached castor leaves

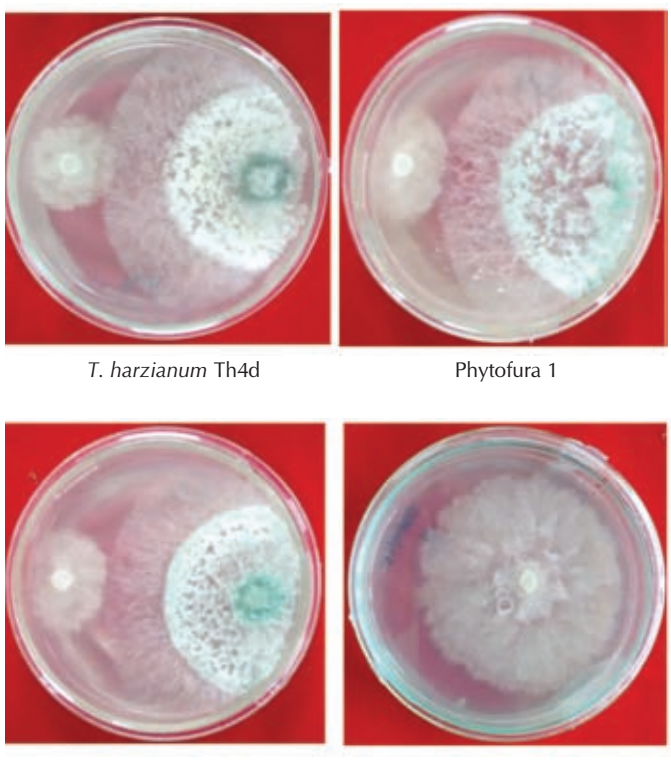
Reaction of castor cultivars to Phytophthora blight

Two castor cultivars GCH -4 and GCH-7 were resistant showing less than 10% disease severity over two years screening and eight cultivars *viz*., GCH-2, GCH-6, PCH-222, PCH-111, RG-3216, RG-3344, RG-907 and RG-1139 were moderately resistant with 10-25% disease severity.

Reaction of castor cultivars to *Phytophthora nicotianae*

Efficacy of biocontrol agents against Phytophthora seedling blight

Fourteen *Trichoderma* isolates were screened against *Phytophthora nicotianae* by dual culture technique. Highest inhibition (54.1%) was obtained with *Trichoderma harzianum* Th4d followed by other isolates *viz*., Phytofura 1, Phytofura 9 and Phytofura 13 which gave 51.7% of inhibition.



T. harzianum Th4d | Phytofura 1

Phytofura 9 | Control

Antagonistic activity of *Trichoderma* against *P. nicotianae*

Six *Trichoderma* isolates and *Pseudomonas fluorescens* Pf2 were screened against *Phytophthora* seedling blight of castor under pot culture conditions. High disease reduction (35.0%) was obtained with *Trichoderma harzianum* Th4d and *P. fluorescens* Pf2 treatments. Two isolates *viz.*, *T. asperellum* T673 and *T. asperellum* N13 were the next best treatments with 28.3% disease reduction.

T. harzianum Th4d

T. asperellum TaDOR7316

Untreated control

Screening of biocontrol agents against *Phytophthora* seedling blight

Microbial Control

Screening of effective isolates of Bt against *Achaea janata* and *Spodoptera litura* at higher temperatures

Six local isolates of *Bacillus thuringiensis* var. *kurstaki* from IIOR collection (127, 145, 151, 154, 171 and 172) found promising against larvae of the three major lepidopteran pests *Spodoptera litura*, *Helicoverpa armigera* and *Achaea janata* were evaluated at high temperatures *viz.*, 30, 32.5, 35, 37.5 and 40 °C through laboratory bioassays employing diet-surface treatment/leaf-disc techniques. Isolates 127, 154 and 172 were effective at high temperatures against all the three pests.

High pressure homogenization and cryomilling of Bt powder

High pressure homogenization of Bt-127 powder (105μ @ 5 g/500 ml) was carried out at CIRCOT, Mumbai at pressures of 10,000 and 15,000 psi for 2 hr duration. Particle size determination by dynamic light scattering (DLS) revealed particle mean diameters of 381.4 and 57.8 nm, respectively.

Cryomilling of the promising Bt isolate Bt-127 was carried out at ARCI, Balapur. 500 g of Bt-127 technical powder was cryomilled at 300 rpm for 2 hr duration. Samples were collected at half hourly intervals. Particle

size was determined by DLS and SEM. DLS of 60, 90 and 120 min samples gave mean diameter of 1533.5, 827.2 and 520.9 nm, respectively. Heat viable spore count of cryomilled Bt powders was reduced to 2 x 10^{11}/g as against 1.6 x 10^{19}/g in control.

Field testing of DOR Bt-1 and Bt-127 oil based SC formulations against *A. janata* and *S. litura*

Oil based Bt SC formulations in two doses of 3.0 and 3.5 ml/l were tested against *S. litura* on castor under field conditions with Delfin (1.0 g/l), Profenophos (1.0 ml/l) and DOR Bt-127 @ 3.5 ml/l was the most effective treatment resulting in 94.3% decrease of larval population by three days after spray.

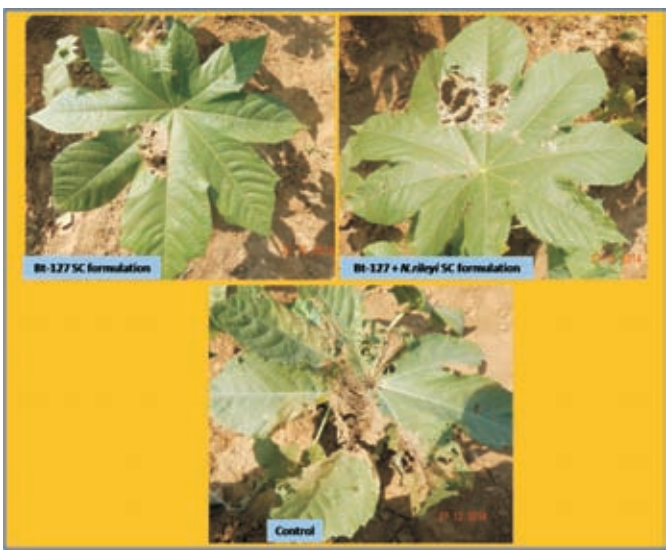
Field testing of Bt-127 SC formulation against *S. litura* on castor

Mass production of DOR Bt-127 isolate through solid state fermentation

Standardization of mass production was carried out for three parameters-nitrogen source (yeast extract, peptone and soybean meal), aeration and temperature. Production was carried out in polythene bags with sponges. Best combination was wheat bran supplemented with yeast extract, soya bean meal at 31°C using two sponge plugs and 2.0 kg of Bt (technical) was obtained from 90 bags.

Evaluation of Bt-127 SC formulation and combination formulations of Bt-127 and *B. bassiana* / *N. rileyi* SC formulations against *S. litura*

Testing of Bt-127 and *B. bassiana* SC formulation was undertaken against *S. litura* under field conditions and treatments were imposed on 40 days old crop against larval masses of 4-5 days old larvae. Bt-127 SC formulation, Bt-127 (cryomilled) SC formulation and combination formulation of Bt-127 + *N. rileyi* were the most promising treatments resulting in 95.4, 91.4 and 93.8% larval mortality, respectively 7 days after spray and were on par with Profenophos (93.1% larval mortality). Average seed yield/plant (primary spike) was highest in Bt-127 SC formulation (72 g) and Bt-127 (cryomilled) SC formulation (71 g) followed by combination formulation of Bt-127 + *N. rileyi* (68 g), *N. rileyi* (68 g) and Profenophos (67 g). All these treatments were significantly higher than the unsprayed control (59 g) and Bt-127 + *B. bassiana* (54 g). Field persistence of the formulations was high in all treatments till five days after spray (90-100%) but decreased by seven days after spray to 50% in Profenophos followed by 40% in Bt-127, Bt-127 + *B. bassiana* and Bt-127 + *N. rileyi* SC formulations. The persistence was negligible in all treatments (10-20%) by 10 days after spray.



Evaluation of microbial pesticidal formulations against *S. litura*

Identification of resistance sources against leafhopper in parental lines and advanced breeding lines

Castor parental lines *viz*., DPC-21, DPC-23, DPC-25, DCS-94, DCS-109, DCS-110, DCS-114, DCS-118, M-571, M-574 and collection from Porbandar were found resistant to leafhopper (hopper burn grade 0 to 1) while susceptible check, DPC-9 recorded maximum hopper burn (grade 4). Entries DCS-64, DCS-107, DCS-108, DCS-112 and DCS-113 were found susceptible to

leafhopper (hopper burn 3 to 4). Among 65 advanced castor breeding lines screened against leafhopper, 10 entries *viz*., PHT-14-4, PHT-14-23, PHT-14-31, PHT-14-33, PHT-14-38, PHT-14-53, PHT-14-54, PVT-12-64, PVT-12-76 and PVT-11-85 were found resistant to leafhopper (hopper burn grade between 0.1 to 1.0) as compared to grade 4.0 in susceptible check, DPC-9.

Confirmation of reaction of DPC-23 selections (mutant DPC-9) to leafhopper

Six selections (Rb-2011-213, Rb-2011-214, Rb 2011-217, Rb-2011-231, Rb-2011-244 and DPC-23) were found resistant to leafhopper with hopper burn grade 0 to 1 (on 0-4 scale) as compared to grade 3 to 4 in susceptible checks (DPC-9, DCH-177).

Confirmation of reaction of promising castor genotypes to capsule borer

Among 14 less susceptible germplasm accessions screened against capsule borer, two genotypes *viz*., RG-2800 and RG-2774 recorded lower capsule borer damage (< 25% in both primary and secondary spikes) under both net and open field conditions (infester row techniques) while susceptible check, DCS-9 recorded 64.4 to 100% capsule damage.

RG-2800 (less susceptible) | RG-2774 (less susceptible) Reaction to capsule borer | DCS-9 (highly susceptible)

Safety of newer and recommended insecticides to egg (*Trichogramma chilonis*) and larval parasitoid [*Snellenius* (*Microplitis*) *maculipennis*] of castor semilooper

Insecticides Flubendiamide, Chlorantraniliprole, Novaluron, Indoxacarb, Btk (Delfin) and DOR Bt-1 had lesser effect on the emergence of *T. chilonis* adults (>70%) compared to other insecticides (31.9 to 67.6%). In laboratory bioassay, Flubendiamide, Chlorantraniliprole, Novaluron, Btk (Delfin) and DOR Bt-1 were found safer to cocoon and adult stages of *S. maculipennis* (>70% adult emergence and <30% adult mortality).

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

De-oiled rice bran with sugarcane and palm jaggery recorded 13.3 and 17.3% attraction, respectively, while, wheat bran with sugarcane jaggery recorded maximum attraction of 25.3% under free-choice test at 24-h after release. Field evaluation of five poison baits against *S. litura* in castor revealed that effectiveness of wheat bran + sugarcane jaggery + chlorpyriphos 20EC (51.1-53.3% larval mortality) was on par with 45.6-50% mortality recorded with the standard check (rice bran + sugarcane jaggery + Monocrotophos 36SC).

Larval mortality after feeding on poison bait

Evaluation of mating disruption technique against *S. litura*

In a field cage experiment on mating disruption with synthetic sex pheromone of *S. litura* [(Z,E)-9,11-14Ac and (Z,E)-9,12-14Ac in 10:1] at two doses (50 g a.i./ha and 100 g a.i./ha), no oviposition of *S. litura* was recorded in caged castor plot treated with pheromone in both the doses, while, untreated control plot recorded 16 egg-masses at 10 days after release of moths.

S. litura sex pheromone treated and untreated caged castor field

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

Seasonal activity of *S. litura* monitored at two locations using pheromone traps during castor cropping seasons (July, 2014 to February, 2015) revealed two peak trap catches, the first during 37th to 39th MW (September second fortnight) and second during 41st to 43rd MW (October). Peak catches of *S. litura* ranged from 83 to 122.5 moths/trap/week. Trap catches declined from 47th MW to 5th MW (November second fortnight to February first week). Moth catches showed a significant positive correlation for minimum temperature (r = 0.44 to 0.59), rainfall (r = 0.36 to 0.43) and rainy days (0.49 to 0.51). Peak oviposition of 4.2 and 7.4 egg masses/5 plants in castor was recorded during 39 and 41st MW at Rajendranagar and Narkhoda, respectively. Significant positive relation found between egg masses in castor and current (r = 0.72 to 0.73) and previous week (r = 0.57 to 0.92) trap catches. The response of *S. litura* to light trap was lower (up to 32 moths /week) than sex pheromone trap.

Field evaluation of sex pheromone and synthetic attractants against major lepidopteran pests

Lures of *S. litura* pheromone (SlP) in combination with synthetic attractants *viz*., phenyl acetaldehyde (PAA) and 2-phenyl ethanol (PE) were developed and evaluated using funnel trap in castor. Mean *S. litura* moth catches in SlP + PAA and SlP + PE ranged between 9.8-32.8 and 12-49.3 moths/trap/week, respectively. Attraction of female moths was low in both the combination lures (2 to 4.5 moths/trap /week in SlP + PAA; 0 to 0.5 moths/trap/week in SlP + PE). Field evaluation of synthetic attractants (PAA, PE and PAA + PE) with three types of traps (funnel trap, sleeve trap and water trap) revealed that water trap baited with PAA + PE was effective in attracting *S. litura* and *C. punctiferalis* moths with maximum catches of 6.8 and 5.8 moths/trap/week, respectively.

Identification of effective synthetic attractants for shoot and capsule borer, *Conogethes punctiferalis*

Electroantennographic (EAG) response of one day old female capsule borer moths to six synthetic kairomonal attractants was studied at two concentrations (0.1 and 1 μl). In both concentrations, female moths showed significant hyper sensitive reaction to 2-phenylethanol (-2.563 to -3.152 mV) and benzaldehyde (-2.152 to -3.089 mV).

Evaluation of sex pheromone of capsule borer

Sex pheromone of capsule borer (improved septa of IICT blend II) was able to attract maximum moth catches of 2.25 moths/trap /week in field. The incidence of capsule borer larvae was observed during 36th MW (3-9 September, 2014) and remained active till harvest of the crop with peak population of 2.6 larvae/plant during 42nd MW (15-21 October). Parasitism of capsule borer larvae by *Eriborus*

trochanteratus (up to 9.5%) and two morphs of *Conogethes* (*Dichocrocis*) *punctiferalis* was also recorded.

Studies on off-season biology of castor shoot and capsule borer (*C. punctiferalis*)

Survey on alternate hosts and off-season survival of shoot and capsule borer, *C. punctiferalis* revealed multiplication of capsule borer on guava fruits (0.03-0.19 larva/fruit/tree), mango inflorescence (0.025-0.15 larva/inflorescence/tree), shoot and capsules of perennial and self-sown crop of castor (0.1-1.3 larva/plant). Laboratory rearing of the larvae revealed that there was no diapause during the off-season.

Alternate hosts of *C. punctiferalis* on guava and mango during off-season

SOCIAL SCIENCES

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

An impact study on frontline demonstrations (FLDs) was surveyed across five years in castor growing states *viz.*, Telangana, Karnataka, Tamil Nadu, Haryana, Gujarat, Rajasthan and Madhya Pradesh. The compilation of socio economic characters and adoption behaviour of castor growers indicated similarities among the growers of irrigated castor across states. But some variation was observed in adoption among the dryland farmers of Telangana and Karnataka states. It was also observed that most of the castor growers belonged to middle to old age group across the study states. It indicates that young farmers are not much attracted towards cultivation of castor and needs to be motivated for taking up the castor crop.

Frontline demonstrations

Eighty castor FLDs were conducted in Anantpur district of Andhra Pradesh and Mahabubnagar district of Telangana state. Of these, 45 demonstrations were conducted in *kharif* and 35 were conducted in *rabi*. During *kharif*, 35 FLDs were conducted in Singanamala and Narpala, while 15 FLDs in Kalyanadurgam mandals of Anantapur district. During *rabi,* two in Achampet and 33 in Godal, Balmoor mandal of Mahabubnagar district. The *kharif* sowings were delayed due to late on-set of south-west monsoon both at Singanamala and Kalyandurg Mandals (between last week of July and first week of August-2014). Due to long dry spells during crop growth period in Kalyandurgam Mandal all the FLDs were vitiated. Even though, Singanamala and Narpala mandals, there were sporadic additional showers received in Chakrayapeta, Bandameedapalle, Peravali Chamaluru, only eight FLDs could sustain, and in six other fields, one/two protective irrigations were given during dry spells, leading to improvement in crop yields. Thus, out of 45 demonstrations conducted in Anantapur district during *kharif* 2014, only 14 demonstrations were successful and rest of them were vitiated due to deficit rains.

Productivity potential and economics of FLDs conducted

Particulars	No. of demos	Yield (kg/ha)		% increase	Cost of cultivation (₹/ha)		Gross returns (₹/ha)		Addl. net returns (₹/ha)	BCR	
		IT	FP*		IT	FP	IT	FP		IT	FP
Rainfed											
DCH-519	8	509	398	28	8250	8906	17815	13930	4541	2.2	1.6
DCH-519	6**	1023	857	19	15917	14750	35700	29995	4540	2.2	2.0
Mean	14	729	595	22	11536	11410	25515	20815	4540	2.2	1.8

Groundnut - 348 kg/ha; under protective irrigation 750 kg/ha, * Castor equivalent yield , ** Protective irrigation
Price: Castor - ₹3500/q, Groundnut - ₹400/q; ,IT-Improved technology, FP-Farmers practice

It can be observed that the mean yield of eight demonstrations under rainfed was 509 kg/ha as against castor equivalent (398 kg/ha). It indicates that castor is one of the options suitable under rainfed condition. The additional net returns accrued was ₹ 4540/ha with a BCR of 2.2 in IT and 1.8 in FP. In case of protective irrigation, the yield in IT was 1023 kg/ha as against 857 kg/ha in FP (castor equivalent yield). The additional net returns accrued was ₹ 4540/ha. The mean yield of 14 FLDs in IT was 729 kg/ha as against 595 kg/ha in FP. The additional net returns was ₹ 4540/ha with BCR of 2.2 in IT and 1.8 in FP.

Tribal sub plan (TSP)

Despite low rainfall during the year, 400 demonstrations in castor, 60 in sunflower and 75 in safflower were conducted during 2014-15 in the districts of Kurnool, Prakasam in Andhra Pradesh, Mahabubnagar, Ranga Reddy in Telangana and Chitradurga in Karnataka. Two NGOs *viz.*, Agri-Biotech Foundation (ABF) and Vikashith Rythu Sanksema Sangam (VRSS) and All India coordinated centre for castor at Hiriyur of Chitradurga have conducted the demonstrations under the guidance of IIOR.

Productivity potential and economics of castor crop under TSP

Village name	No. of demos	Yield (kg/ha)		% increase	Additinal Net Returns (₹/ha)	BCR	
		IT	FP			IT	FP
Sarlapalli	2	813	635	28	4700	2.8	2.4
Kudichintabayalu	2	875	715	22	4300	3.0	2.6
Dubbathanda	10	609	529	16	2368	1.8	1.6
Chedurubavithanda	7	1114	893	25	5807	2.0	1.9
Narlakuntathanda	13	490	365	36	3872	2.0	1.5
Mean	34	695	558	25	3902	2.0	1.7

Thus, despite severe drought, castor hybrids have performed better than other crops and gave more yield than state average of 675 kg/ha. The highest mean yield obtained was 1114 kg/ha as against 893 kg/ha in farmers' practice at Chedurubaithanda. The lowest yield recorded was 490 kg/ha in IT as against 365 kg/ha in farmers' practice at Narlakuntathanda. The overall mean yield in IT was 695 kg/ha against 558 kg/ha in farmers' practice with an increase of 25% yield. The additional net returns accrued was ₹ 3902/ha with BCR of 2.0 in IT and 1.7 in FP.

Consortium approach at Adilabad

Public-funded institutions like, IIOR, CRIDA, ARS and KVK (Adilabad) and Department of Agriculture, Telangana State initiated a programme on a consortium mode under TSP. In the hamlets of Sitagondi grama panchayat, such as Kothwalguda, Malkapur, Chinnamalkapur, Peddamalkapur, six on-farm trials on groundnut with castor (11:1) were conducted where farm pond water irrigation facility was available. The sowings were taken up between December, 2014 and first week of January, 2015. A field day was conducted on March, 28, 2015 in which about 100 farmers including both Gondu and Non-gondu farmers from Kothwalguda, Malkapur, Chinna Malkapur and Pedda Malkapur, Sitagondi participated. The farmers were happy with the performance of K-6 and TAG 24 of groundnut varieties and DCH-519, castor hybrid. Farmers harvested about 7q groundnut and 2q castor/acre.

A society namely "Youth Farmers Sangam" was formed at Kothwalguda. The society aimed at increase in the area and number of farmers under castor-groundnut cropping system. In association with IIOR-TSP, the society distributed 12 kg castor and 180 kg pods of groundnut (TAG 24 and K6) to the farmers who are having farm pond irrigation facility. In turn the farmers

were advised to return double the quantity of groundnut pods to the society in order to provide the seed to other farmers for ensuing crop.

Developing mobile-phone based knowledge modules for sunflower and castor growers

The information needs of sunflower and castor growers were assessed. Farmers' had high information need for improved cultivars, market prices and weather alerts while the need was low for agronomic practices, harvesting and post-harvest management. Based on the information needs, the content for video, voice and text messages were collected and edited for developing text, voice and video advisories for mobile based dissemination. In order to sustain the interest of the farmer, a direct and crisp message 80-90 words per minute was found to be effective. Based on the effectiveness and call charges duration, message was standardized as 50-55 seconds . The most appropriate time for sending voice advisories was found to be 7.00-9.00 AM and 5.00-6.00 PM. Various platforms (NIC, vKVK, LIVES and farmer SMS portal) were used for mobile based dissemination. Evaluation methodology for mobile based advisory system was standardized. It was established that the mobile based knowledge dissemination resulted in an increase in the knowledge of farmers.

Videos of critical interventions influencing the yield of sunflower and castor were developed in Telugu (14 nos), Hindi (13 nos) and English (3 nos). Voice advisories on sunflower (70) and castor (50) and text messages (95) in regional language were developed for mobile phone based dissemination. Sixty nine text messages were developed and more than three lakh text messages were disseminated through farmers SMS portal to 4850 oilseed farmers' mobile telephones. Videos of trainee's interaction and feedback on model training course were recorded and hosted on the IIOR website for wider dissemination.

SUNFLOWER

CROP IMPROVEMENT

Genetic Resources

The Indian Institute of Oilseeds Research maintains 2621 sunflower accessions of which 1750 were stored under medium term cold storage facility available at IIOR. Hundred trait specific germplasm accessions procured during 2013 including lines with high oil (42%), high oleic acid (84%), dwarf plant types and early maturity (43 days) were multiplied and 66 accessions were deposited with NBPGR for long term storage.

Germplasm augmentation and multiplication

During 2014-15, 285 accessions were obtained from USDA-ARS. Out of these, RHA-362 (EC-838668), RHA-275 (EC-838754) and HA-116 (EC-838868) were detained due to downy mildew interception after post quarantine inspection by ICAR-NBPGR Regional Station, Hyderabad. Among the 282 lines, seven accessions are wild belonging to the species, *Helianthus niveus* subsp. *canescens* and the rest belongs to *H. annuus*. The newly procured accessions include 31 CMS lines, of which, 19 CMS lines are

Newly procured germplasm showing variation in reaction to leafhopper, plant height and maturity

with their respective B lines. In addition, the collection includes 90 B lines, 97 restorer lines and 38 inbreds. These lines were sown at IIOR experimental farm, Rajendranagar for testing their germination, local adaptation and seed multiplication.

Maintenance of parental lines

A total of 10 CMS lines with their counterparts (maintainer lines) were maintained through paired crossing and 60 restorer lines and 45 inbred lines were maintained through sib mating during *kharif* 2014 and *rabi* 2015. Around 20-25 promising restorer lines were used in development of new experimental hybrids with diverse CMS lines.

DUS testing: DUS testing trial was conducted during *rabi* 2014 for 26 candidate entries (6 A-lines, 8 R lines and 12 hybrids) with 13 reference entries in three separate replicated trials and data for 26 DUS traits was recorded in accordance with the DUS test guidelines. Final consolidated report was submitted to PPV&FRA for 23 candidates comprising three hybrids (2 new and 1 VCK), 15 new A, B and inbred parental lines and five R lines of sunflower.

Identification of non-dormant accessions: Extended periods of seed dormancy causes problem in efficient seed production of sunflower. During 2013, nine accessions showed precocious germination on the capitula due to untimely rains at harvesting. The non-dormancy in these accessions was confirmed through a simple technique. At the time of physiological maturity (when the back side of head turned yellow) the mature heads were dipped in a water bucket thrice a day for four days in order to provide moisture to the seeds. Two genotypes, GMU-156 and GMU-53 were identified as non-dormant and can be sown within10 days after harvest.

Mature head was dipped in water Seeds of GMU-156 germinating on capitulum

Multilocation evaluation of accessions with high yield and oil content

Thirty one promising accessions for high yield and oil content were evaluated at three locations with two replications along with two checks (DRSF-113 and Morden) at IIOR, Hyderabad, Solapur and Savalvihir. Eight germplasm accessions recorded higher yield than the national check (DRSF-113). GMU-799 followed by GMU-189 and GP2-1217 recorded highest seed yield in evaluation trial. These germplasm accessions will be provided to AICRP centers for development of new populations and inbreds.

Evaluation of the promising accessions in multilocation test

Promising germplasm lines have been identified for high seed yield/plant, high oil content and high test weight and are listed for exploitation in the breeding programmes.

Promising germplasm for key traits

Trait	Germplasm	Breeding material
High yield (40-46 g/ plant)	GMU-440, GMU-776, GMU-189, GMU-779, GMU-211, GMU-286, GMU-571, GMU-1032, GMU-503, GP-91101, GMU-1075/ EC-512683, GMU-1108/EC-512746, GMU-438, GP6-714, GP6-271, GP6-571, GP6-951, GP61475, GP6-644, GP6-211, GP6-1227, GP6-286, GP2-1227, GP6-1254, GP4-745	ARM-243B, CMS-234B; 17A; 7-1A
High oil (40-42%)	GMU-817, GMU-1199, GMU-1048, GMU-1116, GMU-242, GMU-205, GMU-1079, GMU-405, GMU-474, GMU-266, GMU-902, GMU-821, GMU-366, GMU-673, GMU-42, GMU-236, GMU-1200-1, GMU-830, GMU-804, EC-601848, EC-601935, EC-601853, EC-601827-1, EC-601999 EC-601845, EC-601999, EC-601628	6D-1
High test weight (9-10 g/ 100 seeds)	GMU-510 , GMU-525, GMU-556 , GMU-561 , GMU-1218, GP4-1723 , PSCRM-127	-Nil-

Generation advancement of RILs

Recombinant inbred line (RIL) development for mapping powdery mildew resistance is in progress for the cross between PS-2023B x TX-16R using single seed descent method and 123 RILs were advanced to F_7 generation. Days to flowering in the RILs varied from 48 to 70 days. SND incidence was high in these RILs and RIL No 236 was highly susceptible (100%). Among these, 13 RILs had low infection of powdery mildew, 12 RILs had medium infection while, 98 RILs had high infection.

Among the identified sources of resistance to powdery mildew, PI-642072 (TX-16R) was selected as resistance source for mapping gene(s) that confer resistance to

powdery mildew in sunflower. As it possesses multiple resistance, 130 RILs derived from the cross PS-2023 and TX-16R were assessed for their reaction to downy mildew in the sick plot at Latur. In the 1st set of 65 RILs, disease incidence was low and varied from 0 to 62.5 against an incidence of 63.66 in the check, Morden. Forty three RILs had nil incidence.

Advanced 190 RILs of Morden x EC-537925 to F_7 generation through single seed descent method. The flowering ranged from 43 (RIL No 347) to 71 days. SND infection was very severe almost reaching 100% in some of the RILs. RIL No 381 had uniformly 30 g/plant in all the plants. Powdery mildew was low in 39 RILs, medium in 31 RILs and high in 117 RILs. Crosses between two resistant sources (TX-16R x ID-25) were made to isolate genetic stocks conferring resistance to powdery mildew coupled with high yield and oil content. Both the parents are late maturing types and flowering in RILs varied between 55 to 74 days. Powdery mildew reaction in F_4 generation of 162 RILs indicated low incidence in 24 RILs. RIL Nos 21, 39, 43, 45, 83, 86, 99, 106, 127, 156, 161 and 176 had consistently low infection of powdery mildew.

Mapping and tagging of powdery mildew resistance

Interspecific hybridization with resistant donor species (*H. praecox*) and generation advancement was done. The pollen fertility of the hybrids between *H. praecox* and Morden ranged from 1.7 to 40.3%. All the F_1 hybrids of *H. praecox* with cultivated sunflower were found to be resistant to powdery mildew. Backcrossing and selfing is in progress for development of BC_1F_1 and F_2 populations. Transcriptomic profiling has been initiated in resistant donors (TX-16R, ID-25, *H. praecox* and *H. debilis*) along with susceptible line (PS 2023). Control and infected samples at 24, 48, 72 hpi of susceptible and resistant genotypes were fixed for differential gene/protein expression analysis through transcriptome and proteome profiling. RNA isolation, cDNA preparation, library preparation and preliminary sequencing and bioinformatic analysis using reference genome are completed and interpretation of data is being done. Differentially expressed proteins in susceptible (PS-2023) and a wild resistant species (*H. praecox*) following infection with *G. cichoracearum* were studied. A total of 689 proteins were detected in the study. Up-regulation of photosynthetic proteins indicates that powdery mildew affects the regulation of photosynthesis. Heat shock proteins (HSP-70, HSP-93-III, HSP-91, ATHSP-90, disease response) were upregulated after infection in resistant genotype and only HSP-70 in the susceptible genotype.

Molecular characterization of powdery mildew

Morphological and molecular analysis of powdery mildew isolates from all sunflower growing regions confirmed that powdery mildew infecting sunflower in different parts of India is *G. cichoracearum*. There was no sequence variation in the powdery mildew isolates from sunflower for the 418 bp amplicon with primers specific to *Golovinomyces*. Studies on alternate crops and reservoirs showed that cucumbers were predominantly infected with *P. xanthii*. None of the tested powdery mildew samples showed infection of *L. taurica*. Cross infectivity studies of powdery mildew of cucurbits on sunflower failed to spread infection.

Novel alleles at *AHASL1* locus for resistance to sulfonylurea and imidazolinone herbicides in wild *Helianthus* species

Acetohydroxyacid synthase (AHAS) inhibiting herbicides like imidazolinone and sulfonylurea have played a significant role in effective weed control in the cultivation of sunflower since their discovery. The allelic variation in repeat sequences and single nucleotide present in *AHASL1* (AHAS Large subunit1) gene is well captured using molecular markers like SSRs and SNPs for genotyping commercial sunflower lines with herbicide resistance trait. A total of 50 accessions belonging to 21 wild *Helianthus* species including annuals and perennials of different ploidy levels were analyzed for allelic variation at *AHASL1* locus along with some parents of commercial sunflower hybrids and compared with an imidazolinone resistant sunflower line, SCG101 (PI-617099). None of the wild species tested showed the resistant allele (*Ahasl1-1*) similar to SCG101 though it is present in some of the parental lines of hybrids. However, the parental lines having *Ahasl1-1* type allele failed to survive the field dose of imazethapyr (Pursuit®: 100 g ai/ha) spray. Intra-species and intra-accessional allelic variation could be observed among the species. The *AHASL1* allele in *H. praecox* accession 1823 with 3 bp addition showed promising resistance to sulfonylurea based herbicides

(ethoxysulfuron - Sunrise: 50 g ai/ha, pyrazosulfuron ethyl - Saathi: 80 g ai/ha, and sulfosulfuron Fateh: 13.5 g ai/ha) and survived even up to 2X concentration of the tested herbicides. *H. nuttalii* accession NUT05 had a novel allele with 15 bp deletion at the SSR loci and these plants remained green for a longer time in the field after imazethapyr spray when compared to the wild type plants before dying off. The phenotypic attributes of the novel alleles identified in this study could be explored further and utilized in breeding programmes.

Multiple sequence alignment of SSR variation at *AHASL1* locus in *Helianthus* wild species (ACC repeat sequences are italicized and underlined. * indicates conserved sequences)

MAX11	CCGACTCCAAATCCACCACCACCACCACCACCA--------	CTCAACCACCGTTACAGGCGC
Nut1517	CCGACTCCAAATCCACCACCACCACCACCACCA--------	CTCAACCACCGTTACAGGCGC
MAX2010	CCGACTCCAAATCCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
MAX33001	CCGACTCCAAATCCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
MAX30	CCGACTCCAAATCCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
MAX1631	CCGACTCCAAATCCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
MAX07	CCGACTCCAAATCCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
NUT05	CCGACTCCAAATCCACCACCAC----------	TCAACCACCGTTACAGGCGC
SCG101	CCGACTCCAAATCCACCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
ARM243A	CCGACTCCAAATCCACCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
E00292A	CCGACTCCAAATCCACCACCACCACCAC----------	TCAACCACCGTTACAGGCGC
PRA1823	CCGACTCCAAATCCACCACCACCACCACCACCACCA	TCACTCAACCACCGTTACAGGCGC
TX16R	CCGACTCCAAATCCACCACCACCACCACCACCACCA---	CTCAACGACCGTTACCGGTGC
CMS7-1A	CCGACTCCAAATCCACCACCACCACCACCACCACCA---	CTCAACGACCGTTACCGGTGC
RHA6D-1	CCGACTCCAAATCCACCACCACCACCACCACCA--	-CTCAACGACCGTTACCGGTGC
	********** **********	***** ******** ** **

Characterization of phyllody

Symptoms of phyllody on sunflower in India were sporadically reported but during the past few years, appearance of phyllody is frequently observed albeit at a low frequency (0.5 to 3.0%). In some of the accessions like IC-443608, it is observed at a high frequency (30%). Abnormalities in the affected plants were manifested in different forms in both mono-headed and branched accessions. To check if the floral malformations are due to phytoplasma infection, direct as well as nested PCR analysis using universal primers (P1/P7 and R16F2n/R2) specific to the phytoplasma was done which resulted in amplicons of 1.8 and 1.2 kb, respectively. Restriction fragment length polymorphism (RFLP) analysis of the nested PCR product, sequence homology, phylogeny and putative restriction sites of the 16S-23S intron region indicated that the phytoplasma causing sunflower phyllody in India belongs to the 16SrII-D group. Interestingly, it is similar to the phytoplasma causing phyllody in sesame.

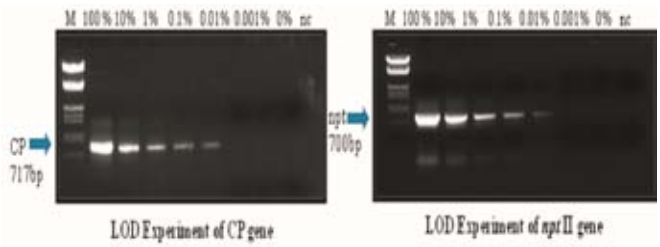
Sunflower phyllody showing floral transformation. In the gel, S represents sesame, H represents sunflower and P and R the P1/P7 and R16F2n/R2 giving 1.8 and 1.2 kb products, respectively

Multiplication and characterization of event no 481 harbouring the TSV-CP gene

Sunflower event No 481 in T_4 generation was multiplied along with its null segregants and presence of the gene in the event harbouring TSV-CP gene was confirmed through dot blot and Southern analysis. Two events *viz.*, CPS-247 and CPS-481 were characterized for junction sequences using In-Tail PCR. Primers for the event 247 were successfully developed (CPS-247 F: caatccatcttgttcaatcatgc; CPS-247 R: gagaattaagggagtcacgttatga): In order to determine the limit of detection (LOD) of the transgene, both the positive plant DNA (Event 481) and negative control DNA were initially diluted to obtain a concentration of

50 ng/μl. The dilution series were made using genomic DNA of positive plant 481 event (GMO) and negative control (untransformed sunflower) DNA to give final dilutions of 100%, 10%, 1%, 0.1%, 0.01%, 0.001% and 0%. PCR was carried out using TSV-CP and *npt*II specific primers with a total of 200 ng of DNA per reaction. Expression of the transgene was detected up to 0.01% in case of both the TSV-CP and *npt*II genes.

Limit of detection of transgene



Development of Hybrids Suited to Different Agro-Climatic Conditions

Diversification of parental base for developing hybrids

Gene pools for respective maintainer and restorer lines were initiated by allowing forced random mating in *rabi* 2013 among high yielding maintainer (B) and multi and mono-headed restorer (R) lines with good combining ability. In *kharif* 2014 and *rabi* 2015 random mating cycles-2 and 3 were completed and the material was advanced through open pollination in isolation. In random mating cycle-3, from B gene pool around 25 individual plants were selected while from restorer gene pool around 50 plants were selected based on flowering duration, plant height, disease and insect reaction in natural field condition.

Evaluation of experimental hybrids

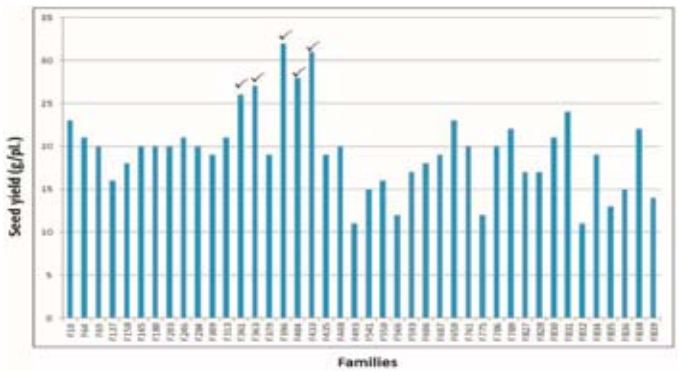
A total of 600 experimental hybrids were evaluated for days to 50% flowering, days to maturity, plant height, head diameter, number of leaves/plant, 100-seed weight, seed yield/plant and oil content (%) during *kharif* 2014 in augmented design. Eighteen hybrids were found superior over the checks (DRSH-1 and KBSH-44) with the desired traits such as early maturity, seed yield and oil content (%) and data of promising hybrids is presented. Based on the data, one hybrid (IOSH-14-02) has been nominated for initial hybrid trial (*kharif* 2015) and two entries for *rabi* 2015.

Data of promising hybrids in comparison to the check hybrids

Hybrid	Seed yield of 5 plants	Days to 50% flowering	Oil content (%)
IOSH-14-1	227.5	53	38.9
IOSH-14-2	310.5	52	39.6
IOSH-14-3	266.0	54	37.9
IOSH-14-4	267.0	56	39.5
IOSH-14-5	256.5	52	36.4
IOSH-14-6	434.0	59	34.6
IOSH-14-7	276.5	59	36.8
DRSH-1	169.5	62	39.9
KBSH-44	224.5	61	32.5

Improving the autogamy in parental line, ARM-243A/B

To improve the autogamy in ARM-243A/B pair, a population of circa 1000 plants of ARM-243B (population-0) was raised and seed yield under selfing was measured during *kharif* 2013. The seed yield ranged from 0.1 to 30 g/plant. More than 85% of the plants recorded seed yield of less than 15 g/plant. From this population, a set of 45 plants having seed yield more than 20 g/plant were selected and raised in progeny rows in late *rabi* 2013 (population-1). The population mean improved from 9 g/plant in the base material (population-0) to 20 g/plant in the first cycle of selection. In population 1, over 100 plants recorded more than 25 g/plant seed yield. Out of 42 families evaluated, 30 plants were selected from five families that showed uniform progeny performance. Progeny testing of these selected plants (20 progenies/plant) was carried out during *kharif* 2014 for phenotypic uniformity and high seed yield under selfing. The improved ARM-243B for high autogamy is being used in A-line conversion.



Seed yield in ARM-243 B

Establishment and seed multiplication of diploid wild accessions

A total of 105 accessions belonging to six wild diploid annual species [*H. annuus* (wild); *H. debilis* sub-species *debilis, cucumerifolius, silvestris, vestitus* and *tardiflorus*; *H. praecox* sub-species *praecox*, *hirsutus* and *runyonii*; *H. niveus* sub-species *canescens; H. petiolaris* sub-species *petiolaris* and *fallax* and *H. argophyllus*] has been assembled through import of seeds from USDA. Fifty four wild accessions belonging to six diploid annual species were established at IIOR and seed multiplication has been taken up.

Development and characterization of the interspecific hybrids

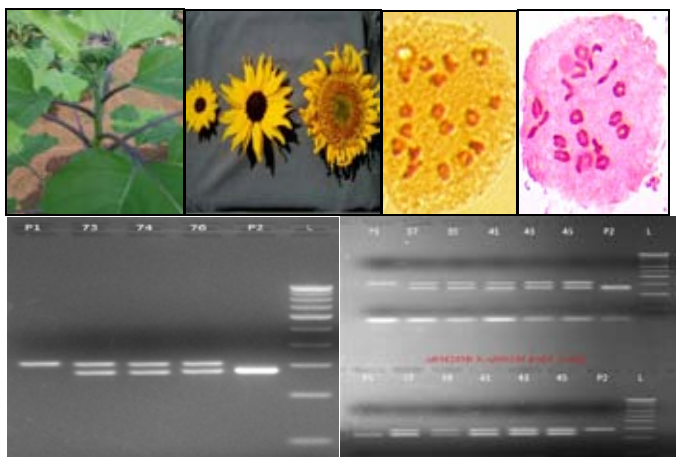
The pre-breeding programme involving wild *Helianthus* species *viz.,* wild *H. annuus, H. praecox, H. petiolaris*, *H. nivious* and *H. argophyllus* has been initiated in *kharif* 2014 and interspecific hybrids were developed. Interspecific hybrids were successfully produced between cultivated sunflower and other wild diploid annual sunflowers *viz.,* (ARM-243A, CMS-10B and CMS-234B) and *H. annuus* (wild) (ANN-2101), *H. petiolaris* (PET-738), *H. praecox* (PRA-1154, PRA-1910, PRA-437, PRA-1142, PRA-1157, PRA-1823, PRA-1158), *H. debilis* (DEB-691, DEB-369, DEB-1676, DEB-367, DEB-1564, DEB-1218) *H. niveus* (NIV-608) using conventional hybridization.

The interspecific hybrids between cultivated sunflower and diploid annual species were characterized for morphological traits. All the F_1 plants showed the dominance of wild traits in terms of plant height, stem and petiole pigmentation, branching, number of capitula, disc colour, leaf size, stem girth, ray flower size, seed size, seed length, plant height, leaf shape, leaf base, seed base colour, days to 50% flowering, days to maturity, etc. The interspecific hybrids between *H. annuus* (wild), *H. argophyllus* and cultivated sunflower were highly fertile and set seeds on backcrossing but seed setting was poor in most of the other interspecific hybrids. These hybrids have been backcrossed with cultivated sunflower for further utilization in breeding programmes.

Pollen fertility per cent of all interspecific hybrids with parental lines

Cross combination	No. of plants	Pollen fertility (%)
ARM-243B x ANN-232	6	91.1
ARM-243B x ANN-1483	4	90.6
ARM-243B x ANN-1529	2	88.5
ARM-243B x ANN-1270	4	92.2
ARM-243B x ANN-243	4	91.4
ARM-243B x ANN-1624	4	89.3
ARM-243B x ARG-1317	6	89.9
ARM-243B x ARG-1575	4	87.5
ARM-243B x ARG-2126	4	89.0

The F_1's of crosses involving *H. annuus* (wild) and *H. argophyllus* were confirmed through meiotic studies and molecular analysis using sunflower specific SSR molecular markers. For cytological study in each F_1 plant, a total of 50 PMC's per combination were used for taking cytological observations (chromosome shape). In F_1 plants, no meiotic abnormality was observed at all stages. In *H. annuus* (wild) combinations maximum of one quadrivalent was observed in most of the PMC's while in some PMC's two quadrivalents were observed which showed that *H. annuus* (wild) genome is similar to cultivated sunflower. However, in *H. argophyllus* combinations of 2-3 quadrivalents were observed in majority of the PMC's. A set of 110 SSR primers in *H. argophyllus* and 358 primers in *H. annuus* (wild) were tested for hybridity confirmation of which ORS-1021 and ORS-677 showed polymorphism in *H. argophyllus* combination and ORS-1021, ORS-1048, ORS-844, ORS-898 and ORS-148 in *H. annuus* (wild) combination.



Morphological variation, chromosome size, shape and number and hybridity confirmation through SSR markers in interspecific hybrids

CROP PRODUCTION

Sustainability of sunflower based cropping system with reference to input management 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 had recorded the highest yield (3272 kg/ha). Response to K was negative for sorghum seed yield up to 2007-08 and from 2009-10 onwards, K application resulted in increase in yield over 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 (1231 kg/ha) compared to 150% NPK (1057 kg/ha) to both the crops in the system. Un-manured 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 (0.22 to 0.31 *vs* 0.42). Soil fertility in general was declining over the years except for an increase that was noticed for organic carbon in treatment receiving FYM or crop residue along with NPK. P build up was significant over the years in all treatments receiving regular P applications compared to only N or no manure applications. Sorghum yield showed a 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.

The total annual rainfall at Narkhoda farm for 2014 was below normal (581 mm in 42 rainy days as against the normal rainfall of 730 mm in 35 rainy days). The monsoon was delayed beyond July 14 and drought situation prevailed during August.

Performance of sorghum

The general growth of sorghum (Hybrid CSH-16) in *kharif* 2014 was normal and significant differences were observed due to treatments. Significantly the highest seed yield (4862 kg/ha) of sorghum was recorded with RDF (60:30:30 kg N:P_2O_5:K_2O/ha) application that was at par with all adequate and balanced nutrient applications and was significantly superior over 50% RDF or only N or only NP or no manure application.

Performance of sunflower

Growth and yield of sunflower (DRSH-1) succeeding sorghum in *rabi* 2013 differed significantly due to nutrient management treatments. Plant height was significantly the highest with NPK (60:30:30 kg N: P_2O_5:K_2O/ha) + FYM 5 t/ha (sorghum) – NPK (60:30:30 kg N: P_2O_5:K_2O/ha) (sunflower) (171 cm) compared to all other treatments. Significantly lowest growth parameters *viz*., plant height, stem girth, head diameter, filling, was recorded in N alone or no manure treatments. Seed yield was significantly highest (1573 kg/ha) with NPK + FYM (sorghum) – NPK (sunflower) that was at par with NPK - NPK+ B (1 kg/ha) or NPK+S (25 kg/ha) + B+ Zn (5 kg/ha) application compared to 150% NPK application (1460 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 SYI (0.73).

Understanding causes for leaf axil branching

Leaf axil 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 2015 clearly established consistently 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 at field level (hybrid, DRSH-1).

Performance of sunflower and castor under integrated crop management

Integrated crop management in Alfisols during *kharif* 2014, resulted in realizing the highest sunflower seed yield of 2.4 t/ha with a B:C ratio of 2.88; in castor, a

seed yield of 2.6 t/ha with a B:C ratio of 3.76 in large plot demonstration under irrigated condition. The ICM included the dynamic adoption of BMPs of crop rotation, summer ploughing, soil test based balanced nutrition, IPM package, harvesting at physiological maturity, etc. Normal yield with only RDF (60:60:30 kg N: P_2O_5: K_2O/ha –sunflower; 40:30:30 kg N: P_2O_5: K_2O/ha) was about 12 q/ha for sunflower and 15 q/ha for castor.

Nitrogen x phosphorus x sulphur interaction studies

To understand the main and interaction effects of nitrogen, phosphorus and sulphur on sunflower, hybrid (DRSH-1), two field experiments were conducted during *kharif* 2014 at ICRISAT-IIOR farm (Vertisol) and IIOR Narkhoda farm (Alfisol). The treatments comprised of three levels of N (0 45 and 90 kg/ha) as main plot and factorial combination of P (5 levels : 0, 20, 40, 60, 80 kg/ha) and S (4 levels : 0, 15, 30, 45 kg/ha)) as sub plots in randomized block design with three replications.

Alfisols

Experimental results revealed that in Alfisol, soil available N and S was significantly influenced by the application of N, P and S levels. N x P and P x S interaction was also found significant with respect to available soil N and S. Soil available P was significantly influenced by the application of P and S levels. N x S and P x S interactions were also found significant with respect to soils available P.

Drymatter yield of sunflower was significantly influenced by the application of P and S levels. P x S, N x S, N x P and N x P x S interactions were found statistically significant. Seed yield of sunflower hybrid (DRSH-1) was significantly influenced by the application of N, P and S levels. Further, P x S and N x P interactions were also found significant with respect to seed yield.

N uptake by shoot was significantly influenced by the application of N, P and S levels. N x P and P x S and N x P x S interactions were also found significant. P uptake by shoot was significantly influenced by different levels of P application. S uptake by shoot was significantly influenced by N and P levels. P x S, N x S, N x P and N x P x S interactions were found statistically significant. N, P and S uptake by seed was significantly influenced by the application of N, P and S levels. N x P and P x S and N x P x S interactions were also found significant.

Vertisols

In Vertisol, P and S were found significant with respect to soil available N. P x S interaction was found significant. Similar trends were observed in case of soil available P and S. Interaction effects were found non-significant.

Drymatter yield of sunflower hybrid (DRSH-1) was significantly influenced by the application of P and S levels. However, interaction effects were found non-significant. Seed yield of sunflower hybrid (DRSH-1) was significantly influenced by the application of N, P and S levels. Further, P x S and N x P interaction was also found significant with respect to seed yield. Other interactions were found non-significant.

N uptake by shoot was significantly influenced by the application of P and S levels. N x P, N x S and N x P x S interactions were found significant. P and S uptake by shoot was found significantly influenced by the application of P levels. No interaction effects were observed. N uptake by seed was significantly influenced by the application of P and S levels. N x P x S interaction was also found significant. P uptake by seed was significantly influenced by the application of P levels. N x P and N x S interactions were found significant. S uptake by seed was significantly influenced by the application of P levels. N x P interaction was found significant.

Performance of sunflower as component crop in integrated farming systems

As a part of IIFSR-IIOR collaborative project, trials were initiated in Coimbatore (*rabi*/summer) Kakdwip (spring) to assess the performance of sunflower as component crop in integrated farming systems. The field trials were conducted in coordination with IFS (Coimbatore)-AICRP (Sunflower) and IFS (Kakdwip)-AICRP (Nimpith) centres.

Coimbatore

The sunflower crop at TNAU, Coimbatore was taken in two cropping systems namely *viz*., bhendi-maize + cowpea (fodder)-sunflower (CS-2) and cowpea (Veg.)-

cotton-sunflower (CS- 4) raised during *kharif*, *rabi* and summer seasons. The details of crop, yield, cost of cultivation and benefit cost ratio are presented. Among the cropping systems, the bhendi in CS-2 recorded the highest yield and benefit cost ratio (2.15). In CS-4, the sunflower crop recorded the maximum benefit cost ratio of 2.19.

Crop details, yield and economics of cropping system

Cropping system	Crop and variety	Area (ha)	Date of sowing	Date of harvest	Yield (kg)	Cost of cultivation (₹)	Gross returns (₹)	B:C ratio
Kharif								
CS4:Cowpea (veg.)-Cotton-Sunflower	Cowpea (Ankur Gomathi)	0.25	02.06.13	27.06.13	1105	8891	11050	1.24
CS2:Bhendi-Maize + Cowpea (fodder)-Sunflower	Bhendi (Arka Anamika)	0.20	31.07.13	26.11.13	2018	13139	28252	2.15
Rabi								
CS4:Cowpea (veg.)-Cotton-Sunflower	Cotton (Bt Mallika)	0.25	02.09.13	26.03.14	512	10940	25600	0.42
CS3:Bhendi-Maize + Cowpea (fodder)-Sunflower	Maize (NK 6240) + Cowpea (F)	0.20	29.01.14	28.04.14 10.03.14	1250	8528	16250	0.52
Summer								
CS2:Bhendi-Maize + Cowpea (fodder)-Sunflower	Sunflower (TNAU SF Hyb. CO-2)	0.20	29.04.14	16.07.14	396	7956	13860	1.74
CS4:Cowpea (Veg.)-Cotton-Sunflower	Sunflower (TNAU SF Hyb. CO-2)	0.25	04.04.14	01.07.14	398	6359	13930	2.19

Sunflower thalamus as cattle feed

About 850 g of sunflower capitulum (moisture content of the harvested product was more than 15%) was chopped into pieces and fed to dairy animals (IFS 0001 & IFS 0002). On an average the dairy animals consumed 67% of the total quantity fed as cattle feed.

Sunflower residue for vermicomposting

The left out stalks and post-harvest residues of sunflower were shade dried and fed to earthworms. A quality vermicompost (100 kg) was produced at the end of June, 2014. The vermicompost was applied for the succeeding crops of the IFS module.

Studies on Drought Tolerance and Water Use Efficiency

Confirmation of drought tolerance under field conditions

Twelve genotypes (9 with high root volume and weight and 3 low root traits) were studied for their drought tolerance in the field. Crop was subjected to drought from 43 to 85 DAS. Drought affected different parameters significantly except days to flowering and leaf number. None of the genotypes showed better growth than checks before relieving stress. No difference in chlorophyll content was observed in control and stress while relative water content and membrane stability decreased in stress by 18 and 21%, respectively.

Significant yield reduction was observed due to stress in all the genotypes except GKVK-1 and 189-R, both poor root types, with very low yield in control. Though check hybrids DRSH-1 and KBSH-44 recorded significantly higher yield than other genotypes both in control and stress, AKSF-42-1, M-1026 and 298-R showed less drought susceptibility index (DSI) compared to the checks. Significant differences among genotypes were observed for harvest index (HI) but stress did not affect the HI. DRSH-1 recorded highest HI both in control and stress followed by KBSH-44.

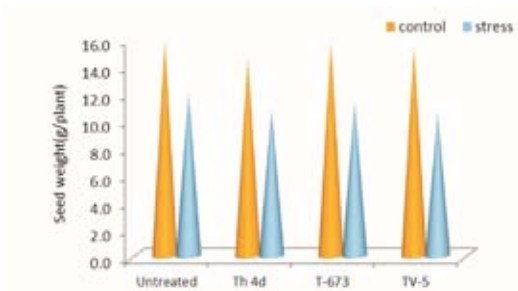
Seed yield and harvest index under drought stress conditions

Genotype	Seed yield (g/plant)			Harvest index	
	Control	Stress	DSI	Control	Stress
DRSH-1	38.0	22.9	0.98	28.8	33.4
AKSF-42-1	21.7	13.9	0.89	16.6	23.6
AKSF-51-6-1	24.7	12.8	1.19	19.7	22.7
CSFI -5261	20.0	8.0	1.48	19.0	18.0
GMU - 519	17.2	10.0	1.04	12.1	15.1
M-1026	19.7	13.2	0.81	17.2	19.8
298-R	20.4	14.5	0.72	19.0	20.2
856-R	29.1	16.8	1.04	21.8	24.0
KBSH-44	38.1	23.5	0.95	23.9	26.5
AKSF-I-46-2*	23.2	9.8	1.42	21.7	20.3
GKVK-1*	12.0	10.2	0.38	11.8	18.2
189-R*	11.3	8.3	0.65	14.1	16.9
Mean	**22.9**	**13.7**		**18.8**	**21.5**
CV (%)	16.5			16.8	
CD (P=0.05)					
Main plot	3.3			NS	
Sub plot	4.9			5.6	
M x S	4.9			NS	

* Poor root genotypes

Effect on *Trichoderma* seed treatment on drought alleviation

Seeds of DRSH-1 treated with 3 isolates of *Trichoderma viz.*, Th-4D, T-673 and TV-5, that showed positive effect on growth and yield in the previous year, were studied along with untreated control for their response to drought under field conditions. Stress was imposed by withholding irrigation from 43 to 83 DAS. Seed treatment with *Trichoderma* isolates had no significant influence either on growth or on yield. But, significant decline in yield was observed due to stress while HI increased.



Effect of *Trichoderma* seed treatment on seed yield

Rapid screening of sunflower genotypes to identify root traits for P acquisition under differential P levels

Rapid screening of 25 sunflower genotypes was conducted in poly bags under net house condition 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 45 day growth period, genotype HoHAL-17 and HoHAL-22 had produced superior root volume (28 and 20 cc/plant, respectively) under P stress situation. The corresponding uptake of P for above genotypes was found to be 6.2 and 5.4 mg P/g DM, respectively. Genotypes CMS-17A and CSFI-5134 had showed poor root volume (< 5.0 cc/plant) and P uptake (< 2.0 mg P/g DM) under P stress condition.

Genotype HoHAL-17 under P stress starvation (4 mg P/kg soil) and sufficient level (30 mg P/kg soil) variation in root volume at 45 day growth period

Biochemical studies

Sixty sunflower parental lines were screened for oil content, high oleic acid, total antioxidant capacity, reducing power and total phenol content. Oil content ranged from 41.04% (RHA-6D1) to 28.13% (GPR-58). Oleic acid content varied from 19.36% (CSFI-5185) to 87.8% (NO-1002). Total antioxidant capacity of sunflower parental lines ranged from 18.24 to 36.47 DPPH (TEAC mm/g), reducing power varied from 11.53 to 24.43 (GAE mg/g), while total phenol content ranged from 49.66 to 72.43 gallic acid equivalent mg/100 g dry weight.

CROP PROTECTION

Alternariaster Leaf Blight

Secondary metabolite profiling of *Alternariaster helianthi*

Nine isolates of *A. helianthi,* the causal agent of sunflower leaf blight were selected based on

pathogenic variability comprising of highly virulent, moderately virulent, less virulent isolates and were used for secondary metabolite profiling. The secondary metabolite profiling has shown differences among the isolates. The isolates under highly virulent (*Ah* 18-Patancheru, TS; *Ah* 38 - Mudhol, KA; *Ah* 125-Jalna, MH) and moderately virulent (*Ah* 157 - Muzaffarpur, BR; *Ah* 142-Sirapur, KA; *Ah* 12-Narkhoda, TS) groups had identical banding and the less virulent isolates (*Ah* 92, *Ah* 160, *Ah* 158) have shown entirely different banding pattern which indicates that secondary metabolites have a role in pathogenicity and disease severity in leaf blight of sunflower.

The mycelial protein analysis of the nine isolates by electrophoresis (native and dissociated protein) showed native protein bands of mol.wt. from 23.3 to 66 KDa and dissociated proteins of molecular weight from 6.6 to 43 KDa. Even though differences were observed in the mycelium protein banding there was no significant variation between the isolates of highly, moderately and less virulent isolates.

Development of IDM module for management of major diseases

Priming of seeds with *Trichoderma viride* or Carbendazim and Thiomethoxam has significantly increased seed germination compared to control. All the six treatments were found effective in reducing the disease severity of necrosis, *Alternariaster* leaf blight and powdery mildew significantly as compared to control. Seed priming with Carbendazim @ 2 g/kg + Thiamethoxam @ 4 g/kg followed by foliar spray of Propiconazole @ 0.1% and Thiamethoxam @ 0.04% twice at 30 and 45 days after sowing recorded the highest yield of 1432 kg/ha with the highest B:C ratio of 2.6. Seed treatment with *T. viride* @ 10 g, Thiamethoxam @ 4 g/kg followed by foliar spraying of Propiconazole @ 0.1% + Thiamethoxam @ 0.04% at 30 and 45 days after sowing was found effective with a sunflower seed yield of 1366 kg/ha and B:C ratio of 2.0.

Integrated management of major diseases of sunflower

Treatment	Germination (%)	Necrosis (%)	Leaf blight (%)	Powdery mildew (%)	Yield (kg/ha)	B:C ratio
Seed biopriming with *T. viride* 10 g/kg + foliar spray of Propiconazole @ 0.1% + Thiamethoxam @ 0.04% at 30 and 45 DAS	95	21.0	34.4	48.2	1289	2.2
Seed priming (Carbendazim 2 g, Thiamethoxam 4 g/kg) followed by foliar spray of Propiconazole @ 0.1% + Thiamethoxam @ 0.04% at 30 and 45 DAS	95	23.2	22.3	47.3	1432	2.6
Seed priming (Carbendazim 2 g, Thiamethoxam 4 g/kg followed by foliar spray of Propiconazole @ 0.1% Azadirachtin @ 0.15% at 30 and 45 DAS	90	23.2	39.5	50.1	1205	2.5
Seed treatment with *Trichoderma viride* @ 10 g Thiamethoxam @ 4 g/kg followed by foliar spray of Propiconazole @ 0.1 % + Thiamethoxam @ 0.04% at 30 and 45 DAS	91	25.6	34.8	46.7	1366	2.0
Untreated control	88	35.7	53.4	64.0	1016	

Evaluation of sunflower genotypes against necrosis disease (SND) in field with artificial inoculation

Five out of six commercial sunflower genotypes tested with artificial sap inoculation in the field were found tolerant to SND. Though these genotypes were tested positive to ELISA, external visible symptoms of SND were not found at any stage and gave normal yields comparable to healthy checks. The infector rows were 100% susceptible and exhibited severe necrotic symptoms and succumbed to death in few weeks.

Disease reaction of sunflower genotypes after sap inoculation. A. no symptoms- tolerant; B. highly susceptible

Insect vector populations, disease severity of SND and sunflower leaf curl (SuLCV) viral diseases

Thrips population was in peak (5-9/3 leaves/plant) during the 3rd week of August to 2nd week of September coinciding with dry spells after moderate rains. The SND incidence was highest in the subsequent next 2 weeks indicating a direct positive correlation between highest vector population and maximum disease incidence. With respect to SuLCV, the incidence was very less during the year though the insect vector whitefly population was observed in abundance.

Field testing of Bt-127 SC formulation and combination formulations of Bt-127 and *B. bassiana* / *N. rileyi* SC formulations against *Helicoverpa armigera*

Field testing of the above formulations was undertaken during *rabi* 2014 and treatments were imposed during the star-bud stage of the crop through releases of 7-days-old larvae @ 3 larvae/head. Bt-127 SC formulation and combination formulation of Bt-127 + *N. rileyi* were the most promising treatments resulting in 98.9 and 92.2% larval mortality, respectively at five days after spray and were on par with Profenophos (100% larval mortality). The seed yield was also highest in combination formulation of Bt-127 + *N. rileyi* (480 g/10 plants) and DOR Bt-127 SC formulation (473 g) and significantly higher than Profenophos (418 g) and unsprayed control (338 g). Field persistence of the formulations five days after spray was 100% in Bt-127 SC formulation and Profenophos, 70-80% in the combination formulations. Seven days after spray, persistence of Bt-127 + *N. rileyi* was 80% while persistence in other SC formulations and Profenophos was lowered to 40-50%. Only Profenophos treatment showed a moderate persistence of 50% after 10 days of spray.

Evaluation of microbial pesticidal formulations against *H. armigera* on sunflower

Identification of resistant sources against leafhopper

Of 20 promising sunflower germplasm lines screened under high pest pressure, GMU-1, 243, 504 were found to be resistant to leafhopper (injury grade-1). GMU-4, 25, 112, 116, 255, 595, 669, 688, 696, 776, 1029 and 1093 were found to be moderately resistant (injury grade-2). Among 150 advanced lines evaluated under high pest pressure, CMS-17A, GP-6-1282, GP-9-472-4-13 were found to be moderately resistant to leafhopper (injury grade-2) compared to the susceptible check morden with injury grade-5 (more than 65% hopper burn).

Effect of resistant sunflower genotypes (cultivated and wild) on the development of leafhopper

Development of leafhopper was totally affected on wild sunflower species (DEC-1887, HIR-03, TUB-07) compared to cultivated sunflower genotypes (GMU-1, 243, 504) where majority nymphs survived and developed into adults. The results are indicative of a high level of antibiosis in wild sunflowers.

Determination of damage potential of leafhopper

Seed yield reduction due to leafhopper was 24.4 and 39.6% in KBSH-53 and morden, respectively in the unprotected crop in comparison to the crop fully protected with insecticide while the reduction with need based protection was 12.7 and 24.9% in KBSH-53 and morden, respectively.

Toxicity of insecticides, biopesticides and fungicides to natural enemies of major insect pests and pollinators

Toxic effect of nine insecticides (Cypermethrin, Fenvalerate, Dichlorvos, Imidacloprid, Spinosad, Profenophos, Novaluron, Chlorpyriphos, Monocrotophos), two biopesticides (HaNPV and NSKE)

and five fungicides (Carbendazim, Mancozeb +Carbendazim, Metalaxyl, Propiconazole and Hexaconazole) to natural enemies and pollinators in sunflower was studied by involving egg parasitoid, *Trichogramma chilonis* Ishii and insect predator, *Cheilomenes sexmaculata*. *T. chilonis* adult emergence (0 to 3.2%) and *C. sexmaculata* adult survival (0 to 13.30 %) was highly affected by insecticides followed by fungicides (0 to 13.5% in *T. chilonis* and 40 to 67% in *C. sexmaculata*). Biopesticides were relatively safer to both natural enemies with 77.14 to 80.30% *T. chilonis* adult emergence and 90 to 93.30% *C. sexmaculata* adult survival up to 24 h after treatment. Activity of pollinators was affected by insecticides followed by fungicides compared to normal activity in the biopesticides treated sunflower crop.

Collection and identification of pollinators

Honey bees are the major pollinators in sunflower. *Apis dorsata* was predominant with maximum activity followed by stingless bee, *Tetragonula laeviceps*, *A. florea* and *A. cerana indica*. Bumble bee species *Xylocopa tenuiscopa*, *X. amethystina*, *X aestuans* and leaf cutter bee *Megachile bicolor* were also found to be frequently visiting sunflower crop and pollinating.

SOCIAL SCIENCES

Frontline Demonstrations

Conducted 50 FLDs on whole package, five demonstrations each on soil test based fertilizer application, soil application of sulphur and foliar spray of boron at 45 DAS during *rabi* 2014-15 in Bodduvanipalle, Obulapuram, Mulapalle, Bavapuram and Thamballapalle villages of Prakasam district, Andhra Pradesh.

Farmer-Scientist interaction in frontline demonstration of DRSH-1 sunflower hybrid

In whole package, sunflower hybrid, DRSH-1 with recommended best management practices were used in comparison with farmers' practice (FP) of growing private hybrids.

Soil samples were collected from the selected 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 and accordingly fertilizers were applied in demonstration plots in comparison with FP of applying urea and DAP fertilizers.

Demonstrations on soil test based fertilizer application increased the seed yield by 19% as compared to FP of applying urea and DAP. In IT (₹24,250/ha) the cost of cultivation also decreased as compared to FP (₹26,000/ha). The additional net returns accrued were ₹13,000/ha with IT. The B:C ratio was 2.86 and 2.24 with IT and FP, respectively. Simple practice of application of boron @ 2 ml/l as directed spray on capitulum at 55 DAS resulted in 12% increase in seed yield in IT plot as compared to FP. An additional net returns of ₹4,813/ha was accrued with IT. The B:C ratio was 2.13 and 1.98 with IT and FP, respectively. Soil application of sulphur @ 25 kg/ha increased the seed yield by 13% in IT plot as compared to FP. The additional net returns accrued were ₹6,063/ha with IT. The B:C ratio was 2.49 and 2.24 with IT and FP, respectively.

A Farmers' field school (FFS) on "Improved Technologies for Increasing Sunflower Production" was organized during *rabi* 2014-15 at Parmeshwarnagar in collaboration with REEDS (NGO). The FFS farmers were shown the fields of the master farmers at critical stages of the crop and discussions were held on benefits of adopting improved technologies with scientists of IIOR and officers of agricultural department.

Participation of IIOR Scientists and Farmers in field school

A field day was organized on February 12, 2015 at peak flowering stage of the crop on one of the master farmers' field to show the benefits of adopting improved technologies in sunflower. Around 120 farmers participated in the field day.

SAFFLOWER

CROP IMPROVEMENT

Genetic Resources

Wide variability was recorded for seed yield (4.5-60.3 g/plant), 100 seed weight (3-6.6 g) and oil content (21.6-36.7%) among 215 trait specific accessions (*rabi* 2013-14). Maximum accessions (44.2%) recorded oil content ranging from 30 to 33%, whereas, 19.5% accessions possessed oil content greater than 33%.

Frequency distribution of accessions for oil content

Oil content (%) (range)	Accessions in each range class (%)
≤25	2.3
25.1-30.0	34.0
30.1-33.0	44.2
33.1-35.0	15.4
>35.0	4.2

Among 148 accessions of IIOR safflower core subset, variability was recorded for seed yield (2.1-63.6 g/plant), 100 seed weight (2.4-8.3 g) and oil content (18.3-33.7%). Among 40 accessions received from USDA, variability was recorded for number of branches (8-16) and capitula (19-44/plant), 100 seed weight (2.5-4.7g), oil content (25.3-40%). A set of 30 accessions from Mexico recorded variability for plant height (95-124 cm), number of branches (5-11), capitula (16-27), seeds/capitula (14-46), 100 seed weight (2.9-4.4 g) and oil content (31.3-38.6%).

Maintenance, Conservation and Supply

Rejuvenation of 1800 accessions and multiplication of 252 accessions was undertaken during *rabi*, 2014-15. Diverse germplasm accessions (180) were stabilized for development of association mapping panel. Seeds of 1314 accessions were conserved under medium-term storage in IIOR gene bank. A total of 641 samples of 518 accessions were supplied for multilocation evaluation and 115 accessions for utilization in breeding programmes.

Development of Improved Varieties and Hybrids

Incorporation of pre-flowering morphological marker to identify pollen shedders in A-lines

A morphological marker having short-non-pricking-spines present sparsely on outer involucral bracts (OIB) on flower-heads and leaves has been incorporated in male sterile plants of A-lines, A-133A and A-153 while the pollen shedders possessed densely distributed long-pricking-spines on the OIB. These A-lines exhibited 90-95% male sterility. The marker differentiation of sterile plants and pollen shedders is quite conspicuous about 40-45 days prior to flower opening which facilitated rouging out of pollen shedders prior to flowering in hybrid seed production blocks.

Morphological marker (a few non-pricking spines) in sterile plant (right) and many long sharp-prickly spines in pollen shedder (left) of an A-line, A-133A of safflower

Development of new CMS-based hybrids

Preliminary yield evaluation of new hybrids: The hybrids, DSH-299 recorded 50% higher (4027 g/13.5 sq.m; CV: 12%; $CD_{0.05}$:121), DSH-290 yielded 48% higher (3895 g/13.5 sq.m), DSH-303 exhibited 47% higher seed yield (3788 g/13.5 sq.m), DSH-289 recorded 35% higher seed yield (3601 g/13.5 sq.m), and DSH-302 (3570 g/13.5 sq.m) and DSH-301 (3562 g/13.5 sq.m) recorded 33% higher seed yield than the check hybrid, NARI-H-15 (2645-2671 g/13.5 sq.m) under minimal irrigation (one irrigation) condition.

Initial and advanced hybrid trials: In the Initial Hybrid Trial (IHT), DSH-242 recorded 36% higher seed yield (2315 kg/ha) than the check hybrid, NARI-H-15 (1704 kg/ha) at the national level. It recorded 45% higher oil yield (665 kg/ha) than the check hybrid, NARI-H-15 (459 kg/ha). DSH-242 exhibited resistance to wilt in wilt sick plots at Solapur and IIOR, Hyderabad. In the Advance Hybrid Trial-I (AHT-I), two hybrids yielded 19-37% higher than the check hybrid NARI-H-15 at the national level; DSH-250 recorded 37% higher seed yield (2336 kg/ha) and DSH-249 yielded 19% higher seed yield (2022 kg/ha) than the check hybrid, NARI-H-15 (1704 kg/ha). DSH-250 recorded 37% higher oil yield (630 kg/ha) while DSH-249 yielded 26.7% higher oil yield than NARI-H-15 (459 kg/ha). Both the hybrids exhibited resistance to wilt in wilt sick plots at Solapur and IIOR, Hyderabad.

Performance of safflower hybrid DSH-185 in farmers' fields: Demonstrations of DSH-185 *vs.* variety A-1 was conducted in the real farm situation in farmers' fields in Chhattisgarh and Maharashtra. DSH-185 yielded 17.5 q/ha whilst the check A-1 recorded 5 q/ha under rainfed conditions in farmers' fields at village Khamhariya, Mungeli district, Chhattisgarh. Under irrigated condition, DSH-185 recorded 21 q/ha while A-1 yielded 18 q/ha in farmer's fields at Jamb village, Parbhani district, Maharashtra.

Development of parental lines

Interspecific derivatives: Interspecific derivatives identified for Alternaria tolerance have continued to show resistance reaction (20%) while the susceptible checks, A-1 and PBNS-12 had 100% disease severity under very heavy natural infestation of Alternaria in August sown experiment. The advanced generation interspecific derivatives of crosses between susceptible cultivated species (*C. tinctorius*) and six wild species, *C. palaestinus*, *C. oxyacantha*, *C. lanatus*, *C. creticus*, *C. turkestanicus*, and *C. glaucus* exhibited resistance reaction against Fusarium wilt (0-5%) in wilt sick plot while the wilt incidence in the susceptible check, Nira was >80%.

Alternaria tolerant advanced generation interspecific derivative (three rows on left) and susceptible check, PBNS-12 (two rows on right)

Alternaria and Fusarium wilt resistant lines: An inbred, DSI-107 showed 17.8% Alternaria disease severity whereas the susceptible check, PBNS-12 and other susceptible entries had 77-86% disease at Solapur under heavy disease pressure when sown in August. The inbreds, DSI-108, DSI-111, DSI-112, W-05-2039 and W-05-2028, identified for wilt resistance at IIOR, Hyderabad in the wilt sick-pots, were confirmed for wilt resistance reaction (6-18% wilt incidence) in wilt sick plot at Solapur.

High yielding disease resistant parental lines: Four Alternaria tolerant advanced generation interspecific parental lines gave 15 to 85% higher seed yield (1440-2315 g/13.5 sq.m) than the best check, PBNS-12 (1250 g/13.5 sq.m; CV: 14%, $CD_{0.05}$: 202) and six wilt resistant advanced generation interspecific derivatives of (*C. oxyacantha* x *C. tinctorius*) *C. tinctorius* recorded 32-54% higher seed yields than the best check, PBNS-12 in a replicated evaluation trial. In a separate replicated evaluation trial of wilt resistant parental lines, three wilt resistant (8-18%WI) lines *viz.*, W-521-4, W-521-12, and W-05-2039-4 have recorded 24 to 26% higher seed yield (1055-1085 g/13.5 sq.m) than the best check, A-1 (855 g/13.5 sq.m CV = 12%; $CD_{0.05}$: 152).

High oil parental lines: Twenty two parental lines developed through poly-crossing among the inbred lines developed at IIOR, Hyderabad followed by backcross and pedigree method, have confirmed high oil content ranging from to 34 to 39% in the second consecutive year.

Short duration parental lines: Twenty nine short duration selections in F_4 generation flowered in 60-65 days after planting while the checks, PBNS-12 and A-1 took 85 days to flower. Rosette stage was absent in these early selections.

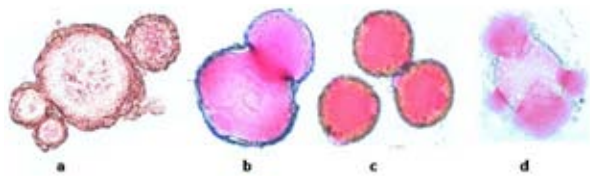
Early maturing selections in flowering stage (right six rows) and normal maturing check, PBNS-12 (far left row with an arrow) at bud stage

Early maturing selection (right) at elongation stage (absence of rosette stage) and normal maturing selection (left) at rosette stage

Pre-breeding

Recurrent introgressive population enrichment (RIPE) programme: The 3rd cycle of recurrent introgressive population of 50 genetically diverse breeding lines possessing high seed yield, seed weight, number of seeds/capsules, early maturity, high oil and resistance to Fusarium wilt and Phytophthora has been developed through random mating in isolation.

New source of male sterility: The male sterile plants observed in population of *C. palaestinus* have continued to segregate into sterile, partial fertile and fully fertile progenies in F_4 generation derived through sib-crossing. Pollen grains in sterile plants were unstained, sticky and of varying sizes while in fertile plants pollen grains were well stained and uniform in size and non-sticky.



Unstained unequal size pollen grains in sterile plants (a), unequal dyad formation in partial fertile plants (b), well stained uniform size pollen grains in fully fertile plants (c), and four colpate fertile pollen grain in *C. palaestinus*.

Yellow-variegated leaf mutant: The yellow-variegated leaf mutant continued to produce three types of variegated mutants (leaf variegation at rosette stage only, leaf variegation at preflowering stage and leaf variegation at all growth stages) in F_4 generation.

Variation in yellow-variegated leaf mutant: mutant having yellow leaf variegation at rosette stage only (a), mutant having yellow leaf variegation from pre-flowering stage (a), and mutant having yellow leaf variegation at all growth stages (c). Arrow shows yellow-variegated leaves.

Maintenance of wild species

Genetic purity in 38 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* has been maintained through self-pollination. Fresh crosses were effected between *C. tinctorius* and the six wild species, and seed has been obtained from two compatible and four incompatible crosses.

Introgression of Fusarium wilt resistance from wild into cultivated species: F_1 to F_5 generations of crosses between Nira x *C. oxyacantha, C. palaesntinus, C. creticus, C. lantaus, C. turkestanicus, C. glaucus* exhibited wilt resistance (0-4.5%) while the susceptible parent, Nira had >80% wilt incidence and the resistant wild species were free from wilt disease in wilt sick plot during *rabi*, 2014.

Maker-assisted selection for wilt resistance: Using the identified SSR makers flanked to wilt resistance in *C. oxyacantha* and *C. palaestinus*, selections for wilt resistance could be done successfully in F_3-F_5 generations of crosses, (Nira x *C. oxyacantha*, Nira x *C. palaestinus*). The results have been validated with phenotyping of F_3-F_5 generations of these crosses for wilt resistance in wilt sick plot during *rabi*, 2014.

Development of high oleic genotypes for Indian conditions and development of protocols for marker-assisted selection for high oleic trait

Data on seed yield/plant and days to flowering of 12,453 F_5 progenies of 330 F_5 families were recorded. All the F_5 progenies flowered between 120-135 days after planting. Seed (in F_6) of 6522 F_5 progenies has been analyzed for oil content and of 1392 F_5 progenies for oleic acid content. Of the 1392 F_5 progeny selections, 927 possessed >70% oleic content (70.09-81.13%) and 465 had 9.88-69.98% oleic content. Among the 1392 progenies, oil content ranged from 19.03-40.1% and yield from 4.3-157.2 (g/plant) while the best check A-1 recorded 27% oil content, 12% oleic acid content and 42 g/plant yield.

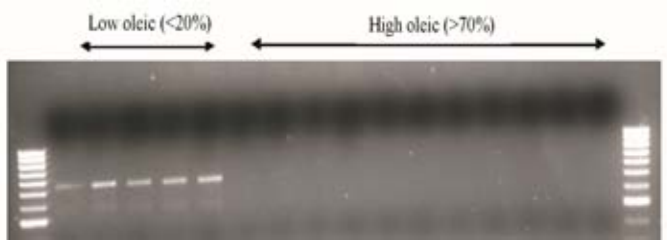
Detection of 'indel' mutation associated with high oleic trait

The candidate gene, *fatty acid desaturase 2-1* (*FAD2-1*), which is responsible for conversion of oleic acid into linoleic acid during fatty acid biosynthesis was partially re-sequenced in a panel of 15 genotypes [low oleic: A-1, Bhima, PBNS-12, NARI-57 and EC-755659-1; high oleic: EC-755660, EC-755661, EC-755662, EC-755664, EC-755665, EC-755669, EC-755671, EC-755675, EC-736515 and EC-736514) using the primer-pair, Intron-s1 (forward) and a1 (reverse). Sequence alignment indicated a point mutation, deletion of 'C' in high oleic genotypes, which has been previously reported in safflower.

'Indel' mutation in high oleic safflower genotypes

Designing of gel based marker assay

An 'indel' specific primer-pair (CtHO-F2 and PR4) was designed which produced an amplicon of ~560 bp in low oleic genotypes and no amplification in high oleic genotypes.



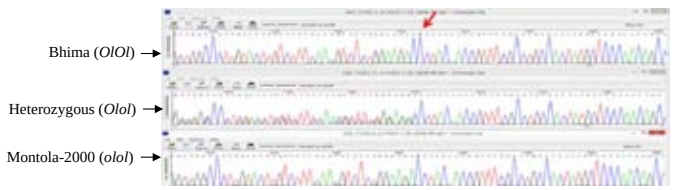
PCR amplification of 'indel' specific primer-pair in a set of 15 safflower genotypes

Validation of marker assay in F_2/backcross populations

The 'indel' specific primer-pair (CtHO-F2 and PR4) was validated in F_2 and backcross (BC_1F_1) populations produced from the cross: Bhima (P_1) x Montola-2000 (EC-736515) (P_2). Out of 96 F_2 plants, the targeted amplicon was present in 69 and absent in 27, which supported Mendelian segregation (3:1) of the marker ($\chi^2 = 0.5$). This was also evident from the analysis of BC_1F_1 progenies. The BC_1F_1 population is expected to segregate for P_1-homozygous (*OlOl*) and heterozygous (*Olol*) genotypes in 1:1 ratio. As

the heterozygous plants could not be predicted, the marker assay produced monomorphic pattern in all BC_1F_1 progenies (n = 96). Therefore, 'sequencing based assay' was needed to predict heterozygous plants in segregating populations. New primer pair (CtFAD2-1_Ol_New-F and CtFAD2-1_Ol_New-R) was designed from *FAD2-1* gene sequence for sequencing based assay to detect heterozygous progenies in the F_2/BC_1F_1 populations. The F_2 or BC_1F_1 plants which had parental sequences without the target deletion were designated as P_1-homozygous; the plants with the deletion were designated as P_2-homozygous and the plants which had mixed parental sequences after the 'indel' mutation were designated as heterozygous.

Monomorphic profile of the 'indel' marker in BC_1F_1 population produced from the cross, Bhima (P_1) x Montola-2000 (P_2)



Genotyping by sequencing of *FAD2-1* gene for detection of heterozygous progeny (*Olol*) in F_2 population. The arrow mark indicates 'indel' region.

The F_3 seeds of F_2 progenies (n = 64) were analyzed for oleic content in gas chromotography (GC). Based on parental values, Bhima (*OlOl*) (19%) and Montola-2000 (*olol*) (81%), oleic content of F_2 progenies were predicted genotypically as < 20% for P_1-homozygous (*OlOl*), > 70% for P_2-homozygous (*olol*) and ~ 35% for heterozygous (*Olol*) plants. The predicted oleic values of $F_{2:3}$ progenies by genotyping were compared with actual oleic values obtained in GC, which matched perfectly in 63 out of 64 samples. The value of F_2-heterozygous progeny is expected to deviate from the predicted value due to sampling bias, which may arise due to mixture of genotypes in F_3 seed-lot. The data on a subset of 20 $F_{2:3}$ plants are presented. The results clearly demonstrate perfect co-segregation of indel marker with oleic level in the $F_{2:3}$ progenies and thereby suggest that the marker assay can be successfully applied in marker-assisted selection (MAS) of high oleic trait in breeding programmes. Marker-assisted backcrossing of *ol* allele into popular variety Bhima is in progress.

Co-segregation analysis of 'indel' marker with oleic content in $F_{2:3}$ progenies produced from the cross: Bhima x Montola-2000

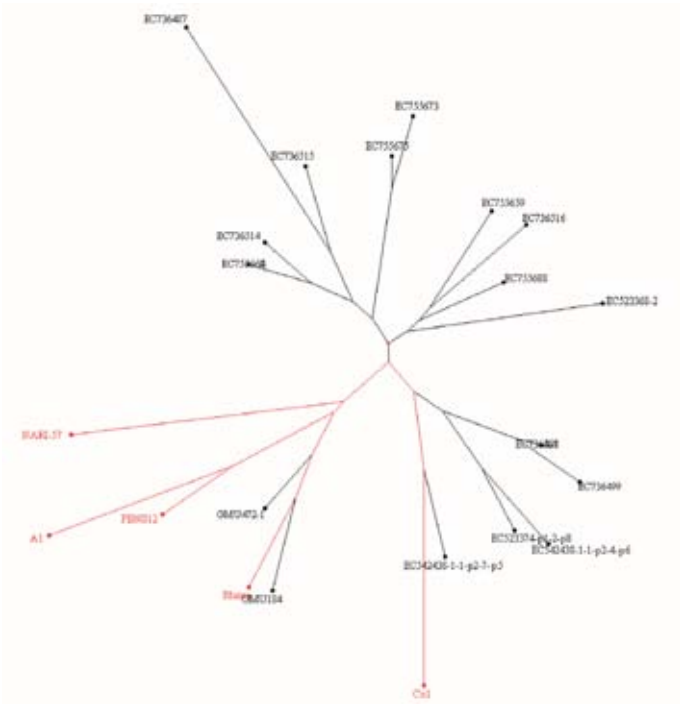
Parent/ progeny	Genotype status	Predicted value of oleic content by genotyping (%)	Actual value of oleic content estimated in GC (%)
Bhima (P_1)	Homozygous (*OlOl*)	< 20	19
Montola-2000 (P_2)	Homozygous (*olol*)	> 70	82
$F_{2:3}$-1	P_1-Homozygous (*OlOl*)	< 20	17
$F_{2:3}$-2	P_2-Homozygous (*olol*)	> 70	79
$F_{2:3}$-3	P_1-Homozygous (*OlOl*)	< 20	19
$F_{2:3}$-4	Heterozygous (*Olol*)	~ 35	29
$F_{2:3}$-5	P_2-Homozygous (*olol*)	> 70	75
$F_{2:3}$-6	P_2-Homozygous (*olol*)	> 70	82
$F_{2:3}$-7	Heterozygous (*Olol*)	~ 35	26
$F_{2:3}$-8	P_2-Homozygous (*olol*)	> 70	80
$F_{2:3}$-9	P_2-Homozygous (*olol*)	> 70	81
$F_{2:3}$-10	Heterozygous (*Olol*)	~ 35	47
$F_{2:3}$-11	Heterozygous (*Olol*)	~ 35	32
$F_{2:3}$-12	Heterozygous (*Olol*)	~ 35	37
$F_{2:3}$-13	Heterozygous (*Olol*)	~ 35	42
$F_{2:3}$-14	P_1-Homozygous (*OlOl*)	< 20	19
$F_{2:3}$-15	Heterozygous (*Olol*)	~ 35	34
$F_{2:3}$-16	Heterozygous (*Olol*)	~ 35	56
$F_{2:3}$-19	Heterozygous (*Olol*)	~ 35	36
$F_{2:3}$-20	P_2-Homozygous (*olol*)	> 70	78
$F_{2:3}$-23	Heterozygous (*Olol*)	~ 35	54
$F_{2:3}$-26	P_1-Homozygous (*OlOl*)	< 20	23

Improvement of Oil Content

Development of gSSRs and screening in parental lines

Newly developed genomic SSRs through microsatellite-enriched genomic library (Acc. Nos. KJ-586129-KJ-586228) were screened in parental line panel (24) for oil content and seed traits. Out of 89 primer pairs yielding PCR products, only 23 (25.8%) markers showed polymorphism in the germplasm analyzed.

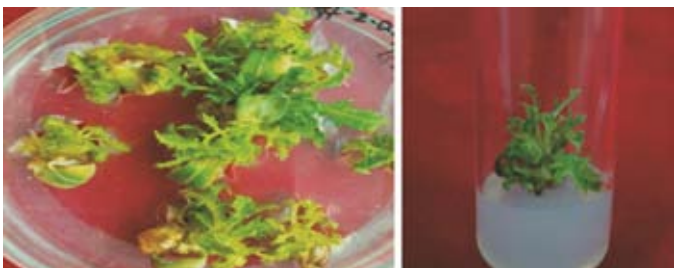
The dendrogram based on simple matching coefficient constructed using the DARwin programme classified the germplasm into three main clusters A, B, C.



Neighbour-Joining tree showing genetic relationship among 24 safflower accessions

Safflower transformation

Embryonic axes of safflower were tested for proliferation ability on different concentrations (0 to 100 mg/l) of benzyladenine (BA), kinetin, 2,4-D which resulted in good proliferation with minimum hyperhydricity and without capitula on medium supplemented with 5.0 mg/l BA.



Multiple shoots from split cotyledons of 2-day-old safflower seedlings inoculated on BA 5.0 mg/l medium for 12-15 days

Development of high oil safflower by multigene engineering

Out of 4223 seedling explants co-cultivated, 242 shoots were realized, of which 49 shoots (> 3 cm) were grafted and the remaining were subjected to rooting. But neither the grafted plants nor the rooted shoots survived till seed setting stage. Thus, the problems with *in vitro* derived transgenic shoots continued and T_1 seeds from these could not be realized. Alternate tissue culture protocols such as obtaining the shoots from cotyledonary explants on medium supplemented with high (> 5.0 mg/l) concentrations of cytokinins (BAP or kinetin) are being tried to overcome the inherent problems associated with the protocol being pursued using hypocotyl explants. Even though the shoots obtained with cotyledonary explants are better in initial growth compared to hypocotyl derived shoots, their further elongation was restricted and different media combinations to achieve elongation are being tried.

A B

Comparison of shoots obtained from both cotyledenary node and hypocotyl explants A. Shoots from cotyledenary explants B. Shoots from hypocotyl explants

To overcome the problems associated with *in vitro* transformation protocols, *in planta* transformation was attempted to realize transgenic plants. About 1200 seedlings were subjected to *in planta* transformation using the *Agrobacterium* strain carrying the double gene construct harbouring DAGAT and GPAT with in the same T-DNA. Out of these transformed seedlings 300 plants produced seeds. Screening of the T_1 progeny was carried out, initially 50 plants T_1 progeny were analysed by PCR, but none of the progeny were positive for the transgene. Kill curve assay was conducted with the untransformed seedlings using the selection agent, hygromycin and the lethal concentration of hygromycin was established. Later the T_1 progeny of 120 *in planta* transformed plants were screened for their transgenicity with the hygromycin. 124 T_1 seedlings survived the selection and were analysed for the PCR but none were positive for the transgene. Screening of the T_1 progeny of the remaining *in planta* transformed progeny will be screened for their transgenicity. Alternately, about 4 experiments comprising 800 safflower seeds

were tried with modified SAAT (sonication assisted *Agrobacterium*-mediated transformation) *in planta* transformation, consisting concoction of DAGAT and GPAT gene constructs. Around 200 plants survived, reached to maturity and the seeds have been harvested for further analysis.

Screening of *in planta* transformed T_1 progeny on soilrite hydrated with hygromycin supplemented Hoagland's solution

Arabidopsis transformation

Homozygous plants carrying different gene constructs (single gene cassettes of GPAT9 or DAGAT or G3PDH as well as double gene cassette carrying GPAT9 and DAGAT) were advanced to T4 generation and these plants were confirmed through PCR and RT-PCR. T_3 generation transgenic plants carrying the empty (basal) vector of three events were also analysed by PCR and RT-PCR and the homozygous lines were identified from these three events. The seed from these homozygous lines would be used as controls to test the effect of transgene on the seed oil content.

CROP PRODUCTION

Sustainability of Safflower-Based Cropping Systems with Reference to Input Management

Site specific nutrient management

Different integrated nutrient management (INM) practices were evaluated with an objective of develope site specific nutrient management for sustainable productivity of safflower. Five treatments of INM (N_1: No fertilizer, N_2: Recommended fertilizer, N_3: STCR based fertilizer application, N_4: STCR based fertilizer + Zn + S, N_5: STCR 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) in sub plots; FYM (5 t/ha) and no FYM in main plot were evaluated in split plot design with four replications. Seed yield response to FYM application, INM and its interaction were found non-significant.

Treatment	Seed yield (kg/ha)		
	FYM	No FYM	Mean
Control	1880	1750	1815
Recommended NPK (40:25:25 kg/ha)	2200	1800	2000
STCR based fertilizer application	2200	1900	2050
STCR based fertilizer application + Zn + S	1900	2200	2050
STCR- crude method	2100	2000	2050
Mean	2056	1930	
	S.Em±	C.D (P=0.05)	
FYM	87	NS	
Nutrient management	90	NS	
Nutrient management at same FYM	128	NS	
FYM at same nutrient management	144	NS	

Zn and S doses were applied as per soil test value

Selected Mexican cultivars response to fertilizer input

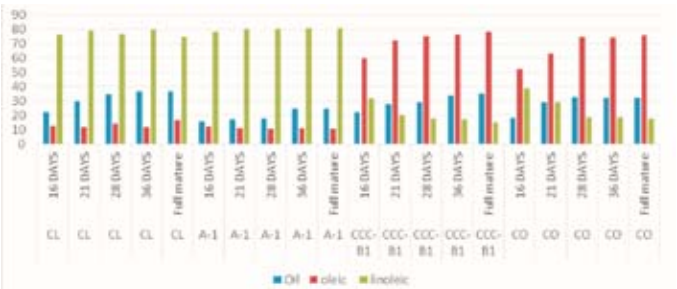
Five Mexican cultivars with one check (NARI-57) of high oil entry were evaluated under three levels of fertilizer input *viz*., 100% NPK, 150% NPK and STCR-based fertilizer (SSNM). Among the cultivars, check entry NARI-57 recorded the highest seed yield which was statistically on par to Mexican entry, CCC-B2. Entries RC-1033-L and CW-99; CCC-B4 and Cianolies were statistically on par. Fertilizer levels did not statistically differ in influencing the seed yield of the six entries. Interaction effect indicated that entry NARI-57 with 150% NPK and SSNM; CCC-B2 with SSNM recorded higher seed yields compared to all other combinations of six entries with three fertilizer level combination.

Cultivar	Fertilizer			
	100% NPK	150% NPK	SSNM	Mean
Cianolies	1200	1450	1450	1367
CCC-B4	1500	1500	1300	1433
RC-1033-L	1700	1600	1900	1733
CCC-B2	2000	2100	2500	2200
CW-99	1500	1550	1900	1650
NARI-57	2150	2350	2600	2367

Mean	1675	1758	1942
	S.Em±	C.D (P=0.05)	
Cultivars	61	174	
Fertilizer	43	NS	
Interaction	105	301	

Biochemical studies

Accumulation of oil content, tocopherols and fatty acid profiling was done during various stages of seed development in high and low oleic acid safflower genotypes. Oil content increased up to 36 days after flowering (DAF) and thereafter stabilized in all the genotypes till maturity. Gradual increase in oleic acid and decrease in linoleic acid was observed during maturity in high oleic types (CCC-B1 and Ciano-OL) while no significant differences were observed during maturity in low oleic types (Ciano-Lin and A-1). Maximum α-tocopherol content was reached at 21 DAF that decreased with maturity in all the



Variation in oil content and fatty acids (%) during maturity in seeds of safflower genotypes

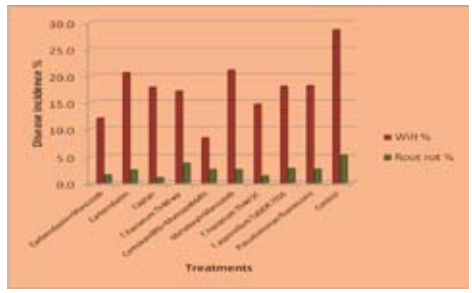
CL = Ciano-Lin; Co = Ciano OL

Variation in total tocopherols (ppm) in the seeds of safflower genotypes

CROP PROTECTION

Management of Wilt and Root Rot

Seed treatment with Cymoxanil 8% + Mancozeb 64% (Curzate-M) @ 0.2% and *Trichoderma harzianum* Th4d SC @ 2 ml/kg were found to be the most effective as they recorded significantly low Fusarium wilt incidence (10.3 and 11.3%, respectively) as compared to control (21.9%). Captan @ 0.2% recorded least *Macrophomina* root rot disease (1%) followed by Carbendazim + Mancozeb (SAAF) @ 0.2% and *T. harzianum* Th4d SC@ 2 ml/kg when compared to control (3.5%).



Effect of fungicides and biological agents on Fusarium wilt and Macrophomina root rot in safflower under field conditions

Cymoxanil 8% + Mancozeb 64% | *Trichoderma harzianum* Th4d SC | Control

Management of Fusarium wilt and Macrophomina root rot in safflower

Pathogenic variability in isolates of *Phytophthora nicotianae*

Nine isolates of *P. nicotianae,* the seedling blight pathogen were tested for their pathogenic variability on five different safflower cultivars (Bhima, PBNS-12, SSF-708, SSF-658 and Phule Kusuma) and the cultivars PBNS-12, SSF-658 and Phule Kusuma were found to be highly susceptible.

Reaction to *P. nicotianae*

Eleven safflower breeding lines *viz*., SAF-1203-2(R), SSF-GMU-6878, PBNS-116, PBNS-123, PBNS-114, SAF-1205-(W), DSI-101, DSF-2014, DSI-118, SSF-GMU-4912 and Manjeera were promising with less than 25% disease severity.

SSF-GMU-6878 | PBNS-116 | DSI-101 | PBNS-12 (Susceptible)

Reaction of safflower cultivars to seedling blight

Standardization of mass screening technique for aphid resistance

The new mass screening technique for identification of resistance to aphids developed during 2013-14 was evaluated consecutively during *rabi* 2014-15. Susceptible CO-1 plants were raised in a separate block one month before sowing of the test accessions. These infested plants with a rating of 5.0 were up rooted and spread over the field uniformly when the test plants reached stem elongation stage. In plots where infestation was natural, the damage on susceptible CO-1 was inconsistent with 2.6, 3.2 and 4.1 (on 1-5 scale) in 3 replications. However, the damage and the reaction of CO-1 under new method were uniform. The same trend was noticed with other test entries also. It was confirmed that the new screening method with artificial release of aphids gave consistent and reliable results.

Identification of vulnerable stage to aphids

Stem elongation stage as the most vulnerable stage to aphids was identified during 2013-14 and to confirm it further, an experiment was conducted during 2014-15. Through staggered sowings safflower plants of 30-80 day old were raised and uniformly infested with aphids. The test entries were well differentiated in aphid damage with a rating ranging from 2 to 5 (on 1-5 scale) when aphids were released on 30 day plants. Susceptible CO-1 was completely killed at elongation stage. The aphid damage on susceptible CO-1 was very less (1 to 2) when aphids were released on 60, 70 and 80 day old crop but the damage was scale 5 on 30 day old crop. There were no differences among test entries after flowering stage (60 days).

Stem elongation stage 50 day old | 80 day old crop with no significant damage

Vulnerability of different stages of safflower to aphids

Confirmation of reaction to aphid infestation

One hundred and eight safflower accessions found resistant earlier under natural infestation of aphids were screened for the second year i.e., 2014-15 during *rabi* season. Based on the two years results, 32 accessions were confirmed as susceptible or highly susceptible and 14 accessions i.e., GMU-184, 219, 332, 668, 904, 948, 958, 1101, 1102, 1301, 2252, 5131, 6299, 6401 were found moderately resistant to aphids.

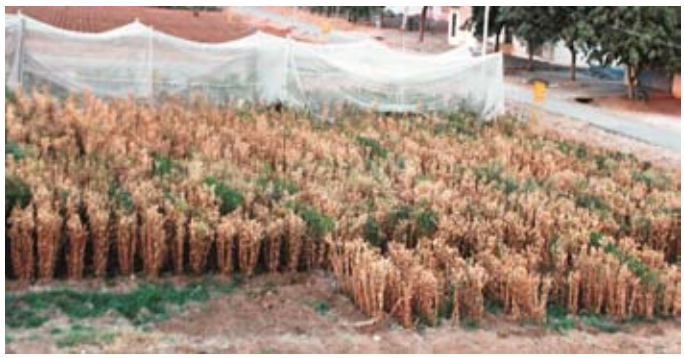
Inheritance of resistance to aphid

A subset of F_3 families (102 from the cross CO-1 x A-1 and 120 from the cross CO-1 x EC-523368-2) were screened against aphid using the modified method of field screening during *rabi* 2014-15. The plants were scored for resistance or susceptibility based on their survival status. Inheritance results suggested the possibility of two recessive genes involved in resistance to aphid in A-1 and EC-523368-2. Development of recombinant inbred lines (RILs) through single seed descent method is in progress. 200 F_5 RILs of the cross: CO-1 x A-1 and 350 F_5 RILs of the cross: CO-1 x EC-523368-2 have been produced towards mapping of aphid resistance in safflower.

Chi-square test for significance of Mendelian genetic ratios of aphid resistance in safflower crosses

Cross	Number of F_3 families				Mendelian ratio of F_2 population	χ^2 value
	Total	R	Segregating	S		
CO-1 x A-1	102	7	47	48	15 (S):1 (R)	0.177
CO-1 x EC-523368-2	118	11	39	68	15 (S):1 (R)	2.429

χ^2 significance value at (P = 0.05) = 3.841; R – Resistant, S – Susceptible



Screening of F_3 families of the crosses CO-1 x EC-523368-2 for reaction to aphid using modified field screening method

SOCIAL SCIENCES

Minimising Supply Chain on a Public Private Partnership (PPP) Mode

The project attempts to examine the growth and instability of castor, sunflower and safflower, to estimate the economics and efficiency of oilseeds based production system, to identify and quantify the magnitude of constraints confronted in the oilseed production system, to identify the present supply chain existing in oilseeds and more importantly to identify and examine the key players and the role played by the intermediaries in the supply chain.

During the period under report, an attempt was made to initiate linking the farmers and the industry with the objective of minimising the length of supply chain in safflower on a public private partnership (PPP) mode. A thorough analysis was undertaken for Anantapur district in Andhra Pradesh as a whole. This was included as a key aspect in the crafting mechanism based on several rounds of discussion with the farming community, Agricultural department, SAU's in the district and M/s Marico Industries Pvt. Ltd., Mumbai.

Analysis of the rainfall pattern of the district showed that most of the mandals are prone to mild drought conditions (11-25% deficit of the long-term average rainfall). Since, the average rainfall of the district was only around 550 mm and the moisture holding capacity of the soils was very poor, even mild drought conditions lead to crop losses. This triggered the necessity for interventions for supply chain management in safflower production through PPP since safflower is cultivated on residual moisture conditions and the dis-economies in the production of the competing crop (chickpea).

The present initiative zeroed down to three villages in Uruvakonda mandal of the district during *rabi* 2014-15 considering the positive response of the farming community to venture safflower production in particular. These mandals were selected based on the aforesaid characteristics, the prevailing cropping pattern, the biotic and abiotic stresses in the production of competing crops, the performance of competing crops *viz.*, chickpea and above all the economic returns of the rainfed farmers. This initiative was taken up in 250 ha in varied scenarios *viz.*, sole cropping, intercropping and strip cropping.

The initiative paid rich dividends and the three villages able to reap healthy economic returns *vis-a-vis* the competing crop (chickpea). The output marketing through PPP has made a significant dent in minimizing the drudgery of farmers in marketing their produce.

Economics of safflower and chickpea cultivation (per ha)

Item	Safflower	Chickpea
Operational cost of cultivation (₹/ha)	9375	21250
Productivity (q/ha)	7.75	9.75
Output price (₹/q)	3025	3000
Gross returns (₹/ha)	23638	30713
Net returns (₹/ha)	14263	9463
Benefit cost ratio	1.52	0.45

Additional benefit to the farmer through supply chain in PPP mode *vis-à-vis* traditional marketing

Particulars	PPP (₹)	Traditional (₹)	Difference in price/q due to PPP
Output price/q	3050	2550-2800	350-500
Transportation cost/q	25-30	45-80	20-50
Incidental	10-15	70-90	60-75

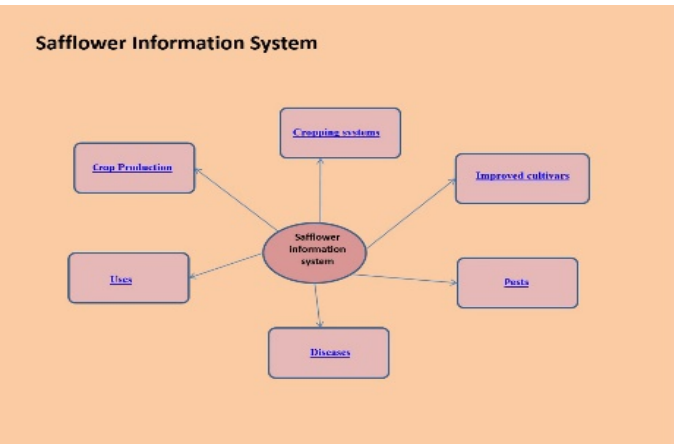
Such initiatives need to be replicated in different vegetable oilseed crops across various agro-ecological situations for increasing the contribution of domestically produced edible/vegetable oils that would have a cascading effect on the Indian economy. Up scaling such initiatives on a cluster approach would further improve the supply chain culminating to a WIN-WIN situation to all the stakeholders. Cluster approach can

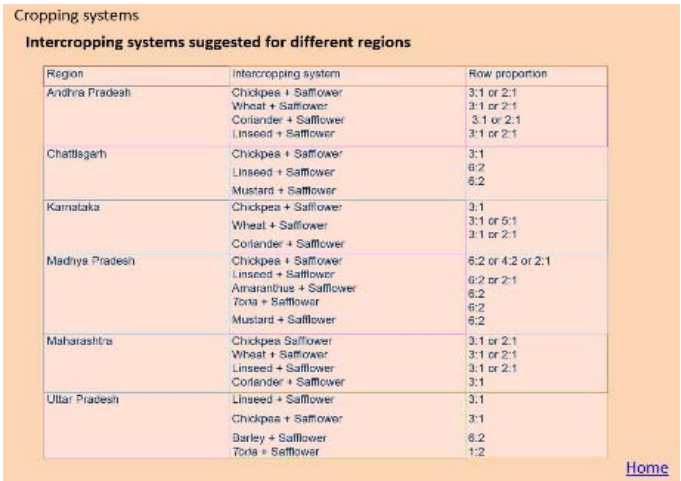
revitalize the functioning of MSME's in oilseeds and tend to effective supply chain operations.

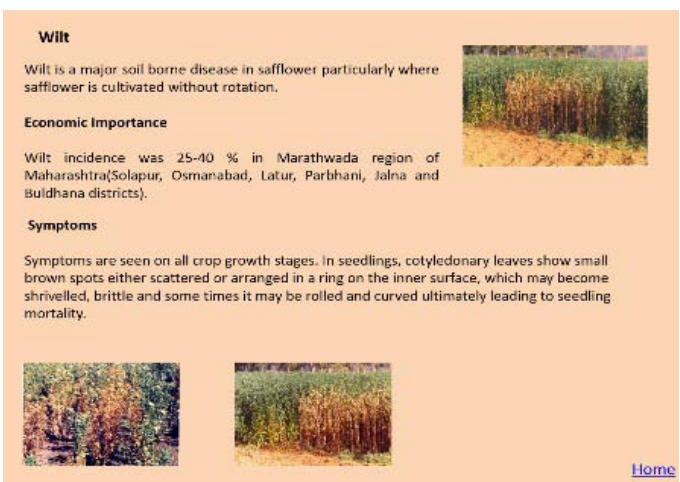
Safflower Crop Information System for Kiosk

Crop information system for safflower was developed which includes sub-modules on various cultivars, crop management practices like land preparation, sowing, seed treatment, interculture operations, etc. The pest and diseases modules includes the details of the various pests and diseases attacking the crop at various crop growth stages and their control measures and management practices was included. An user friendly interface was created for the crop information module and the same was uploaded into the information Kiosk. The information Kiosk has a touch screen monitor which enables the user to navigate from one screen to another by means a single touch on the screen. The information module has a gallery of photographs wherein the user can navigate to any part of the module by identifying the images.

In addition to the various modules related to the crop, the information module includes dynamic market prices for the major markets from the major safflower growing states. The minimum, maximum and modal prices over past years are included in the market information module. The price information for a particular period/day can be easily retrieved. The retrieved information can either be exported into excel sheet and saved for further use or it can be directly saved into PDF format.







SESAME

Three sesame wild species (*S. malabaricum* – 2 accessions, *S. mulayanum*, *S. radiatum* were collected from AICRP centres during *kharif* 2014 (Vridhachalam). Five accessions of S. *malabaricum*, two accessions of *S. mulayanum*, one accession of *S. laciniatum*, one accession of *S. alatum* were germinated and successfully established in the sesame wild species garden. Fourteen paired interspecific crosses were generated using different accessions of wild species as female parent and TKG-22 and GT-10 as male parents. F_1s of only eight crosses germinated and different levels of male sterility was seen in these progeny plants of *S. malabaricum* x GT-10 (81.1%), *S. malabaricum* x GT-10 (82.4%), *S. malabaricum* x GT-10 (81.0%), *S. malabaricum* x TKG-22 (84.5%).

National crossing programme for hybrid development

To understande the extent of reasonable heterosis in sesame, 131 best combining parents from seven AICRP centres (Amreli, Jagtial, Jalgaon, Dharwad, Mandor, Vridhachalam) and one voluntary centre (Coimbatore) were collected and based on the previous reports, 100 accessions were further selected. These selected 100 common male parents were distributed to all the AICRP centers for crossing with two female lines of the respective centres to develop 200 new crosses. Sixty experimental hybrids were evaluated in replicated trial during *kharif* 2014 and observed that hybrids DS-5 x JLS-9707-2 and DS-5 x TKG-22 performed better with 20% and 17% standard heterosis, respectively over the best check GT-10. Also, 125 new crosses were generated by using 25 females and five male parents for assessing combining ability and heterosis. Three hundred and thirty germplasm lines were purified, multiplied and stored for supplying the germplasm lines to different research workers.

Survey and preliminary observational studies on phyllody

Phyllody was observed in the experimental fields of IIOR up to 35% in SI-250 and 14% in TC-25 sesame varieties. It was observed that the incidence at the flowering stage was comparatively less and suddenly

increased as the crop grew older. In farmers field, the incidence was 15-40% in six of 11 locations surveyed. The observations on staggered sowings at 15 days interval indicated that the incidence was higher in *kharif* sowing compared to *rabi* and summer sowings.

Preliminary studies on leaf webber and capsule borer infestation

The leaf webber and capsule borer, *Antigastra cataulanalis* infestation on sesame crop began in September. The infestation was very high on the crop sown during the first week of August compared to the crop sown on 15th and 25th August. Infestation of 20.5 and 7.5% was observed on the crop (TC-25) sown on 15th and 25th August, respectively. The infestation steeply increased to 80.6% in TC-25 by the end of September.

Leaf webber on sesame

Antigastra infested sesame crops

Frontline demonstrations on oilseeds funded by NMOOP

The annual action plan (AAP) for conducting frontline demonstrations on oilseed technologies was developed which was approved by the National Mission on Oilseeds and Oil Palm (NMOOP). The implementation of the AAP by all the oilseed Institutions/Directorates/ Coordinating units and centres was monitored, which resulted in successful conduct of 4915 demonstrations with 96.5% implementation across nine oilseed crops. Realizing the importance of input dealers, they were included along with agricultural officers and extension workers in training programmes and 52 trainings were conducted. The exploitable yield gaps in nine oilseed crops were estimated. Based on the existing yield gaps, it was observed that there is potential to increase oilseeds production in India from 29.89 million t. to 45.75 million t. by adoption of available improved technologies by the farmers even without increasing the area. The details of FLDs on oilseeds and oilseed-based cropping systems conducted by 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) are presented.

Physical progress of FLDs on oilseeds during 2014-15

Crops	Season	Sanctioned	Area covered (ha)	Conducted
Indian Institute of Oilseeds Research, Hyderabad				
	kharif	400	160	400
	rabi	100	40	100
Castor	Total	500	200	**500**
	kharif	50	20	50
	rabi/spring	550	220	550
Sunflower	Total	600	240	600
Safflower	*rabi*	600	240	**600**
PC Unit (S&N), JNKVV, Jabalpur				
	kharif	490	196	400
	rabi	0	0	90
Sesame	Total	490	196	**490**
Niger	*kharif*	220	88	220
	Total	220	88	**220**
	Grand total	710	284	**710**
PC Unit (Linseed) CSAUA&T, Kanpur				
Linseed	*rabi*	500	200	**500**
Directorate of Rapeseed Mustard Research, Bharatpur				
Rapeseed Mustard	*rabi*	500	200	**500**
Directorate of Groundnut Research, Junagadh				
	kharif	350	140	350
	rabi/summer	320	126.5	320
Groundnut	Total	670	266.5	**670**
PMT		125	50	**0**
Directorate of Soybean Research, Indore				
Soybean	*kharif*	700	280	**700**

Project Directorate for Farming Systems Research, Modipuram				
Farming Systems	*kharif*/*rabi* /summer	100	40	**85**
AICRP on STCR, Bhopal				
STCR technologies	*kharif*/*rabi* /summer	100	40	**50**
	Total	5105	2040.5	4915

E Kapas

Around 3809 farmers were registered into the advisory system from four districts *viz*., Adilabad, Karimnagar, Nalgonda and Warangal of Telangana State. More than two lakh voice based advisories on production, protection, harvest and post-harvest technologies apart from weather alerts and market information were disseminated to the registered cotton farmers during *kharif* 2014. More than 83% success was observed in delivery of voice advisories. To evaluate the effect of these advisories, 400 farmers were selected among the registered farmers by random sampling method and data were collected by telephone interviews. The results indicated that the messages were useful in alerting the farmers on the market prices, weather and control measures for pests and diseases of cotton. Based on the evaluation, it is concluded that the mobile advisory system can create awareness on improved technologies and improve the access to scientific knowledge by the farmers

OTHER SCIENTIFIC ACTIVITIES

Extant Variety/Hybrid Registered under PPV&FRA

Sunflower hybrid KBSH-44, safflower hybrids (NARI-NH-1, NARI-H-15) and variety NARI-6 were registered under extant category by the Protection of Plant Varieties and Farmers Rights Authority, New Delhi and certificates were received.

Crop	Variety	Acknowledgement no.	Registration certificate number	Applicant
Sunflower	KBSH-44	REG/2012/138 dated 27.04.2012	185 of 2014 dated 21.05.2014	ICAR
Safflower	NARI-H-15	REG/2012/567 dated 29.10.2012	492 of 2014 dated 5.08.2014	ICAR
Safflower	NARI-NH-1	REG/2012/566 dated 29.10.2012	496 of 2014 dated 5.08.2014	ICAR
Safflower	NARI-6	REG/2012/565 dated 29.10.2012	589 of 2014 dated 21.08.2014	ICAR

Institute Technology Management Unit (ITMU)

The ITMU of this Institute has facilitated to license Bt-1 technology and *Trichoderma harzianum Th4d* SC to four bio-pesticide entrepreneurs. Besides the data base of IP assets and commercialisable technologies updated, MoA signed for 2 contract services, one with T. Stanes & co. Ltd., Coimbatore for the study on feasibility of stabilizing powder formulation of *P. lilacinus* by spray drying technique and other with NIPHM, Hyderabad for bio-efficacy data generation of bio-agent cultures. A Bio-pesticide consortium with the objective of fostering public-private partnerships in the area of bio-pesticide production and commercialization in India established at this Institute in which 10 bio-pesticide entrepreneurs became members. A meeting was held with 7 bio-pesticide consortium members to review the progress of application forms submitted to NBA/SBB. Prepared the application Form-III for seeking prior approval from NBA for obtaining Indian Patent for four applications. Assisted three private biopesticide entrepreneurs in submitting the application Forms-I to Andhra Pradesh/Telangana State Biodiversity Board to obtain the technology on DOR Bt-1 WP and *T. harzianum* (*Th4d* SC) bio-pesticide formulations and licensed them the said technologies after signing the agreement between concerned state biodiversity board and companies.

Agriculture Knowledge Management Unit (AKMU)

The AKMU involves in regularly updating the Institutes website with pertinent databases on oilseeds, tender documents, photographs of the various events, AICRP & FLD releases, employment opportunities, etc. During the year under report, the unit had updated the state-wise data on annual oilseeds for the period 2009-10 to 2013-14. The updating of database on the price information system for the IIOR mandate crops for the major Agricultural Produce Market Committees (APMC's) with respect to date-wise transactions on arrivals, minimum, maximum and modal price for the date wise transactions for the year 2014 are uploaded to the database. AKMU was also involved in imparting training related to the ICAR-ERP package to IIOR staff in collaboration with IBM.

Priority setting, Monitoring and Evaluation (PME)

The priority setting, monitoring and evaluation (PME) cell has prioritized the researchable areas based on the recommendations of RAC and QRT, thrust areas of research in XII plan and action plan submitted to PMO to increase the oilseed production. The progress of all the existing research projects were reviewed and recommendations made to reduce the number of projects as per the instruction of the council through merging the projects.

Accordingly action has been initiated to take up the new projects as per the priority areas. 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 Institute. RPP-II of 39 Institute research projects were reviewed as per the IRC recommendations and submitted to Director for approval. The database on publications updated and maintained. More than 10 project proposals were evaluated for submitting to different funding sources.

Six monthly reports on targets and achievements in HYPM have been uploaded. It has coordinated and arranged Institute Research Committee meeting to review the progress of on-going projects and externally funded projects.

Seed Production

IIOR 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. A total of 13.65 q of breeder seed of castor (SKP-84, SKI-215, DCS-107, 48-1, VP-1, DCS-78, M-574, PCS-4 and TMV-5-1) was produced by various centres against 4.88 q of DAC indent. Breeder seed of sunflower (DRSF-108, 234A, 234B, CMS-17A, 17-B, CMS-335A, 335B and RHA-95-C-1) was produced to the tune of 8.80 q as against 2.29 q of DAC indent. 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 of IIOR has produced and distributed breeder and truthfully labelled seeds of hybrids and varieties released by IIOR under the ICAR Seed Project "Seed Production in Agricultural Crops".

Production of Sunflower Hybrid, DRSH-1

Seed of sunflower hybrid DRSH-1 was produced both at IIOR-ICRISAT and IIOR-Narkhoda farms in about eight acres during *rabi*/summer 2014-15. The total seed yield was about 12 q.

Production of Castor Hybrids

About 80 q of DCH-177 castor hybrid was produced both under TSP-Seed production of ICAR Seed Project in 16 acres of tribal farmers of Doddigadda Thanda of Krishnanagar, Farooqnagar Mandal and five acres of general farmers of Chilkur village of Veldenda Mandal, Mahabubnagar district, Telangana State during *rabi* 2014-15. The tribal farmers were supplied with inputs *viz*., parental seed, fertilizer, pesticides, Taiwan sprayers, etc.

Production of DCH-519 was undertaken in about four acres at IIOR- ICRISAT farm during *rabi* 2014-15 and about 12 q seed was produced.

Trainings Organized in Seed Production

Trainings in quality seed production of castor hybrid DCH-177 were organized under ICAR Seed Project to tribal and general farmers in small groups from time to time. A field-day-cum-seed production training in hybrid castor was organized for 200 farmers on February 12, 2015 at seed production site.

An eight-day training programme on "Seed Production in Oilseed Crops" sponsored by Directorate of Extension, Ministry of Agriculture, Govt. of India was organized for the extension personnel across India during January 21-28, 2015 at IIOR, Hyderabad.

AICRP ON CASTOR, SUNFLOWER AND SAFFLOWER

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

CASTOR

- RG-43 (IC-0584671), which is wilt and leafhopper resistant, has confirmed its early maturity (DF: 53 days; GCH-7: 67 days) at four locations and RG-3491 confirmed its high yielding ability (2740 g total yield/5.4sq.m; GCH-7: 2580 g total yield /5.4sq.m) at Mandor, S.K. Nagar (irrigated), Palem and IIOR, Hyderabad (rainfed).
- The accession, RG-226 recorded the highest ricinoleic acid content (92%), followed by RG-2685 (IC-37425), RG-380 (IC-432907), and RG-357 (IC-522049) (91%) at multilocation testing. The high ricinoleic acid accession, RG-3467 (IC-405711) (RA: 90.56%) recorded higher total yield (2413 g/ net plot) than the best check hybrid GCH-7 (1969 g/net plot) at Mandor, S.K. Nagar (irrigated), Palem and IIOR, Hyderabad (rainfed).
- Registered a Macrophomina resistant germplasm selection, RG-2822 (IC0346626; INGR1 4028), with Plant Germplasm Registration Committee (PGRC), NBPGR, New Delhi.
- Promising male lines developed are PVT-12-160 and PVT-12-104 (2361 and 2309 kg/ha and 45-55 days 50% flowering) at IIOR, Hyderabad; SKI-390 and SKI-385 (1613 and 1372 kg/ ha) at SK Nagar and PVT- 36-14 and PVT-14-14 (2760 and 2444 kg/ ha and 63 days 50% flowering) at Mandor.
- JP-106 (JP-89 x DCS-9), a dwarf pistillate line with red stem color, double bloom, spiny capsules, 18 nodes to primary spike is developed at Junagadh.
- At Bhawanipatna, PCH-111 is the highest yielding hybrid over the last three years, with a significant mean seed yield (1276 kg/ha) compared to the check DCH-177 (1231 kg/ha).
- Among the 11 hybrids in IVHT, two hybrids, Maharaja-9 (8%), DCH-1720 (2%), with 8 % and 2% yield increase over the best check, DCH-519 (3276 kg/ha) were promoted to AHT-I, based on their wilt resistance in all the three wilt sick plots at IIOR, Hyderabad, SK Nagar and Palem.
- A total of 13.65 q of breeder seed of varieties and parental lines of castor was produced against the DAC indent of 4.88 q by various centers
- Application of Pendimethalin 1.0 kg/ha as pre-emergence followed by two hand weedings at 40 and 60 DAS at Kanpur and Navasari (*rabi*, castor) or post-emergence application of Quizalofop-ethyl 0.05 kg/ha at 20 DAS along with hand weeding at 60 DAS (1957 kg/ha) at Navasari was effective to control weed.
- Foliar application of $ZnSO_4$ @ 0.5% twice at 50 and 90 DAS resulted in realizing higher seed yield of castor (2456 kg/ha) over soil application of $ZnSO_4$ or $FeSO_4$ and control grown on clay loam soils at Hiriyur under rainfed conditions.
- At Navasari, GCH-7 recorded significantly higher seed yield (1704 kg/ha) and oil yield (810 kg/ha) over castor hybrid DCH-177 raised with minimum tillage (Rotavator followed by harrowing).
- At Bawal, significantly higher seed yield (3997 kg/ ha) was recorded when sowing was done on June 20th. Higher seed yield (3378 Kg/ha), net returns (₹85566/ha) were recorded with spray of sulphuric acid by minimizing the adverse effect of low temperature/frost.
- Field trials to assess the comparative efficacy of biophos and PSB culture revealed seed treatment with PSB and biophos were equally effective in influencing the seed yield, yield attributes and realizing higher economic returns and soil phosphatase enzyme activity in different soil types across irrigated and rainfed centres with medium available P(24.7-45.6 kg P_2O_5 /ha) status. At 20 kg P_2O_5/ ha +PSB, the phosphatase enzyme activity was found significantly higher than 20 kg P_2O_5/ ha at Palem and Navsari centres.
- Among various intercropping systems demonstrated, castor + groundnut (1:1) system gave highest additional net returns of ₹1,04,979/ha at Junagadh.

- In studies on influence of weather parameters on Botryotinia gray mold development, disease severity of scale 5 observed on 26th June sown crop at Hyderabad during September month. Minimum temperature of 25^{0}C, 84% RH with total rainfall of 102.8 mm received during August to November favoured the development of moderate disease.
- At Palem, gray mold severity of scale 5 observed on primary spikes only both in June 15th, July 15th sown crops following rainfall during August-September where as July 15th sown crop recorded scale 3 at Yethapur after rainfall of 86 mm with 63% RH and 24^0 C in September month.
- In confirmation studies, RG-3105 showed resistance (< 20%) to wilt at Hyderabad, Palem and S.K. Nagar.
- Seed treatment and soil drenching with carbendazim recorded low wilt incidence (19 %) with more seed yield (1308 kg/ha) at Yethapur. Seed treatment and soil application of *Trichoderma viride* – Yethapur local isolate and *T. harzianum* also recorded low wilt incidence (23.5 and 25.7%, respectively) with more seed yield (1246 and 1247 kg/ha, respectively) at Yethapur.
- In management of gray mold of castor, foliar spray of carbendazim and propiconazole two times at 15 days interval recorded low gray mold disease with high seed yield (1259 kg/ha, 1185 kg/ha) at Yethapur. Minimum temperature of 20^0 C with 76-78% RH favoured development of gray mold during the crop period.
- RG-43, RG-631, RG-1621, RG-2462, RG-2661 and RG-3060 confirmed resistance (Hopper burn grade 0 to 1 on 0-4 scale as compared to grade 4 in susceptible checks) at Palem, Yethapur and IIOR, Hyderabad. RG-3060 was also resistant to wilt.
- Clothianidin 50WDG @ 0.1g/l found superior in reducing the leafhopper population. However, higher or comparable benefit cost ratios were obtained from Profenofos 50EC @ 1 ml/l and Dimethoate 30EC @ 1.7 ml/l.
- IPM module (application of *Btk* against early instar larvae of semilooper, monitoring *Spodopteralitura* using pheromone trap and mechanical control of gregarious stages of lepidopteran defoliators, need based application of flubendiamide against lepidopteran defoliators and profenofos against capsule borer and leafhopper) found superior in reducing the insect pest population over farmers' practice at Palem, Yethapur and IIOR, Hyderabad. Higher larval parasitisation of semilooper was recorded in IPM module (56.9 to 65.1%) as compared to farmers' practice (28.6 to 32.8%). Higher seed yield (1060 to 1650 kg/ha) and benefit cost ratios (1: 1.64 to 1: 2.12) were obtained from IPM module over farmers' practice (seed yield of 825 to 1400 kg/ha and benefit cost ratios of 1: 1.16 to 1: 1.86) at different locations.

Technology recommended

- Application of 20 kg P_2O_5 + seed treatment of castor with biophos @ 600g/kg seed in irrigated conditions of Haryana and U.P. application of 40 kg P_2O_5/ha + biophos @ 600g/kg seed in Saurashtra region of Gujarat and application of 20 kg P_2O_5/ha along with biophos @ 600g/kg seed in rainfed conditions of Telangana State for enhancing the seed yield and economic returns.
- Adoption of *kharif* maize-*rabi* castor cropping system for higher castor productivity and higher economic returns as compared to *rabi* castor alone in Telangana State.
- Foliar application of 0.5% $ZnSO_4$ twice (at 50 and 90 DAS) for increasing the seed yield (23.5%) with higher profitability under rainfed conditions of Telangana State.
- Maintain plant population of 9,260 plants/ha and adopt plant geometry of 120 x 90 cm spacing and application of 120 kg N/ha for improvement in seed yield for irrigated *rabi* castor (GCH 7) in South Gujarat.
- Pre-emergence application of Pendimethalin (1.0 kg/ha) + hand weeding at 40 DAS for realizing higher weed control efficiency, seed yield and economic returns as compared to farmers' practice both under rainfed and irrigated conditions of Karnataka and Haryana.

SUNFLOWER

- Genotypes AKSF1-54-3, EC-623025 and EC-512684 were found promising at Hisar for both α-tocopherol

and total tocopherol and can be exploited for the development of inbred lines enriched with vitamin E.

- At Latur, two germplasm accessions with high oil content *viz*., EC-640342 (42.0%) and EC-512673 (42.5%) and GMU-1199/EC-469114, GMU-1048, GMU-1116/EC-512758, GMU-1200-1/EC-469113, EC-601848, EC-601935, EC-601853, EC-601827-1, EC601999, EC601845, EC601999 and EC601628 with high oil content (40-42%) at IIOR were identified.
- Hybrids with high seed (≥10%) and/or oil yield (≥ 5%) than the existing popular hybrids of each zone and across the zones were developed.
- LSFH-2411 (1814 kg/ha), PKVSH-959 (1840 kg/ha) followed by PKVSH-958 (1793 kg/ha) and PKVSH-960 (1676 kg/ha) found best hybrids for out crossing the check, DRSH-1 (1560 kg/ha) at Akola for the state of Maharashtra.
- The performance of MLT sunflower entries at Raichur centre revealed that the hybrid H-10-408 (3516 kg/ha) was significantly superior for seed yield followed by SMLHT-KH-14-01 (2934 kg/ha) and SMLHT-KH-14-03 (2802 kg/ha) as compared to the check hybrids, RSFH-130 (3064 kg/ha), KBSH-44 (2681 kg/ha), KBSH-53 (1918 kg/ha) and SB-207 (2790 kg/ha).
- IIOR, Hyderabad procured 105 accessions belonging to six wild diploid annual species [*H. annuus* (wild); *H. debilis* sub-species *debilis*, *cucumerifolius*, *silvestris*, *vestitus* and *tardiflorus*; *H. praecox* sub-species *praecox*, *hirtus* and*runyonii*; *H. niveus* sub-species *canescens*; *H. petiolaris* sub-species *petiolaris* and *fallax* and *H. argophyllus*] through import from USDA. About 54 wild accessions were established in the wild species garden at IIOR, Hyderabad during 2014-15 and seed multiplication and interspecific crosses were initiated.
- Under the National crossing programme, CMS lines from AICRP centres (CMS 430A, CMS 17A, CMS 243A) and IFVCNS, Serbia (HA-44, SUN-35, CHA-98A, UK-90) that resulted in promising hybrids (>15% higher yield/>10% higher oil content) were used for production of 120 experimental hybrids at Latur, Bengaluru and IIOR, Hyderabad during *rabi* 2014.
- LSFH-4951 (Seed yield-1953 kg/ha and oil yield – 770 kg/ha) in IHT – I; KSFH-011-384 (Seed yield-1682 kg/ha and oil yield – 676 kg/ha) in AHT- I and II reported promising in multilocation trials.
- As per the indent for breeder seed received from DAC, GOI for the year 2015-16, a total of 8.80 q of breeder seed was produced during 2014-15.
- Dual inoculation of *Azospirillum* + *Azotobacter* as seed treatment can save up to 25% of N requirement of *rabi* sunflower under paddy fallow conditions leading to higher profitability at Nimpith, West Bengal. In spring season at Hisar, Haryana, seed yield of sunflower can be further increased with the dual inoculation with *Azospirillum* + *Azotobacter* along with 100% N.
- Application of Pendimethalin 1.0 kg a.i/ha as pre-emergence and Fenoxypropethyl and Quizalofopethyl as post emergence sprays was effective in controlling weeds and higher sunflower yields in most centres in different soil types. The treatment was at par and superior in terms of economics to manual weed control methods with at par weed control efficiency and weed index. There was no phytotoxicity to either crop or succeeding blackgram as residual toxicity. Instances of low germination was recorded when Agil followed by Chlorimuron Ethyl were used as post emergence herbicides.
- Frontline demonstrations showed that the public hybrids (DRSH-1, KBSH-41, KBSH-53, APSH-66, LSFH-171, PSH-996, RSFH-130, PKVSH-952 and TNAUSFH CO-2) gave higher seed yield (11-42%) as compared to private hybrids (SB-275, SB-207, Siri, Sandoz, PAC-361, Ganga Kaveri hybrid).
- By bridging the yield gap II (yield gap between improved technology and state average yield) and adoption of available improved technologies, sunflower production can be enhanced from 1.53 lakh t to 3.09 lakh t during *kharif* and to 8.19 lakh t from 4.68 lakh t during *rabi*/spring/summer in the current area under sunflower.
- Disease survey conducted during the year indicated that the incidence of all major diseases was very low to moderate except sporadic high incidences of powdery mildew at Raichur center.

- Among the co-ordinated trial entries screened in three seasons against major diseases, the entries that showed less incidence than the checks are: *rabi*-S-2216 and H-1187 to *Alternaria*, necrosis, powdery mildew and downy mildew, KSFH-284 to powdery mildew and KSFH-284, KSFH-8005, SSFH-280, Armoni Gold to downy mildew; spring-KSFH-280 to *Alternaria* and powdery mildew; *kharif*-LG-52-01 and LSFH-4951 of IHT and NSFH 1201 to *Alternaria*, necrosis, powdery mildew and downy mildew.
- The epidemiological studies of *Alternaria* leaf blight carried for three years at Coimbatore and Nandyal and the regression analysis indicated that spore load, dew point, relative humidity, minimum temperature were the most influencing weather parameters for the disease severity.
- For the management of powdery mildew disease, two sprays of Difenoconazole @ 0.05 percent at 45 and 60 DAS was effective in most of the centres which reduced disease severity by 46 to 87% and increased the seed yield up to 31 to over 100%.
- For management of charcoal rot, seed treatment with SAAF (Mancozeb + Carbendazim @ 2 g/kg seed with weekly irrigation) reduced the disease intensity by 34% and increased the seed yield up to 28%.
- For the management of collar rot, ST with *T. viride* (0.4%) + *P. fluorescens* (0.4%) + soil application of *T. viride* @ 2.5 kg/ha) and ST with *T. viride* @ 0.4% + soil application of *T. viride* @ 2.5 kg/ha + *Pseudomonas fluorescens* @ 2.5 kg/ha) reduced the disease intensity by 69% and 66%, respectively.
- Seed treatment with *Pseudomonas fluoroscens* @ 10 g/kg seed followed by spray of Propiconazole @ 0.1% at 45 DAS and *P. fluoroscens* @1.0% at 60 DAS were found effective compared to other treatments to manage of *Alternaria* leaf blight.
- The pheromone trap catches of moths of *Spodoptera* and *Helicoverpa* showed their peak during the second week of October (59.0 moths/trap) and third week of October (11 moths/trap), respectively at Bengaluru.
- S-2216, DRSH-I, KBSH-71 and RSFH-130 were found to be promising against leaf hoppers with a injury grade of 0 at Raichur and LSFH-4951 had injury grade 1 against leaf hopper at Akola.
- Under uniform pest nursery (UPN) germplasm lines GMU-383, 834, and 952 were found promising against leaf hopper with injury grade 2 at Akola. GMU-922 had injury grade 2 against leaf hopper at Hyderabad under assured pest pressure.
- The hybrid TNAUSFH (CO-2) showed tolerance to water and salt stress at seedling level consecutively for two years as compared to the check hybrids, KBSH-44 and DRSH-1.

Technology recommended

- Adoption of recommended dose of fertilizers (RDF) and thinning and need based plant protection resulted in significantly higher yield (34 to 75%) and income (B:C ratio of 1.45 to 1.89) to farmers in Western Maharashtra.
- Application of 100% RDF + 5 t FYM/ha for groundnut in *kharif* and application of 100% RDF for succeeding *rabi* sunflower increased the system yield (16%) and system economics (B:C ratio of 2.77) in Alfisols in Southern dry zone of Karnataka
- Application of 100% RDF + 5 t FYM/ha for sunflower in *kharif* and application of 100% RDF for succeeding groundnut increased the system yield and system economics in Alfisols
- The revised fertilizer rates (30 kg lower P than previous recommendation with same N and K level) resulted in higher seed yield of sunflower (8 to 12%) with higher profitability in Western Maharashtra.
- Growing legumes preceding sunflower can save 25% of N with an increase of 17% yield and a higher B:C ratio of 2.22 Vs 1.79 without growing legumes in Alfisols in Southern dry zone of Karnataka .
- Soil test based fertilizer application with balanced fertilization with NPK has resulted in 33% higher seed yield and a B:C ratio of 2.03 over the farmers' practice in Southern dry zone and 6.62% higher seed yield over the farmers' practice in Northern dry zone of Karnataka.

SAFFLOWER

- Based on overall mean values over 4 locations, EC-755671 (37.1%) was identified as the most promising exotic accession for oil content.
- Five *viz*., GMU-2380 (IC-337923), GMU-2687, GMU-2757 (IC-338226), GMU-2928 and GMU -3206 (EC-181840-1) were found promising across different locations and years for P use efficiency.
- Maximum petal oil content at Phaltan and DOR was recorded in EC-739383-1 (4.93%) and EC-739374 (5.39%), respectively with Palmitic acid being the predominant fatty acid. GMU-1920 [EC-337713] (44.09%) was identified for highest α linolenic acid content at DOR and maximum petal yield (116 kg/ ha) compared to check cultivar NARI-6 (98 kg/ha) at Phaltan.
- GMU-4983/IC 13884 [NIC-7133 (SD5-1278)] was registered with PGRC, New Delhi as INGR14002 for resistance to Fusarium wilt caused by *Fusarium oxysporum* f.sp. *carthami*.
- Six CMS hybrids *viz*.,DSH-289, DSH-299, DSH-290, DSH-301, DSH-302, and DSH-303 yielded higher (3.56-4.02 kg/13.5 sq.m, 2637-2978 kg/ha) than the check hybrid, NARI-H-15 (2.64-2.67 kg / 13.5sq.m; 1977 kg/ha) yielded higher than the best check variety A1 (2.27 kg/13.5sq.m, 1681 kg/ha) in preliminary hybrid yield evaluation trail at IIOR, Hyderabad under minimal irrigation (1 irrigation) condition.
- At Parbhani, three populations *viz*., PBNS-122, PBNS-123 and PBNS-124 yielded 12-35% (1932-2330 kg/ha) than the best check variety, PBNS-12 (1715 kg/ha) under irrigated conditions.
- NARI-96 exhibited 10.2% increase in terms of oil yield (706 kg/ha) over the best check variety, PBNS-12 (641 kg/ha) in IVT.In IHT, DSH-242 recorded 35.8% higher seed yield (2315 kg/ha) and 44.8% higher oil yield (665 kg/ha) than the check hybrid, NARI-H-15 (1704 kg/ha, 459 kg/ha).In AHT-I, DSH-250 recorded 37% higher seed yield (2336 kg/ha) and 37% higher oil yield (630 kg/ha) than the check hybrid, NARI-H-15 (1704 kg/ha, 459 kg/ha) and 14% higher seed yield.
- A total of 331.05q breeder seed of ten safflower varieties was produced against the target of 20.55q. Two AICRP (Safflower) centres produced 216.88q of breeder and truthfully labelled seed of four varieties.
- In greengram-safflower cropping system (rainfed) and soybean-safflower (irrigated), application of safflower residues could save 50% NPK of *kharif* crop; *kharif* crop residues could save 50% NPK of safflower in Maharashtra (Akola and Phaltan) and in soybean-safflower (irrigated), application of 2.5 t/ha FYM + safflower residues could save 50% NPK of soybean; 2.5 t/ha FYM + soybean residues could save 50% NPK of safflower in Maharashtra (Parbhani).
- The net returns of non-spiny safflower hybrid NARI-NH-1 (Akola, Annigeri, Indore, Phaltan, Solapur, Tandur), PBNS-40 (Parbhani) could be enhanced to the tune of 2 to 3 times over spiny safflower (A-1), with the harvest and sale of petals.
- Pre-emergence application of Pendimethalin 30 E. C @ 1 k.i/ha followed by one hand hoeing at 25 DAS was effective in controlling weeds in rice fallow safflower in Chhattisgarh plains (Raipur).
- 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 1307 kg/ ha in FLD plots and 1092 kg/ha in farmers' practice (FP) plots. Whereas, under rainfed conditions, FLD plots recorded a mean safflower seed yield of 914 kg/ha and 814 kg/ha in FP plots.
- By adoption of improved production technologies, it was estimated that safflower production in the country during post-rainy season could be increased from 1.09 lakh tonnes to 1.25 and 1.91 lakh tonnes by bridging yield gap I (gap between improved technology and farmers's practice yield) and II (gap between IT and state average yield), respectively.
- In uniform disease nursery at Solapur, the entry W-2039-4 was resistant (8.8% wilt) to wilt and eight entries *viz*., W-521-5, W-521-12, W-521-9, W-521-3, W-SFS-2035, W-SFS-2036, EC-755664 (CW 99) and EC-755669 (CW- B2) were moderately resistant. The entry W-521-12 recorded significantly higher seed yield (1159 kg/ha) than all other entries.

- Seed treatment with Carboxin + Thiram at Solapur, Captan at IIOR, Hyderabad, Metalaxyl + Mancozeb at Annigeri were more effective and economical in managing Phytophthora seedling blight at different locations.
- Carboxin + Thiram at Solapur, *Trichoderma harzianum* Th4d SC at Parbhani, Vitavax powder at Annigeri, Captan at IIOR, Hyderabad were most effective in reducing seed and soilborne diseases incidence.
- The severity of Alternaria leaf spot is significantly low with spray of Azoxystrobin and Iprodione + Carbendazim (14.1%, control-92.6%) at Annigeri and Propiconazole (34.3%, control-84.3%) at Parbhani.
- Aphids, *Uroleucon compositae* was the major insect pest in safflower growing areas. Other minor pest recorded was *Helicoverpa armigera* on capsules. Natural occurrence of predators and parasites was low. Only 30% of safflower farmers have taken up plant protection measures in Maharashtra.
- Tank mixing of insecticides, Thiamethoxam or Clothianidin or Acetamaprid with the fungicide combination of [Carbendazim + Mancozeb] did not cause any phytotoxicity to safflower, or affected their effectiveness against aphids. Their physico-chemical properties were not affected after mixing.

Technology recommended

- NARI- H- 23, a wilt and aphid tolerant hybrid released and recommended for Maharashtra, Karnataka, Madhya Pradesh, Chattisgarh, Rajasthan and West Bengal and NARI- 57, a wilt resistant variety with high oil content released for Maharashtra, Karnataka, Madhya Pradesh, Uttar Pradesh, Punjab, Rajasthan and West Bengal
- In Northern transition zone of Karnataka, apply N @ 60 kg/ha to safflower for higher yield and economic returns.
- In Southern zone of Telangana State, apply P @ 40 kg/ha to safflower for higher yield and economic returns.
- For Marthwada region of Maharashtra, foliar application of Propiconzole (0.1%) twice at 15 days interval starting with first appearance of disease is found effective in reducing Alternaria leaf spot of safflower with benefit : cost ratio of 2.09.
- For management of safflower aphids, foliar sprays of Clothianidin @ 50g/ha or [Chlorpyriphos 50% + Cypermethrin 5%] 55 EC @ 1000 ml/ha were very effective with a field efficacy of 94.4% and 84.0%, respectively and IBC ratio of 10.7 and 12.2, respectively.
- In Akola region of Maharashtra, soil application of Phorate 10G @10 kg/ha at sowing + foliar spray of Chlorpyriphos 20 EC @ 2.5 ml/l at 10 DAE + 2nd spray if required, significantly reduced gujhia weevil damage and recorded the higher yield (1627 kg/ha) and IBC ratio of 4.8.

IIOR

वार्षिक प्रतिवेदन

Annual Report

2014-15

Institutional Activities

- Extension and other Activities
- Education and Training
- Awards and Recognitions
- On-going Research Projects
- Meetings and Events
- Human Resource Development
- Hindi Activities
- Publications
- Infrastructure Development
- Visitors
- Promotions/Upgradations/Transfers/Superannuations
- Personnel
- Results Framework Document

EXTENSION AND OTHER ACTIVITIES

Tribal Sub-Plan

Tribal sub-plan programme was implemented in 48 villages of 10 districts spanning over seven states (Andhra Pradesh - 2 villages of Kurnool, Rajasthan - 1 village of Serohi, Karnataka - 5 villages of Chitradurga, Tamil Nadu - 5 villages of Salem, Telangana – 14 villages of Ranga Reddy and Mahboobnagar, West Bengal – 20 districts of Bankura, Paschim Medinipur, West Medinipur and Purulia and Chattisgarh – 1 village of Balode). Under this programme, 908 demonstrations of latest released varieties/hybrids of castor, sunflower and safflower along with improved technologies were conducted in association with NGOs such as, Viksit Rythu Sankshema Samastha and Agri-Biotech Foundation and AICRP centres such as Nimpith, Yethapur, Hiryur, Palem, Mandor, Raipur and Tandur. The farmers of these villages were growing a less remunerative crops. These farmers were trained about the improved cultural practices to cultivate these crops. The farmers were given the inputs such as seed, fertilizer and pesticides. Periodically, the concerned scientists visited the fields and monitored the programmes. They were also given different agricultural implements *viz.*, power sprayer, hand sprayer, manual weeders, sprinkler, tarpaulin, castor thresher, rotavator, furrow MB plough, secature, castor shellers, plough planter, seed planter, bullock drawn weeder, delivery pipe for irrigation- 300', portable pump set, sunflower threshing unit, spade, sickle and submergible bore well with pump.

In West Bengal the tribal farmers got the profit of ₹ 9000 to10,000/acre through cultivation of sunflower. The average profit due to cultivation of castor in Rajasthan was ₹ 11938/acre, whereas in Telangana it was varying from ₹ 7000 to 10,000. The farmers of Andhra Pradesh of the net income of ₹ 9385/acre by growing castor and the net profit of growing castor in Tamil Nadu was ₹ 8074/acre. The net profit due ot cultivation of safflower in Telangana was ₹ 8225/acre.

TSP at Samakuttapatti village, Tamil Nadu

Television Programme

Scientist	Topic	Media	Date of telecast
Dr. S.N. Sudhakara Babu	Improved Management Practices for Increasing Oilseeds Production	Doordarshan Yadagiri	March 2, 2015
Dr. K. Anjani	*Kusuma panta, dani pramukhyatha*	Doordarshan Kendra	March 10, 2015

Other Extension Activities

- Surveyed drought effected districts of Medak, Warangal and Khammam in collaboration with other ICAR Institutes in Hyderabad for assessing the damages to the crop in *kharif* and advise the farmers to take the contigent actions.
- Participated in the farmers day at IRR, Hyderabad, in Kisan Mela at Shivamogga and Raichur of Karnataka organized by respective Universities and in the exhibition organized by NIPHM, Hyderabad and showcased the IIOR improved technologies.

- A field day was oprganised at ICAR- IIOR farm at Narkhoda on September 19, 2014 to show case the castor and sunflower crops grown with improved technologies to the farmers of Medak, Warangal and Mahabubnagar of Telangana.
- A field day was conducted at Doddigadda thanda of Mahabubnagar district of Telangana on February 2, 2015 where castor seed production was undertaken by IIOR and about 120 farmers from Cherkur and surrounding villages were exposed to the seed production fields.
- A field day was conducted to show the potential of castor + groundnut intercropping system at Kothwalguda of Adilabad district of Telangana on March 28, 2015 wherein about 120 farmers participated.

EDUCATION AND TRAINING

Details of students working for Ph.D.

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 & 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	Genetics	OU, Hyderabad 15.4.2008
MTarakeswari	Development of transgenic castor for resistance to lepidopteran pests through deployment of Cry1 AabcF 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. 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. Lakshmidevi	Strategies to develop transgenic castor (Ricinus communis L.) tolerant to necrotropic fungi	Bio-technology	ANGRAU,Hyd. 1.8.2012
	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
V. Vineela	Development, characterization and evaluation of nanocarrier embedded toxin of Bacillus thuringiensis var. kurstaki for management of insect pest	Micro-biology	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

Name of the student	Title of thesis	Discipline	University/Date of registration
T. Navaneetha	Development of suitable formulations of potential bioagents for management of important diseases in castor,sunflower & safflower	Micro-biology	OU, Hyderabad 2.4.2009
P. Sowmya	Study of molecular mechanisms involved in high temperature stress tolerance in Trichoderma species	Bio-technology	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. Santha Lakshmi Prasad**		
K. Sujatha	Study of resistance mechanism and manage-ment 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	Micro-biology	OU, Hyderabad 30.03.2011
N. Naresh	Diversity analysis of Alternaria leaf blight in sunflower based on morphological, pathogenic and molecular characters	Bio-technology	JNTU, Hyderabad 3.10.2011
E. Bharathi	Variability in pathogen population of castor wilt fungus and its management	Micro-biology	OU, Hyderabad 12.02.2013
	Major advisor: **Dr. S. Senthilvel**		
J. Poornima Kumari	Genetic and molecular analysis of nematode resistance in castor (*Ricinus communis* L.)	Genetics 05.03.2013	OU, Hyderabad
Ranjan Kumar Shaw	Molecular mapping of Botrytis resistance in castor (*Ricinus communis* L.)	Genetics 05.03.2013	OU, Hyderabad

Training Programmes organized

Programme	Period	Participants	Sponsor
Scientific Professional Attachment Training	May 7-August 6, 2014	Jinu Jacob, DSR, Hyderabad	DOR, Hyderabad
Scientific Professional Attachment Training	May 12-August 11, 2014	Shanmugavadivel, P.S, Scientist, Indian Institute of Pulses Research	DOR, Hyderabad
Scientific Professional Attachment Training	June 9- September 9, 2014	Sharon Aravind, Scientist, Division of Crop Improvement and Biotechnology Cardamom Research Centre, IISR, Appangala	DOR, Hyderabad
Use of ICTs for increasing production and productivity of oilseeds	October 7-14, 2014	State Agricultural departments officials	DE, Ministry of Agriculture, GoI
Seed production in oilseed crops	January 21-28, 2015	State Agricultural departments officials	DE, Ministry of Agriculture, GoI

GERMPLASM-CUM-BREEDERS DAY

Sunflower Germplasm Field Day

Sunflower germplasm field day was organized on October 17-18, 2014 at AICRP (Sunflower) centre ZARS, GKVK, UAS, Bengaluru in collaboration with IIOR, Hyderabad and NBPGR, New Delhi. Dr. D.P. Kumar, Vice-Chancellor, UAS, Bengaluru inaugurated the field day. Dr. M.A. Shankar, Director of Research, UAS, Bengaluru; Dr. K.S. Varaprasad, Director, IIOR, Hyderabad; Dr. R.K. Tyagi, Head, Germplasm Division, NBPGR, New Delhi participated in the field day. Dr. Y.G. Shadakshari, Professor and Head, AICRP (Sunflower), UAS, GKVK, Bengaluru co-ordinated the sunflower germplasm field day. Three thousand and fifty nine germplasm accessions including the accessions received from NBPGR, IIOR and germplasm maintained at UAS, Bengaluru, were grown. These accessions were comprised of CMS A & B Lines, RHA Lines, Inbred Lines, Gene pool B lines, Confectionary types & Ornamental types. Characterization of all germplasm accessions received from NBPGR, New Delhi was done as per DUS guidelines. About 20 breeders working on sunflower crop in different AICRP centres of the country and scientists from IIOR, Hyderabad visited the field and selected the germplasm lines with specific traits.

Castor Germplasm-cum-Breeders Day

Castor germplasm-cum-breeders day was organized at AICRP-Castor centre, JAU, Junagadh on November 26, 2014 in collaboration with IIOR, Hyderabad. Seventeen scientists participated in the field day. On-farm performance of different accessions and breeding lines having resistance to Fusarium wilt and root rot, pistillateness, good combiners, basal branching, early and high yield were demonstrated. Participants indented for 149 accessions/lines possessing long spikes, early, extra-early and medium duration, good branching characters.

Safflower Germplasm-cum-Breeders Day

Safflower germplasm-cum-breeders day was organized at ICRISAT-IIOR farm on February 13, 2015. Safflower breeders from seven AICRP centres and two voluntary centres attended the programme. Breeders observed the variability among trait-specific accessions for high oil content and bold capitula. Participants also visited plots of parental lines, wild species, preliminary varietal/hybrid trials of IIOR material in various generations and experimental material raised for development of mapping population and association mapping panel.

AWARDS AND RECOGNITIONS

Best Worker Awards

The Best Worker Awards in different categories of IIOR staff were awarded on the occasion of IIOR Foundation Day held on August 1, 2014.

Name	Category
Sri B. Kistaiah	Technical
Sri P.R. Vara Prasad Rao	Administration
Sri B. Giri	
Sri G. Yadaiah	Skilled Supporting Service
Smt. K. Bhagyamma	TSL, Narkhoda Farm
Sri C. Kumar	TSL, Narkhoda Farm
Smt. C. Bhagya	TSL, Rajendranagar Farm

Best Research Paper Award

- Dr. G.D. Satish Kumar received best paper (oral) award for the paper on "Productivity potential and profitability of sunflower in India" at the "Seventh National Extension Education Congress on Translational Research-Extension for Sustainable Small Farm Development organized by Society of Extension Education, Agra at ICAR Research Complex for NEH Region, Umiam, Meghalaya from November 7-11, 2014.
- Dr. K. Anjani has been selected for the best research paper award for the presentation of research paper entitled "Breeding for high oil in safflower (*Carthamus tinctorius* L.) during National Seminar on "Challenges and Innovative Approaches in Crop Improvement" organized by Tamil Nadu Agricultural University and Indian Society of Plant Breeders from December 16-17, 2014 at Madurai.
- Dr. S.N. Sudakara Babu received best poster award at the 2nd International Conference on Climate Change Agriculture at PJTSAU, Hyderabad during February 7-9, 2015.
- Dr. S.N. Sudakara Babu received best poster award at the National Seminar on "Strategic Interventions to Enhance Oilseeds Production in India" organized by Indian Society of Oilseeds Research ICAR-Indian Institute of Oilseeds Research Rajendranagar, Hyderabad and DRMR at Bharatpur during February 18-21, 2014.
- Dr. Mangesh Y. Dudhe received best paper and poster award (3rd Prize) in National Seminar on "Strategic Interventions to Enhance Oilseeds Production in India" organized by Indian Society of Oilseeds Research ICAR-Indian Institute of Oilseeds Research Rajendranagar, Hyderabad and DRMR at Bharatpur, Rajasthan from February 19-21, 2015.
- Dr. G.D. Satish Kumar received best poster for the paper on "Private Sector Participation in Agricultural Extension of Safflower in India" at the National Seminar on "Strategic Interventions to Enhance Oilseeds Production in India" organized by Indian Society of Oilseeds Research and DRMR, Bharatpur, Rajasthan from February 19-22, 2015.
- Dr. Praduman Yadav received best oral presentation award in Chemical conversion theme on Improvement of Biodiesel traits in castor in International conference on "Recent Advances in Bio-Energy Research" organized by SSS National Institute of Renewable Energy at Kapurthala, Punjab during March 14-17, 2015.
- Dr. Praduman Yadav received best Poster presentation award on breeding for high oil in safflower (*Cathamus tinctorius* L) in National Seminar on "Challenges and Innovative Approaches in Crop Improvement", organised by college & Research Institute, Madurai, Tamil Nadu Agricultural University during December 16-17, 2014 at Madurai.

Recognitions

- Dr. V. Dinesh Kumar, Principal Scientist (Biotechnology) has been selected as DBT nominee for IBSC of SNIST, Hyderabad for a period of three years.
- Dr. S. Chander Rao has been nominated as Editor for the Indian Journal of Oilseeds Research, published by Indian Society of Oilseed Research (ISOR), Hyderabad.
- Dr. R.D. Prasad served as member of IRC, DSR, Hyderabad for 2014.
- Dr. Mangesh Y. Dudhe has been elected as Editorial Board Member for the year 2015-16 of "Electronic Journal of Plant Breeding", published quarterly by the Indian Society of Plant Breeders, TNAU, Coimbatore.
- Dr. H.P. Meena has been nominated as one of the Editor in the Editorial Board of the "*Journal of Plant Science and Research*".
- Dr. G.D. Satish Kumar is Member of the Editorial Board of Food, Agriculture and Environment (JFAE), WFL Publishers, Finland.

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. H.P.Meena
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	Physiological evaluation of castor for drymatter partioning, harvest index, drought and temperature stress tolerance	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

Project code	Project title	Project leader
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 nematode pests of castor, safflower 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 facto	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. Jawahar Lal Jatothu

Externally Funded Projects

Sponsor	Project title/Project Scheme	Principal Investigator	Budget (₹ in lakhs)
ICAR-NPTC AMAAS	Development of transgenic castor for resistance to lepidopteran pests Development of practicable technologies for field level exploitation of consortia of microbial agents as ameliorators of biotic and abiotic stresses in crops	Dr. M. Sujatha Dr. R.D. Prasad	6.87 9.04
ICAR Network Project	Phytophthora, Fusarium and Ralstonia diseases of horticulture and agricultural crops	Dr. R.D. Prasad	9.37
ICAR Plan	Seed production in agricultural crop	Dr. M. Lakshminarayana	3.50
ICAR Plan	Intellectual property and technology management	Dr. S.V. Ramana Rao	10.14
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	-
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, IIOR Dr. R. Makandar, UoH	36.96
DBT	Discovery of genome-wide SNPs and its use in developing a reference linkage map and association analysis in castor	Dr. Senthilvel Senapathy IIOR Dr.Sanjay K. Shahi, Xcelris Genomics Ltd.,	17.00
DST	Crop management options to make safflower cultivation profitable for small farmers through enhanced utilization of petals	Dr. P. Padmavathi	5.77

Sponsor	Project title	Principal Investigator	Budget (Rs. in lakhs)
DST	Molecular tagging and mapping of powdery mildew resistance in sunflower (Helianthus annuus L.)	Dr. M. Sujatha	-
Central Sector Project	Protection of Plant Varieties and Farmers Rights Authority	Dr. N. Mukta	8.00
PPV&FRA	Special test for plant variety protection	Dr. Praduman Yadav	-
NMOOP, DAC	Frontline demonstration on oilseed crops	Dr. G.D. Satish Kumar	1.29
TMC, DAC	EKAPAS Network and technology dissemination	Dr. G.D. Satish Kumar	6.00
MARICO	Developing high oleic safflower genotypes for Indian conditions development of protocols for market assisted selections for high oleic traits in safflower	Dr. K. Anjani Dr. P. Kadirvel	20.00

MEETINGS AND EVENTS

Research Advisory Committee

The 28th RAC meeting was held during April 9-10, 2014 at IIOR, Hyderabad. Dr. E.A. Siddiq, Hon. Chair Professor, Biotechnology, ANGRAU & former DDG (CS), ICAR & Chairman RAC and members *viz*., Dr. V. Muralidharan, Retd. Professor, TNAU, Coimbatore, Tamil Nadu; Dr. N. Seetharama, Former Director, DSR, Hyderabad; Dr.S.P.Singh, Former Director, NBAII, Chandigarh (UT); Dr. H.S. Sen, Former Director, CRIJAF, Kolkatta; Dr. R.B.N. Prasad, Chief Scientist & Head (LST), IICT, Hyderabad; Dr. M.N. Reddy, Former Director, MANAGE, Hyderabad; Sri P. Gopal Reddy, East Kodipalli, Anantapur were present. Dr. K.S. Varaprasad, Director, IIOR welcomed the Chairman and Members of RAC and presented the highlights of IIOR activities for the year, 2013-14. It was followed by the presentation on Action Taken Report on the recommendations of 27th RAC meeting by the Member Secretary, RAC. The designated scientists of this Institute made presentation on research highlights pertaining to their discipline. On 10th April forenoon, the committee visited the experimental farms at Rajendranagar and transgenic glasshouse and other facilities of IIOR. The two-day meeting of the Research Advisory Committee reviewed the status of research progress and strategies in the mandated oilseed crops of the Institute and made recommendations.

Annual Group Meeting on Sunflower, Sesame and Niger, 2014

The Annual Group Meeting on Sunflower, Sesame and Niger was held at Agriculture University, Mandor, Jodhpur Rajasthan during May 20-21, 2014 to review the results of research conducted during 2013-14 and formulate the strategies to increase the production and productivity of sunflower for the year 2014-15. The meeting was attended by the scientists working under AICRP (Sunflower), officials of Central and State Department of Agriculture, Public and Private Seed Entrepreneurs and host University.The session was stared with the welcome address by Dr. B.R. Choudhary, Director of Research, AU, Jodhpur. Dr. K.S. Varaprasad, Project Director, IIOR, presented the research highlights of AICRP (Sunflower) for the period 2013-14.

The Introductory Session was chaired by Dr. L.N. Harsh, VC, AU, Jodhpur. The other dignitaries attended were Dr. S. Paroda, former Chairman, ASRB; Dr. J.S. Chauhan, ADG (Seeds), ICAR; Dr. T.S. Rathod, Director, AFRI, Jodhpur. The important decisions taken are:

- The hybrids developed till today under AICRP programme were based on the available CMS and R lines that were obtained initially from USDA, UAS. To widen the genetic base and tap the yield QTLs, prebreeding using compatible wild diploid species (Coimbatore- *H.debilis*, Latur- *H.annuus*, Ludhiana- *H.argophyllus*, DOR- *H.praecox, H. niveus*) is to be initiated.
- Hybrids in pipeline reported to be tolerant to downy mildew, necrosis and Alternaria leaf spot were selected based on disease severity. Now it has been decided to identify promising hybrids based on both infection level and yield.
- Sunflower germplasm holding as on date is 2500 accessions including the core set developed at USDA, UAS (112 accessions). For better utilization of the germplasm, it is decided to develop an Indian core germplasm set.

- Development of experimental hybrids mainly done by analyzing the heterosis and combining ability estimates which are resulted in the utilization of the same CMS or R lines for different hybrids. Hence, a decision was taken to invariably subject the lines and testers for diversity analysis before exploitation of inbreds in the heterosis breeding programme.

Institute Research Committee

IRC meeting was held from May 23-26, 2014 under the chairmanship of Dr. K.S. Varaprasad, Director, IIOR. Results of the 39 Institute projects were reviewed and technical programme for 2014-15 was finalized.

Annual Group Meeting on Castor

The Annual Group Meeting of Castor was held at Regional Research Station, CCSHAU, Bawal during May 29-31, 2014 to review the results of research conducted under AICRP (Castor) during 2013-14 and formulate the strategies to increase the production and productivity of castor for 2014-15. The meeting was attended by the scientists working under AICRP (Castor), officials of central and State Department of Agriculture, Public and Private Seed Entrepreneurs and host University. The Introductory Session was chaired by Dr. K.S. Khokhar, Hon'ble Vice-Chancellor, CCSHAU, Hisar. The other dignitaries included Dr. K.S. Varaprasad, Director, IIOR, Hyderabad; Dr. S.S. Siwach, Director of Research, CCSHAU, Hisar and Dr. S.K. Jha, Principal Scientist (OP), ICAR.

The session commenced with the welcome address by Director of Research, CSHAU, Hisar. This was followed by the presentation of Research Highlights of Castor by Dr. K.S. Varaprasad, Director, IIOR, Hyderabad. New initiatives / decisions taken are as follows:

- To expose the large volume of breeding material to all breeders the germplasm field day should be planned at Junagadh center during December 2014.

- To identify suitable hybrids for newer castor growing regions, hybrids in pipeline/state released by other lead centers are to be evaluated by new centers *viz*., Kanpur, Bhavanipatna, Bhattapara, Bawal, Navsari and Hiriyur atleast for two years.

- New voluntary centers were identified in states like Haryana, Rajasthan, Uttar Pradesh, Odisha, Andhra Pradesh, Tamil Nadu and Karnataka for conducting yield trials in non-traditional areas which will facilitate evaluation of the varieties/ hybrids at more locations in a particular state.

Annual Group Meeting on Safflower and Linseed

The Annual Group Meeting of Safflower and Linseed was held at UAS, Raichur during August 24-26, 2014 to review the results of research conducted under AICRP (Castor) during 2013-14 and formulate the strategies to increase the production and productivity of castor for 2014-15. The meeting was attended by the scientists working under AICRP (Castor), officials of central and State Department of Agriculture, Public and Private Seed Entrepreneurs and host University. The introductory session was chaired by Dr. B.S. Janagowdar, Hon'ble Vice-Chancellor, UAS, Raichur. The other dignitaries include Dr. B.B. Singh, ADG (OP), ICAR and Dr. K.S. Varaprasad, Director, IIOR, Hyderabad. The session commenced with the welcome address by Dr. Shanker Gowd, Assoc. Director of Research, UAS, Raichur. This was followed by the presentation of Research Highlights of Castor by Dr. K.S. Varaprasad, Director, IIOR, Hyderabad. New initiatives / decisions taken are as follows:

- Development of short duration parental lines and stabilization of parental lines by testing at multilocations for male sterility per cent.
- Identification of ideotypes suitable to different growing situations.
- Pre-breeding for enhancing oil content in parental lines using high oil types Mexican and USDA germplasm.

Institute Management Committee

The 34th to 36th meetings of the Institute Management Committee were held during the period under report under the Chairmanship of Dr. K.S. Varaprasad, Director, IIOR. The Chairman welcomed the Management Committee Members and presented the research achievement of the Institute 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 Institute. The revenue generated and expenditure incurred in each quarter were also presented to the committee. The proposals on renovation of glass house, equipments to be purchased in 2014-15, enhancement of expenditure on security services were approved in the IMC meeting.

Foundation Day Celebrations

IIOR Foundation Day was observed on 1st August 2014. The Foundation Day Lecture on "Talents Search for Manning Agriculture Teaching, Research and Extension – Need of the Sector" was delivered by Dr. C.D. Mayee, Former Chairman, ASRB and Adjunct Professor IRI. Dr. A. Padma Raju, Hon'ble VC, ANGRAU presided the function and Dr. D. Rama Rao, Director, NAARM, Hyderabad was the Guest of Honour. In this celebrations, the staff of IIOR belonging to different category were awarded based on their contribution to the Institute.

Vigilance Awareness Week

As per the instructions of the Central Vigilance Officer, ICAR, New Delhi Vigilance Awareness Week was observed from 27th October to 1rd November 2014, at IIOR, Rajendranagar, Hyderabad. The main focus of observing Vigilance Awareness Period is "Combating Corruption – Technology as an enabler". On October 27, 2014, the VIGILANCE PLEDGE in Hindi and English was administered to all the scientists, officers and staff of the Institute in response to the advance circular regarding the event. Relevant to the theme, on October 29, 2014, a talk on "Increasing Transparency & Fighting Corruption through ICT" was delivered by Dr S.N. Sudhakara Babu, Principal Scientist and Vigilance Officer, IIOR and discussed in detail various aspects of happenings in the world where the technology through ICTs are employed to raise awareness against corruption. Many aspects of measuring and reporting corruption by general public through ICTs were highlighted. The information from Transparency International, a global organization devoted to monitor and advise governments about the ways and means of reducing corruption and the use of ICTs were highlighted with examples and comparisons. Many examples in terms of Aadhar card linkages, Samagra kutumba survey, elimination of middle man, GPS enabled tracking system, etc., were emanated. 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 IIOR 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 at IIOR.

Talk on "Increasing Transparency & Fighting Corruption through ICTs" by Dr S.N. Sudhakara Babu, Vigilance Officer, IIOR

National Seminar on Technologies for Enhancing Oilseed Production

A National Seminar on "Technologies for Enhancing Oilseeds Production through NMOOP" jointly organized by Department of Agriculture & Cooperation, Government of India, New Delhi and ICAR-Indian Institute of Oilseeds Research, at Hyderabad during January 18-19, 2015. Dr. K.S. Varaprasad, Director, IIOR welcomed the dignitaries and delegates. The inaugural session was presided by Dr. M.V. Rao, Ex-Spl. Director General, ICAR and Ex-Vice-Chancellor, ANGRAU. Dr. S. Ayyappan, Secretary, DARE & Director, General, ICAR in his opening remarks lauded the efforts of oilseed researches and technologies in increasing oilseeds production and its utilization. He emphasized that demand driven innovations in oilseed sector is need of the hour. Suitable innovative approaches are essential to increase oilseed production and productivity. Identifying districts having high productivity and implementing the latest technologies in these districts on mission mode approach will enhance the oilseed production according to him. Marching towards Swasth Bharat through healthy oilseeds/oil should be the goal for future. Dr. David Bergvinson, DG, ICRISAT in his remarks said that market driven research, enhanced mechanization and exploring market opportunities will play key role in improving oilseeds production. He opined that best management practices with farmers participation is essential. Other eminent experts like Dr. S.K. Datta, DDG (CS), ICAR; Dr.J.S. Sandhu, Agril. Commissioner, GOI; Dr. A. Padma Raju, VC, ANGRAU; Dr. V. Praveen Rao, Spl. Officer & Registrar, PJTSAU; Sri K. Madhusudhan Rao, IAS, Commissioner & Director of Agriculture, Government of Andhra Pradesh also highlighted various issues related to oilseed production and productivity as well as technologies with an emphasis on mechanization and adoption of micro-irrigation system in oilseeds on a massive scale. Four publications related to oilseeds research and development brought out by DAC & IIOR were released on this occasion. Dr. Anupam Barik, ADC (OS), DAC, New Delhi proposed the vote of thanks. On this occasion, an oilseeds "Crop Cafeteria" was inaugurated by Dr. S. Ayyappan, Secretary, DARE & DG, ICAR at IIOR premises which showcased latest varieties/hybrids as well as important oilseed based cropping systems and micro-irrigation systems (drip, sprinkler, rain gun).

Dr. J.S. Sandhu, Agril. Commissioner, GOI inaugurated the exhibition stalls at the Seminar venue depicting various technologies developed by different oilseed institutes/organisations. Inaugural Session was followed by four technical sessions *viz*., (i) Research Strategies for Promotion of Oilseeds; (ii) Development Efforts on Oilseeds Cultivation; (iii) Commercial Use of Oilseeds and (iv) Good Agricultural Practices and Farmers' Interaction. Eminent subject-matter-specialists have

delivered lectures for the benefit of oilseed stakeholders on technologies and strategies for enhancing oilseeds production in the country. The Directors of Agriculture of different states; Central Seed Agencies like NSC, KRIBHCO, NAFED, HIL, IFFDC, SFAC, SEA, IOPEPC, State Seed Corporations, officials of State Department of Agriculture, and non-government agencies, scientists from different AICRP centres and representatives from KVKs have participated in the National Seminar. In addition to above, about 1000 farmers are also visited the Crop Cafeteria and Exhibition stalls during the period of Seminar and benefitted with the latest technologies of oilseeds.

The Plenary Session of the above seminar was graced by Sri Avinash K. Srivastava, Addl. Secretary, Dept. of Agriculture & Cooperation, New Delhi as Chairman and Dr. B.B. Singh, Asst. Director General (OP), ICAR, New Delhi as Co-Chairman.

Demonstration of proven production technologies in an integrated manner in selected high spread-low productive and low spread-high productive districts for enhancing the production and productivity of oilseeds, moonitoring of seed production chain and rolling plan for effective replacement of varieties, confirmation/commitment from the Central/state governments for procurement of quantity of seed indented by them and continuation of ongoing assistance on production and supply of seed of oilseed crops, exploring the possibilities of area expansion in north eastern Region, mechanization, use of micro-irrigation and water carrying pipes deserves enhanced support with liberal assistance to the farmers, enhancement of MSP of oilseeds commensurate with increase in MSP of wheat and rice with assured procurement, documentation of improved packages of practices on oilseeds in regional languages by the states and its wider distribution and integration with the industry on PPP mode for seed production, technology transfer and output marketing, major emphasis to be given for micro-nutrients use based on soil test for sulphur, zinc and boron in all oilseed growing regions and cropping systems are some of the action points emerged in the seminar.

HUMAN RESOURCE DEVELOPMENT

National Trainings

Name	Programme	Venue	Date
Ms. J. Vijaya Lakshmi Bhushan	Training Programme for Assistants of ICAR/Institutes	Institute of Secretariat Training & Management (ISTM), New Delhi	June 9-20, 2014
Dr. P.S. Srinivas	MDP on "Technology Management for Researchers"	NAARM, Hyderabad	August 19-23, 2014
Dr. M.A. Aziz Qureshi Dr. P. Duraimurugan	Application of Electrospun Nanofibres in Crop Health & Post-Harvest Technology	ICAR-CIRCOT, Mumbai	September 15-24, 2014
Dr. M. Sujatha Dr. P.S. Vimala Devi	Integrated Scientific Project Management for Middle Level Women Scientists	Centre for Organisation Development, Hyderabad	September 22-26, 2014
Dr. H. Basappa	Stress Management	Institute of Secretariat Training & Management (ISTM), New Delhi	October 07-10, 2014
Dr. P. S. Vimala Devi	MDP on "Emotional Intelligence for Personal and Work Excellence"	NAARM, Hyderabad	November 25-28, 2014
Dr. H. Basappa Dr. G. Suresh Sri N. Prabhakara Rao Sri Pradeep Singh Sri M. Bhaskar Reddy	Communication Skills	Institute of Secretariat Training & Management (ISTM), New Delhi	January 19-20, 2015

Participation in Conference / Seminars / Workshops / Meetings

Name	Programme	Venue	Date
Dr. M. Padmaiah	Workshop on upliftment of tail end areas of Nagarjunasagar canals	SAMITI, Malakpet, Hyderabad	April 15, 2014
Dr. S.N. Sudhakara Babu	CVRC meeting	Almora	June 2, 2014
Dr. V. Dinesh Kumar	Brain storming session on “Strategies to develop efficient male sterility system in rice to exploit hybrid vigour”	New Delhi	June, 2014
Dr. N. Mukta	Impact of capacity building programmes under NAIP	Jointly organized by National Agricultural Innovation Project (NAIP), ICAR & the International Food Policy Research Institute (IFPRI), New Delhi.	June 6-7, 2014
Dr. K.S. Varaprasad Dr. I.Y.L.N. Murthy Dr. P. Padmavathi	FAI workshop "Balanced Fertilization in agricultural crops"	Fertilizer Association of India, Hyderabad.	July 9, 2014

Name	Programme	Venue	Date
Dr. P. Kadirvel	Short course on "Non- destructive Phenotyping and Phenomics for Dissection of Abiotic Stress Tolerance, Gene Discovery and Crop Improvement".	Crop Physiology Division, IARI, New Delhi.	July 14-23, 2014
Dr. S.N. Sudhakara Babu	"Expert Consultation on Regulatory Science for Risk Assessment in Agriculture Biotech"	ILSI-India and Regulatory Science Division of RCGM	July 23, 2014
Dr. I.Y.L.N. Murthy	2nd National consultation meet on oilpalm	IIOR, Hyderabad	July 26, 2014
Dr.S. Chander Rao Dr. R.D. Prasad	National Workshop of AICRP on Palms	IIOR, Hyderabad.	July 27-29, 2014
Dr. K. Anjani	VI Brazilian Congress on Castor	University of Ceara parliament Fortaleza, Institute for Studies & Research on Development of the State of Ceara-INESP & EMBRAPA	August 12-15, 2014
Dr. N. Mukta Dr. P. Padmavathi	Workshop on Developing winning research proposals	NAARM, Hyderabad	September 9-11, 2014
Dr. A. Aziz Qureshi	"Application on Electrospun Nano-fibres in Crop Health and Post-Harvest Technology"	CIRCOT, Mumbai	September 15-24, 2014
Dr. M. Sujatha	Integrated Scientific Project Management for Women Scientists/ Technologists	Center for Organization Development, Hyderabad	September 22-26, 2014
Dr. G.D. Satish Kumar	Workshop on Content Creation in Regional Languages, Information Security & Knowledge Sharing through Vikaspedia Platform	IIRR, Hyderabad	September 26, 2014
Dr. A.R.G. Ranganatha, Dr. M.R. Deshmukh, Dr. Raju Panse, Dr.Shikha Sharma, Dr. A.K. Pandey and Dr. Alok Jyotishi	Strategies for self-reliance in oilseeds through improved production technologies - Agro-ecological approaches towards sustainable agriculture production	Centre of Advanced Faculty Training, JNKVV, Jabalpur	October 1, 2014
Dr. A. R. G. Ranganatha	"Improved varieties of oilseed crops and quality seed supply" - ICT use for increasing oilseed production	IIOR, Hyderabad	October 7-14, 2014
Dr. M. Sujatha	ILSI International Conference on New Breeding Technologies	Jaipur	October 9-10, 2014
Dr. M. Padmaiah	Impact of mobile phones on outreach of castor production technologies	IIOR, Hyderabad	October 13, 2014
Dr. I.Y.L.N.Murthy	Ethics and values in public governance	ISTM Institute, New Delhi	October 13-15, 2014
Dr. H. Basappa	DOR Exhibition stalls at Krishi Mela -2014	UAHS, Shimoga	October 18-20, 2014
Dr. R.D. Prasad	The 13th International *Trichoderma* and *Gliocladium* Workshop (TG 2014)	Shanghai, P.R., China	October 19-23, 2014

Name	Programme	Venue	Date
Dr. V. Dinesh Kumar	"Development of GM oilseed crops: Overview of research and developments" - "Awareness Workshop on Issues Related to Genetically Modified(GM) Crops"	LAM farm, ANGRAU, Guntur	October 27, 2014
	-do-	Agricultural College, ANGRAU, Bapatla	October 28, 2014
Dr. P.S. Srinivas	Workshop "Open Access to Agricultural Knowledge for Inclusive Growth and Development"	NAARM, Hyderabad	October 29-30, 2014
Dr. P.S. Vimala Devi	National Seminar on "Current Trends in Food and Agriculture Microbiology"	St. Pious X Degree & P.G college for Women, Hyderabad.	October 30-31, 2014
Dr. P.S. Vimala Devi	Interface Meeting with Bio-pesticide Industry	IIOR, Hyderabad	November 3, 2014
Dr. G.D. Satish Kumar	"Interaction meeting with Biopesticide Consortium members"	IIOR, Hyderabad	November 3, 2014
Dr. G.D. Satish Kumar	Seventh National Extension Education Congress on Translational Research-Extension for Sustainable Small Farm Development".	Society of Extension Education, Agra at ICAR Research Complex for NEH Region, Umiam, Meghalaya	November 7-11, 2014
Dr. H. Basappa	IIOR Exhibition stalls at Krishi Mela -2014	UAS, Raichur	November 14-16, 2014
Dr. C. Sarada	Workshop on Introduction and advanced Next Generation Sequencing Application and Data Analysis	Institute of Bioinformatics, Bengalure	November 15-16, 2014
Dr. C. Sarada	2014 Next Gen Genomics & ioinformatics Technologies (NGBT) Conference	NIMHANS, Bengalure	November 17-19, 2014
Dr. M. Sujatha	Brainstorming meeting cum Workshop on Proteomics: Present & Future	CCMB. Hyderabad	22-24 November, 2014
Dr. Lakshmi Prayaga	National Conference of Plant Physiology on "Frontiers of Plant Physiology research:food security and environmental challenges"	OUAT, Bhubaneswar	November 23-25, 2014
Dr. I.Y.L.N. Murthy, Dr. A. Aziz Qureshi	79th Indian Society of Soil Science national seminar on Developments in Soil Science	ANGRAU, Hyderabad	November 24-26, 2014
Dr. V. Dinesh Kumar	Meeting and Round Table discussion on 'Seed Production Technology'	Dupont Pvt Limited, Hyderabad	November 2014
Dr. P. Padmavathi	Brain-storming session on 'Sustaining soybean productivity and production in India: A Resource Domains Initiative	NASC, New Delhi	November 28, 2014
Dr. Sujatha, T.P.	CAFT Training on "Functional Genomics & Proteomics: Techniques and tools for Crop Improvement"	CAFT, IARI, New Delhi	November 12 - December 2, 2014
Dr. V. Dinesh Kumar	"Transgenics in oilseed crops: advances & challenges" in National Conference on "Emerging Challenges and Opportunities in Biotic & Abiotic Stress Management (ECOBASM-2014)".	IIRR, Rajendranagar, Hyderabad	December 14, 2014

Name	Programme	Venue	Date
Dr. H. Basappa, Dr. R.D. Prasad, Dr. S. Chander Rao Dr. M. Santha Lakshmi Prasad, Dr. P.S. Srinivas and Dr. P. Duraimurugan	Meeting on "Scaling up Sustainable Plant Health Management in India through Skill Enhancement"	IIOR, Hyderabad	December 23, 2014
Dr. P. Kadirvel	National Seminar on “Challenges and Innovative Approaches in Crop Improvement”	ARI, TNAU, Madurai	December 16-17, 2014
Dr. Praduman Yadav	Basic Computer Training Programme in Hindi	Bharat Heavy Dynamics Ltd., Hyderabad	December 15-9, 2014
Dr. P. Padmavathi	Project Monitoring Review workshop of DST project on Crop Manage-ment options to make safflower cultivation profitable for small farmers through enhanced utilization of petals	New Delhi	December 23, 2014
Dr. V. Dinesh Kumar	Brainstorming session on the preparation of manual on guide-lines for implementation of PME activities.	NAARM, Hyderabad	December 24, 2014
Dr. S.N. Sudhakara Babu	Second International conference on ‘Climate Change and stress management’	PJTSAU, Hyderabad	January 7-9, 2015
Dr. P. S. Srinivas Dr. P. Duraimurugan Dr. G.D. Satish Kumar	Second International Conference on Bioresource and Stress Management	PJTSAU, Hyderabad	January 7-10, 2015
Dr. S.N. Sudhakara Babu	International seminar on ‘Sustainable agriculture and Rural development’	Centre for Good Governance, Gachibowli, Hyderabad	January 9, 2015
Dr. Senthilvel Senapathy	Molecular marker data analysis & software’s in training programme on “Recent trends in Bioinformatics and its applications in Agriculture”	NAARM, Hyderabad	January 10, 2015
Dr. I.Y.L.N. Murthy Dr. M. Sujatha, Dr. K. Anjani, Dr. H. Basappa, Dr. S.N. Sudhakara Babu, Dr. N. Mukta Dr. R.D. Prasad, Dr. S. Chander Rao, Dr. P.S. Srinivas, Dr. P. Duraimurugan, Dr. P. Padmavathi Dr. Praduman Yadav, Dr. M. Padmaiah,	National seminar on “Technologies for Enhanced Oilseed Production through NMOOP”	PJTSAU, Hyderabad	January 18-19, 2015

Name	Programme	Venue	Date
Dr. S.V. Ramana Rao, Dr. C. Sarada, Dr. G.D. Satish Kumar, Dr. K. Alivelu and Mrs. P. Madhuri			
Dr. V. Dinesh Kumar	Development of GM oilseed crops: Overview of research and developments" - One-day Awareness Workshop on Issues Related to Genetically Modified (GM) Crops	RARS, PJTSAU, Jagtial	January 21, 2015
Dr. A.R.G. Ranganatha and Dr. J. Jawahar Lal	Hybrid Seed Production Technologies in Sesame and Niger	IIOR, Hyderabad	January 21-28, 2015
Dr. M. Padmaiah	Participatory seed production: problems and prospects on Model training course of DOE	IIOR, Hyderabad	January 21-28, 2015
Dr. A.R.G. Ranganatha and Dr. J. Jawahar Lal	Improved varieties of sesame, mustard, soybean and groundnut	IIOR, Hyderabad	January 21-28, 2015
Dr. V. Dinesh Kumar	Hybrid purity assessment using molecular markers with special reference to oilseed crops. Model training programme on "Seed production in oilseed crops"	IIOR, Hyderabad	January 27 , 2015
Dr. G.D. Satish Kumar	10th Convocation of Jamsetji Tata National Virtual Academy (NVA) Fellowship for Grassroots Social Worker and 9th Convention of Grameen Gyan Abhiyan	MS Swaminathan Research Foundation, Chennai	February 2-4, 2015
Dr. P.S. Srinivas	Meeting on "ABS provisions under BDA Act, 2002"	Visakhapatnam	February 4, 2015
Dr. Senthilvel Senapathy and Dr. P. Kadirvel	5th International Conference on "Next Generation Genomics and Integrated Breeding for Crop Improvement"	ICRISAT, Patancheru	February 18-20, 2015
Dr. S.N. Sudhakara Babu, Dr. H. Basappa Dr. P.S. Srinivas Dr. A. Aziz Qureshi Dr. Praduman Yadav, Dr. H.P. Meena, Dr. C. Sarada and Dr. G.D. Satish Kumar	National seminar on "Strategic interventions to enhance oilseeds production in India"	ICAR-D RMR, Bharatpur	February 19-21, 2015
Dr. V. Dinesh Kumar	Brain storming sessions about the preparation of manual on guidelines for implementation of PME activities.	NAAS Complex, New Delhi	February 23, 2015

Name	Programme	Venue	Date
Dr. V. Dinesh Kumar	18th ADNAT Convention Symposium on "Genetic Engineering of Agricultural Crops and Live Stock: Current Status, Social, Ethical and Regulatory Aspects"	University of Hyderabad.	February 24, 2015
Dr. P.S. Srinivas	Workshop on "Training Needs Assessment" for HRD Nodal Officers of ICAR	WALAMTARI, Hyderabad	February 26, 2015
Dr. M. Santha Lakshmi Prasad	Workshop on "Introduction to plant pest and disease risk forecasting"		March 7, 2015
Dr. P.S. Srinivas and Dr. P. Duraimurugan	International Conference on "Recent Advances in Bio-Energy Research"	National Institute of Renewable Energy, Kapurthala	March 14-17, 2015
Dr. Praduman Yadav		Agri Biotech Foundation, Hyderabad	
Dr. V. Dinesh Kumar	Refresher course on Molecular Biology and Biotechnology		March 16, 2015
Dr. P. Kadirvel	16th Shri. Vasantrao Naik Memorial National Agriculture Seminar on Conventional and Biotechnological Approaches for Crop Improvement	Dr. PDKV, Akola	March 19-20, 2015
Dr. G.D. Satish Kumar	ICT Workshop on "Technology mediated training in agricultural and allied organizations	Extension Education Institute, ANGRAU, Hyderabad.	March 27, 2015

हिन्दी पखवाड़ा समारोह का आयोजन

निदेशालय में 01 से 15 सितंबर, 2014 तक हिन्दी पखवाड़ा समारोह का आयोजन किया गया। जिसका समापन समारोह 15 सितंबर, 2014 को आयोजित किया गया। समापन समारोह की अध्यक्षता डॉ. के.एस. वरप्रसाद, परियोजना निदेशक ने की।

पखवाड़े के समापन कार्यक्रम का शुभारंभ डॉ. एन. मुक्ता, प्रधान वैज्ञानिक के स्वागत भाषण एवं मुख्य अतिथि के परिचय से हुआ। तत्पश्चात श्री. प्रदीप सिंह, सहा. निदेशक (रा.भा) ने राजभाषा कार्यान्वयन की प्रगति रिपोर्ट प्रस्तुत की ।

हिन्दी सप्ताह के दौरान आयोजित स्मरण, शब्द बनाइए, सामान्य ज्ञान तथा एक मिनट प्रतियोगिताओं के विजेताओं को मुख्य अतिथि डॉ. नरहर देव, भूतपूर्व उप–महाप्रबंधक, भारत डायनमिक्स लिमिटेड द्वारा पुरस्कार वितरित किए गए। कार्यालयीन कार्य हिन्दी में करने के लिए चलाई जा रही प्रोत्साहन योजना के तहत अधिकारी/कर्मचारियों को वर्ष 2013–14 के दौरान हिन्दी में सर्वाधिक कार्य करने हेतु नगद पुरस्कार दिए गए।

समारोह के मुख्य अतिथि डॉ. नरहर देव, भूतपूर्व उप-महाप्रबंधक, भारत डायनमिक्स लिमिटेड ने अपने संबोधन में इंटरनेट और सोशल मीडिया द्वारा सूचना प्रौद्योगिकी के क्षेत्र में हो रहे तेजी से विकास और उसके साथ हिन्दी की प्रगति पर अपने विचार रखे।

हिन्दी कार्यशालाएँ

निदेशालय के हिन्दी का कार्यसाधक ज्ञान प्राप्त वैज्ञानिक, अधिकारियों एवं कर्मचारियों के लिए वित्त वर्ष के दौरान चार कार्यशालाओं का आयोजन क्रमशः 23 जून, 2014; 12 सितंबर, 2014; 19 नवंबर, 2014 और 27 मार्च, 2015 को किया गया।

इन कार्यशालाओं में निदेशालय के वैज्ञानिक, अधिकारी एवं कर्मचारियों ने भाग लिया।

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Research Centre for Integrated Pest Management,New Delhi,India. Pp.44-61.

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Alivelu, K. Satish Kumar, G.D., Sarada, C. and Padmaiah, M. 2014. Mobile apps (m-apps) for Agriculture lecture notes given for Training manual : Use of ICTs for increasing production and productivity of oilseeds for model training course held at DOR, Hyderabad during 07-14, October, 2014.

Praveen Reddy, A., Dudhe, M.Y., Lavanya C. and Mukta, N. 2015. PPV&FR Act and DUS testing in Oilseed crops. In: Training Manual of Model Training Course on Seed Production in Oilseed Crops held at DOR, Hyderabad from 21st to 28th January, 2015.

Madhuri, P. 2014. Knowledge dissemination through kiosk. lecture notes given for Training manual : Use of ICTs for increasing production and productivity of oilseeds for model training course held at DOR, Hydeabd during 07-14, October, 2014.

Sarada, C., Alivelu, K. and Srinivas, P.S. 2014. Statistical Nonlinear Techniques for Pest modeling – case study of Aphid lecture notes given for Training manual: Advances in Pest Forecast Models and Decision Support Systems for Crop Protection in Changing Climate Scenario, Winter school held at CRIDA, Hyderabad during from October 29 -November 14, 2014.

Satish Kumar, G.D., Padmaiah M. and Alivelu, K. 2014. Evaluation of mobile phone based agro-advisory programme and its implications for scaling up. *In*: Model Training Course on Use of ICTs for increasing production and productivity of oilseeds. DOR, Hyderabad. Pp. 8-20.

Presentation in Conference / Symposia

Name of the Scientist(s)	Title / Conference / Place / Date(s)
Alivelu, K.	Presented a poster on "Safflower yield forecasting in India-An application of Autoregressive Integrated Moving Average (ARIMA) Model" Alivelu, K. Padmvathi, P. Sarada, C. and Lakshmamma, P. by first author in International Conference on Bio-Resource and Stress Management at Hyderabad, India during January 7-10, 2015 pp.118.
Anjani, K.	Challenges for castor breeding and production in India. Presented in Open technical Seminar, August 8, 2014, Embrapa Algadao, Campina Grade, Brazil
Anjani, K.	Production of Castor in India" presented in VI Brazilian Congress on castor (VI Congresso Brasileiro de Mamona), August 14, 2014, University of Ceara parliament Fortaleza, Fortaleza, Brazil.
Anjani, K. Praduman Yadav and Md. Sharif	Baba Breeding for high oil in safflower (Carthamus tinctorius L.). *In*: National Seminar on Challenges and Innovative Approaches in Crop Improvement, December 16-17, 2014, AC & RI, TNAU, Madurai, India.
Aziz Qureshi, A.	79th Annual convention of Indian Society of Soil Science, November 24-27, 2014 at PJTSU-ANGRAU, Hyderabad. (oral presentation)
Aziz Qureshi, A.	National Seminar on "Technology for enhancing oilseeds production through NMOOP, January 18-19, 2015 at PJTSU Auditorium, Hyderabad.
Bhavana, P., Debadutta Mishra, Demudu Naidu Panchada, Md. Sharif Baba, Prasad, R.D. and Anjani, K.	EST-SSR markers flanked to Fusarium wilt resistance in safflower. In: National Seminar on Challenges and Innovative Approaches in Crop Improvement, December 16-17, 2014, AC & RI, TNAU, Madurai, India.
Duraimurugan, P. and Lakshminarayana, M.	Evaluation of integrated pest management module for insect pests of castor. In: Compendium of Abstracts, The Second International Conference on Bioresource and Stress Management, January 7-10, 2015, Professor Jayashankar Telangana State Agricultural University and Acharya N.G. Ranga Agricultural University, Hyderabad. p. 384.
Lakshmamma, P., Lavanya, C., Lakshmi Prayaga and Alivelu, K.	"Identification of parents and hybrids of castor with early vigor and high total drymatter production in National Conference of Plant Physiology on "Frontiers of Plant Physiology Research: Food security and Environ-mental challenges" from November 23-25, 2014 at OUAT, Odisha.
Lakshmi Prayaga, Lakshmamma, P. and Sarada, C.	"Characterization of sunflower genotypes for root and shoot traits in National Conference of Plant Physiology on "Frontiers of Plant Physiology Research: Food security and Environmental challenges" from November 23-25, 2014 at OUAT, Odisha
Lavanya, C., Duraimurugan, P. and Santha Lakshmi Prasad, M.	Genetic enhancement of parental lines in castor (Ricinus communis L.) for development of high yielding hybrids with resistance to leafhopper (Poster presentation). In: Proceedings of the National Symposium on Crop Improvement for Inclusive Sustainable Development, November 7-9, 2014, Punjab Agricultural University, Ludhiana. pp. 406 to 408.
Meena, H.P.	Poster presentation on 'Identification of maintainers/restorers in sunflower (Helianthus annuus L.)' during National Seminar organized by ISOR from February 19-21, 2015 at DRMR, Bharatpur, Rajasthan.
Meena, H.P.	Poster presentation on 'Sunflower genetic resources management at DOR' during National Seminar organized by ISOR from February 19-21, 2015 at DRMR, Bharatpur, Rajasthan.
Patil B.V, Basappa, H, Duraimurugan, P., Ghante, V.N., Santha Lakshmi Prasad, M Prasad, R.D. and Gururaj Sunkad.	Protection technologies for major oilseed crops In : Lead papers - National seminar on "Technologies for Enhanced Oilseed Production through NMOOP" at PJTSAU, Hyderabad from January 18-19, 2015, pp 39-60.

Name of the Scientist(s)	Title / Conference / Place / Date(s)
Praduman Yadav	'Nutritional virtues of oils' in Model training course on Use of ICTs for increasing production and productivity of oilseeds at IIOR, Hyderabad during October 7-14, 2014.
Praduman Yadav	Breeding for high oil in safflower (*Cathamus tinctorius* L) in national seminar on Challenges and innovative Approaches in crop improvement, organised by college & Research Institute, Madurai, Tamil Nadu Agricultural University during December 16-17, 2014.
Prasad, R. D., Dinesh Kumar, V., Navaneetha, T. and Sowmya, P.	Identification of Thermotolerant Trichoderma and their proteome and transcriptome analysis. Reseach paper presented in "The 13th InternationalTrichoderma and GliocladiumWorkshop (TG 2014)", October 19-23, 2014; Shanghai, P.R.China
Prasad, R.D.	Delivered a guest lecture on "Nano interventions in agriculture" in EEI, South Region Hyderabad training programme on "Recent advances in agriculture and allied sectors" on July 18, 2014.
Prasad, R.D.	Delivered a guest lecture on "Trichoderma- a wonder fungus for agriculture" national workshop of AICRP on Palms on July 27, 2014 held at DOR, Hyderabad.
Sarada, C.	Delivered lecture on "Statistical Nonlinear Techniques for Pest modeling –case study of Aphid" on November 11, 2015 in training programme organized by CRIDA, Hyderabad on "Advances in Pest Forecast Models and Decision Support Systems for Crop Protection in Changing Climate Scenario" from October 29-November 14, 2014."
Sarada, C.	Participated a poster on " Genome wide search for "Genome Wide Search for Microsatellites in Castor (*Ricinus Communis* L.)" Sarada, C. Alivelu, K. Ushakiran, B. and Kanti Meena in "2014 Next Gen Genomics & Bioinformatics Technologies (NGBT) Conference" November 17-19, 2014 at NIMHANS, Bangalore, India.
Sarada, C. Venkattakumar, R., Padmaiah, M. and Alivelu, K.	Poster presentation on Determinants of resource use management behaviour and technical efficiency of castor farmers in Andhra Pradesh in National seminar on "Strategic interventions to enhance oilseeds production in India" February 19-21, 2015 at ICAR-Directorate of Mustard and Rapeseed, Bharatpur.
Satish Kumar, G.D.	Presented (oral) a paper on "Productivity potential and profitability of sunflower in India" in the technical session on "Small farm complexities and priorities for sustainable economic development" at the "Seventh National Extension Education Congress on Translational Research-Extension for Sustainable Small Farm Development organized by Society of Extension Education, Agra at ICAR Research Complex for NEH Region, Umiam, Meghalaya from November 7-11, 2014.
Satish Kumar, G.D.	Presented (oral) a paper on "E kapas: An innovative mobile based voice advisory system" during the second international conference on Bio-resource and Stress management organized by Ratikanta Maiti Foundation and Acharya NG Ranga Agricultural University (ANGRAU) at ANGRAU, Hyderabad from January 7-10, 2015.
Satish Kumar, G.D.	Presented invited paper (oral) on "Frontline Demonstrations (FLDs) on Oilseeds" during the National Seminar on "Technologies for Enhancing Oilseeds Production" organized by IIOR sponsored by NMOOP, DAC held at Hyderabad from January 18-19, 2015.
Satish Kumar, G.D.	Acted as one of the panelist and made a presentation on "Mobile based agro-advisories for cotton and oilseed farmers" at the 10th Convocation of Jamsetji Tata National Virtual Academy (NVA) Fellowship for Grassroots Social Worker and 9th Convention of Grameen Gyan Abhiyan – "The Role of Information Communication Technologies (ICT) in Achieving Sustainable Development Goals and Achieving the Zero Hunger Challenge" held at MS Swaminathan Research Foundation, Chennai from February 2-4, 2015.
Satish Kumar, G.D.	Presented a paper (poster) on "Private Sector Participation in Agricultural Extension of Safflower in India during the National Seminar on "Strategic interventions to enhance oilseeds production in India" organized by Indian Society of Oilseeds Research and DRMR, Bharatpur, Rajasthan from February 18-23, 2015.
Satish Kumar, G.D. and	Frontline demonstrations on Oilseeds in Lead Papers book on Technologies for enhancing Oilseeds production Through NMOOP. pp 99-116

Name of the Scientist(s)	Title / Conference / Place / Date(s)
Sudhakar Reddy, K. Padmaiah, M.	Enhancement of Oilseeds production : Entrepreneur perspective. in Lead Papers book on Technologies for enhancing Oilseeds production Through NMOOP. pp 131-133.
Sudhakara Babu, S.N. and Padmaiah, M.	'Scope for cultivation of sunflower, safflower, castor, sesame and linseed in North eastern states' in NMOOP review workshop for NE states at Guwahati during November 10-11, 2014.
Sudhakara Babu, S.N.	'Seed Crop Management for Increasing Seed Production in Oilseeds' on 23 January, 2015. Model Training Course on "Seed Production in Oilseeds" conducted at Directorate of Oilseeds Research, Rajendranagar, Hyderabad during January 21-27, 2015.
Sudhakara Babu, S.N.	Agronomic management for Hybrid Seed Production and Management of Inputs to Hybrids, on February 3, 2015.
Sudhakara Babu, S.N.	"Hybrid Seed Production" held at IIOR, during February 3-7, 2015 at Hyderabad.
Sudhakara Babu, S.N.	"Increasing Transparency & Fighting Corruption through ICT" at Directorate of Oilseeds Research, Hyderabad as part of Vigilance Awareness Week.
Suresh G.	Efficient weed management practices for quality seed production in oilseed crops during Model Training Course on seed production in oilseed crops on January 23, 2015. Sponsored by DOE, New Delhi and organized at IIOR, Hyderabad.
Suresh, G.	Status Report of Collaboration with PDFSR and DOR/AICRP, during Regional Workshop on "Strengthening partnerships and refined methodology for on-station experiments of AICRP on IFS" held at ANGRAU, June 9, 2014.
Suresh, G.	Castor as a component crop in Farming Systems: during Regional Workshop on "Strengthening partnerships and refined methodology for on-station experiments of AICRP on IFS" held at SDAU, S.K.Nagar on August 28, 2014.
Suresh, G.	Guest lecture during International training programme on "Regional Plant Health System Analysis" held at National Institute of Plant Health Management (NIPHM), Hyderabad on November 27, 2014.
Suresh, G., Singh, I. Ramanjaneyulu, A.V., Yadav, J.S., Thirukumaran, K., Srivastava, K.S., Vekariya, K.D., Rathore, B.S. Shah, S.K., Prabakaran, A.J. and Varaprasad, K.S.	Response of castor to bio-phos application at varying phosphorous levels under rainfed and irrigated conditions during the Second International Conference on bio-resource and stress management held from January 7-10, 2015 at PJTSAU, Hyderabad.
Uma Sah., Hem Saxena, Rajesh Kumar and Duraimurugan, P.	On-farm validation of bio-rational module for management of Helicoverpa armigera in chickpea crop in Bundelkhand region of India (Poster presentation). In: Proceedings of the National Conference on Pulses: Challenges and opportunities under changing climate scenario, 29th September – October 1, 2014, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. pp. 125 to 126.
Usha, D., Santha Lakshmi Prasad, M., Sujatha, K. and Venkateswara Rao, L.	*In vitro* evaluation of Alternariaster helianthi crude toxin on germination of sunflower in" National conference on empowering mankind with microbial technologies (AMI-EMMT-2014) November 12-14, 2014 at TNAU, Coimbatore, TN.
Varaprasad, K.S. and Sudhakara Babu, S.N.	'Technology for increasing oilseeds production' in National seminar on Technologies for enhancing oilseeds production through NMOOP during January 18-19, 2015 at IIOR, Rajendranagar, Hyderabad.

INFRASTRUCTURE DEVELOPMENT

Library and documentation

The Library and Documentation unit continued to collect, store, organize and disseminate information on all aspects of crop improvement, crop production, crop protection and utilization of oilseed crops. An amount of ₹ 16,00,000/- was spent during the period under report to acquire 150 books and for subscription to 60 periodicals, four databases *viz*., Crop Science database and AGRIS on CD, AGRICOLA and Biological and Agricultural Index. A total of 236 publications were received on gratis, besides newsletters and annual reports from different organizations. New records of books were added to the computerized library catalogue database. The KOHA Integrated Library Management Software has been in operation at IIOR. Four issues of "IIOR Newsletter" and 235 electronic article delivery though e-mails have been brought out and circulated to all scientists working in AICRP (Sunflower, Safflower and Castor) centres across different states and a IIOR. An amount of ₹ 4,920/- was realized through sale of 70 IIOR Publications. Literature searches have been carried out in the mandate crops using in-house database, CROP CD, AGRIS on CD. AGRICOLA. The online databases Indiagristat.com (Agriculture) and Plant Science Protocols has been subscribed for the year 2014-15.

Other Civil Works

- Estimate and drawings for the proposed new Central Laboratory Complex are obtained from CPWD and is under consideration by ICAR.
- Repairs & Maintenance of Farm Bulding Complex at Narkhoda Farm have been carried out as a part of periodical maintenance.
- Re-carpetting of B.T Roads at Narkhoda Farm was done to provide better approach to the experimental plots.
- Facelift of Main Entrance at Narkhoda Farm has been carried out.
- Extension of Threshing/Drying yard at Rajendranagar Farm has been taken up to cater to the needs of expanding research works including DUS testing and seed production.
- Renovation of shelter shed at Rajendranagar Farm has been undertaken to serve as dining-cum-rest room for farm labour.
- Repairs and maintenance of IIOR Hostel has been carried out as a part of periodical maintenance and for better ambience and upkeep.
- Repairs of pathways, septik tank, drains, etc., at Rajendranagar Farm were carried out as a part of regular maintenance.
- The old bio-tech lab has been renovated with required modifications for facilitating pathology lab works.
- Consequent to the upgradation of the Directorate as IIOR the name boards are changed wherever required.

VISITORS

During the year under report, about 1850 visitors including farmers and students from 11 states visited this Institute and interacted with the scientists. This include the farmers from Maharashtra, Madhya Pradesh, Chhatishgad, Uttar Pradesh, Telangana, Tamil Nadu, Andhra Pradesh and students from Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Gujarat, Maharashtra, Uttar Pradesh and Odisha.

PROMOTIONS / UPGRADATIONS / TRANSFERS / SUPERANNUATIONS

Promotions

Name	Post	Promoted to post	Date of promotion
Shri J. Balram	T2 (Technical Asst) Farm/Field	T3 (Sr. Technical Asst) Farm/Field	28-06-2012
Dr. P. Padmavathi	Sr. Scientist (Agronomy)	Principal Scientist (Agronomy)	15.04.2013
Dr. P.S. Srinivas	Sr. Scientist (Entomology)	Principal Scientist (Entomology)	15.04.2013
Shri G.Y. Prabhakar	T4 (Sr. Technical Asst.) Farm/Field	T-5 (Technical Officer) Farm/Field	01-01-2014
Shri P. Ashok	T4 (Sr. Technical Asst.) Farm/Field	T-5 (Technical Officer) Farm/Field	01-01-2014
Shri L. Krupakar	T4 (Sr. Technical Asst.) Farm/Field	T-5 (Technical Officer) Farm/Field	01-01-2014
Shri D. Mallesha	T4 (Sr. Technical Asst.) Farm/Field	T-5 (Technical Officer) Farm/Field	01-01-2014
Shri S. Narasimha	T4 (Sr. Technical Asst.) Lab	T-5 (Technical Officer) Lab	01-01-2014
Shri Shaik Shoukat Ali	T4 (Sr. Technical Asst.) Lab	T-5 (Technical Officer) Lab	01-01-2014
Dr. Md. A. Aziz Qureshi	Sr. Scientist (Soil Science)	Principal Scientist (Soil Science)	12.02.2014

Financial upgradation under MACP

Name	Post	Date of effect
Shri G.B. Nagendra Prasad	UDC	03-10-2011
Shri T. Bichanna	UDC	15-07-2012
Shri G. Chandraiah	PS	20.08.2013
Smt. R. Raji	PA	29.08.2013
Shri G. Yadaiah	SSS	18-08-2013
Shri G. Rajamouli	SSS	18-08-2013
Shri G. Mallesh	SSS	20-03-2014
Shri D. Narasimha	SSS	22.03.2014
Shri C. Prabhudas	Duplicating Machine Operator	10-01-2015
Smt. R.A. Nalini	Assistant	29-03-2015

Transfer

Name	Post	Date of effect
Dr. A.R.G. Ranganatha	Principal Scientist (Pl. Breeding)	Rejoined IIOR on 25-09-2014 after completion of his tenure as PC(S&N) from JNKVV, Jabalpur
Smt. V. Kalpana	UDC	Transferred on 22.10.2014 to NRC for Meat, Hyderabad
Dr. P. Giribabu	Scientist (Nematology)	Transferred on 28.11.2014 to NRC for Banana, Tirchurapalli
Dr. K.T. Ramya	Scientist (Gen. & Pl. Breeding)	Joined IIOR on 22-12-2014 on transfer from ICAR Research Complex NEH Regon, UMROI Road, Maghalaya
Sri Raghava Kiran Kumar	Jr. Steno	Joined IIOR on 01-01-2015 on transfer from ICAR Research Complex for Goa, Goa

Superannuation

Name	Post held	Date of Retirement
Smt G. Kalavathy	Assistant	January 31, 2015
Shri G. Yadaiah	SSS	February 28, 2015

PERSONNEL

(as on March 31, 2015)

Dr. K.S. Varaprasad	**Director**

Project Director's Cell

Dr. D. Pati	T-9 (Chief Technical Officer)
Mr. G. Chandraiah	Private 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 (Plant Breeding) (deputation with ICRISAT)
Dr. Senthilvel Senapathy	Sr. Scientist (Pl. Breeding)
Dr. Kadirvel Palchamy	Sr. Scientist (Genetics)
Mr. H.H. Kumaraswamy	Scientist (Biotechnology)
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. Jawahar Lal 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. Mallesha	T-5 (Technical Officer) (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 (Agric. Chemistry)
Dr. S.N. Sudhakara Babu	Pr. Scientist (Agronomy)
Dr. Lakshmi Prayaga	Pr. Scientist (Pl. Physiology)
Dr. P. Lakshmamma	Pr. Scientist (Pl. Physiology)
Dr. G. Suresh	Pr. Scientist (Agronomy)
Dr. P. Padmavathi	Pr. Scientist (Agronomy)
Dr. Md. A. Aziz Qureshi	Pr. Scientist (Soil Science)
Dr. Praduman Yadav	Scientist (Biochemistry)
Mrs. Ch.V. Haripriya	T-6 (Senior Technical Officer) (Lab Tech.)
Mr. P. Ashok	T-5 (Technical Officer) (F/F)
Mr. L. Krupakar	T-5 (Technical Officer) (F/F)
Mr. S. Narasimha	T-5 (Technical Officer) (Lab. Tech.)

Crop Protection

Dr. P.S. Vimala Devi	Pr. Scientist (Agric. Entomology)
Dr. H. Basappa	Pr. Scientist (Agric. Entomology)
Dr. R. Durga Prasad	Pr. Scientist (Pl. Pathology)
Dr. M. Lakshminarayana	Pr. Scientist (Agric. Entomology)
Dr. S. Chander Rao	Pr Scientist (Pl. Pathology)
Dr. M. Santha Lakshmi Prasad	Pr. Scientist (Pl. Pathology)
Dr. P.S. Srinivas	Pr. Scientist (Agric. Entomology)
Dr. P. Duraimurugan	Sr. Scientist (Agric. Entomology)
Dr. P. Giribabu	Scientist (Nematology) (transferred on 28.11.2014)
Mr. M. Ramulu	T-5 (Technical Officer)
Mr. Shaik Shoukat Ali	T-5 (Technical Officer) (Lab. Tech.)
Mr. J. Balram	T-3 (Technical Assistant) (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 (Agric. Extension)
Dr. S.V. Ramana Rao	Pr. Scientist (Agric. Economics)
Dr. Ch. Sarada	Pr. Scientist (Agric. Statistics)
Dr. G.D. Satish Kumar	Sr. Scientist (Agric. Extension)

Dr. K. Alivelu	Sr. Scientist (Agric. Statistics)
Mrs. P. Madhuri	Scientist (Comp. Applications)
Mr. B. Krishna	T-6 (Senior Technical Officer)
Mr. B. Kistaiah	T-5 (Technical Officer) (F/F)

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
Mr. G. Raghava Kiran Kumar	Jr. Stenographer

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) (FM)
Mr. M. Bhaskara Reddy	T-7-8 (Assistant Chief Technical Officer) (F/F)
Mr. Y. Ramagovinda Reddy	T-6 (Senior Technical Officer) (F/F)
Mr. M. Panduranga Rao	T-5 (Technical Officer) (F/F)
Mr. G.Y. Prabhakar	T-4 (Senior Technical Assistant) (F/F)
Mr. Surender Prasad	T-4 (Senior Technical Assistant) (Electrician)
Mr. V. Sarath Babu	T-3 (Technical Assistant)
Mr. A. Srinivasa Raju	T-3 (Technical Assistant) (AC Mechanic-cum-Electrician)
Mr. N. Vasanth	T-3 (Technical Assistant) (Fitter)
Mr. K. Srinivas	T-3 (Technical Assistant) (Gen. Operator)
Mr. M. Indrasena Reddy	T-3 (Tractor Driver)
Mr. Y. Venkateshwara Rao	T-3 (Tractor Driver)
Mr. B. Giri	UDC

Seed Section

Mr. G. Keshauloo	T-5 (Technical Officer) (F/F)
Mr. T. Veeraiah	T-4 (Senior Technical Assistant) (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 (retired on 31.01.2015)
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
Mr. G. Rakesh	Assistant
Mr. G.B. Nagendra Prasad	UDC

Audit & Accounts

Mr. H. Ganesha	Finance & Accounts Officer
Mr. A. Prem Kumar	Junior Accounts Officer
Mrs. S. Swaroopa Rani	Assistant
Mr. E.V.R.K. Nagendra Prasad	Assistant
Mrs. B. Gyaneshwari	UDC

Drivers

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

Skilled Supporting Service

Mr. G. Rajamouli	SSS (Beldar)
Mr. G. Yadaiah	SSS (Beldar) (retired on 28.02.2015)
Mr. G. Mallesh	SSS (Peon)
Mr. D. Narsimha	SSS (Cleaner)
Mr. K. Ramulu	SSS (Farash)
Mr. M. Venkatesh	SSS (Peon)
Mr. A. Rambabu	SSS (Peon)
Mr. M. Ramulu	SSS (Mali)
Mr. P. Krishna	SSS (Peon)
Mr. D. Balaiah	SSS (Beldar)
Mr. B. Narsimha	SSS (Mali)
Mrs. P. Mary	SSS (Beldar)
Mrs. M.H. Elizabeth	SSS (Beldar)
Mrs. P. Narsamma	SSS (Beldar)
Mrs. B. Kistamma	SSS (Beldar)
Mr. K. Sanjeeva	SSS (Beldar)
Mr. Ch. Balaiah	SSS (Beldar)
Mr. J. Narsimha	SSS (Beldar)
Mr. B. Vishnu	SSS (Cattleman)
Mrs. G. Bharathamma	SSS (Beldar)
Mr. Narasimha	SSS (Peon)
Mr. B. Gyaneshwar	SSS (Peon)
Mr. P. Srinivas	SSS (Peon)

RESULTS-FRAMEWORK DOCUMENT (RFD)

FOR

DIRECTORATE OF OILSEEDS RESEARCH

2014-2015

DIRECTORATE OF OILSEEDS RESEARCH
Rajendranagar, Hyderabad-500 030 (Telangana State)

Website: www.icar-iior.org.in

Section 1: Vision, Mission, Objectives and Functions

Vision : Enhanced productivity/production of sunflower, safflower and castor

Mission : Contributing to the sustained growth of oilseeds production by harnessing frontier scientific tools and through generation, refinement, validation and dissemination of improved technologies in sunflower, safflower and castor

Objectives :

1. Genetic enhancement and development of improved cultivars.
2. Development and identification of appropriate crop production and protection technologies.
3. Technology dissemination and capacity building.

Functions :

- Germplasm augmentation, evaluation and characterization.
- Developing varieties/hybrids insulated for resistance to major biotic and abiotic stresses and production of breeder seed.
- Research on resource use management for maximizing production.
- Integrated pest management.
- Dissemination of improved technology through frontline demonstrations and training

Section 2: *Inter-se* priorities among Key Objectives, Success Indicators and Targets

S. No	Objective(s)	Weight	Actions(s)	Success indicator(s)	Unit	Weight	Target/Criteria values				
							Excellent (100%)	Very good (90%)	Good (80%)	Fair (70%)	Poor (60%)
1	Genetic enhancement and development of improved cultivars	35	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	8	1434	1195	956	717	478
				Lines identified for unique traits	Number	6	20	17	14	11	8
			Development of improved cultivars	Entries contributed for multilocation trial	Number	6	70	58	46	34	22
				Varieties identified for release	Number	5	4	3	2	1	0
			Development of resources for molecular breeding for biotic stresses and quality traits	Mapping population and mapping panels developed	Number	5	4	3	2	1	0
			Seed production programme	Breeder seed produced	Quintal	5	54	45	36	27	18
2	Development and identification of appropriate crop production & protection technologies	25	Development of new technologies	New technologies tested/ validated	Number	15	9	8	7	6	5
			Microbials for stress amelioration	Strains identified	Date	10	Mar 18 2015	Mar 21 2015	Mar 24 2015	Mar 27 2015	Mar 30 2015
3	Technology dissemination and capacity building	20	Demonstrations conducted	Frontline demonstrations conducted	Number	12	1446	1205	964	723	482
			Farmers/Extension officials training programmes organized	Trainings / fairs organized	Number	8	13	11	9	7	5
4	Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	Number	3	12	10	8	6	4
			Timely publication of the Institute Annual Report(2013-2014)	Annual Report published	Date	2	Jun 30 2014	July 02 2014	July 4 2014	July 7 2014	July 9 2014

4	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90
	Efficient functioning of the RFD system	3	Timely submission of draft RFD for 2014-2015 for approval	On- time submission	Date	2	May 15 2014	May 16 2014	May 19 2014	May 20 2014	May 21 2014
			Timely submission of results for 2013-2014	On- time submission	Date	1	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014
	Enhanced transparency/ Improved Service delivery of Ministry/ Department	3	Rating from Independent Audit of implementation of Citizens/ Clients Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80
			Independent Audit of implementation of Grievance Red-ress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80
	Administration Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov 1 2014	Nov 2 2014	Nov 3 2014	Nov 4 2014	Nov 5 2014
			Implementation of agreed milestones of approved Mitigating Strategies for reduction of potential risk of corruption (MSC)	% of implementation	%	1	100	90	80	70	60
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80
			Implementation of milestones of approved Innova-tion Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60

Section 3: Trend Values of the Success Indicators

S. No	Objective(s)	Action(s)	Success indicator(s)	Unit	Actual Value for FY 12/13	Actual value for FY 13/14	Target Value for FY 14/15	Projected Value for FY 15/16	Projected Value for FY 16/17
1.	Genetic enhancement and development of improved cultivars	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	1176	1215	1195	1200	1205
			Lines identified for unique traits	Number	13	15	17	19	20
		Development of improved cultivars	Entries contributed for multilocation trial	Number	68	66	58	60	62
			Varieties identified for release	Number	2	3	3	4	5
		Development of resources for molecular breeding for biotic stresses and quality traits	Mapping population and mapping panels developed	Number	0	0	3	3	3
		Seed production programme	Breeder seed produced	Quintal	13.6	46.04	45	46	47
2.	Development & identification of appropriate crop production and protection technologies	Development of new technologies	New technologies tested/ validated	Number	8	10	8	9	10
		Microbials for stress amelioration	Strains identified	Date	-	-	Mar 21 2015	Mar 24 2016	Mar 25 2017
3.	Technology dissemination and capacity building	Demonstrations conducted	Frontline demons-trations conducted	Number	1192	1242	1205	1210	1215
		Farmers/Extension officials training programmes organized	Trainings / fairs organized	Number	8	11	11	12	13
	Publication/ Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	Number	11	12	10	11	12
		Timely publication of the Institute Annual Report(2013-2014)	Annual Report published	Date	-	-	July 2 2014	-	-
	Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%	100	100	96	97	98

Efficient functioning of the RFD system	Timely submission of draft RFD for 2015-16 for approval	On- time submission	Date	-	-	May 16 2014	-	-
	Timely submission of results for (2013-2014)	On- time submission	Date	-	-	May 2 2014	-	-
Enhanced transparency/ Improved Service delivery of Ministry/ Department	Rating from Independent Audit of implementation of Citizens/ Clients Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
	Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-
Administration Reforms	Update organiza-tional strategy to align with revised priorities	Date	Date	-	-	Nov 2 2014	-	-
	Implementation of agreed milestones of approved Mitigating Strategies for reduction of potential risk of corruption (MSC)	% of implementation	%	-	-	90	-	-
	Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	95	-	-
	Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	-	-	90	-	-

Section 4 (a): Acronyms

S.No	Acronym	Description
1	DAC	Department of Agriculture and Co-operation

Section 4(b): Description and definition of success indicators and proposed measurement methodology

Sl. No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Breeding and germplasm lines evaluated	Source material for the improved varieties to be evaluated	Material generated from the basic germplasm	Number of breeding/ germplasm lines evaluated	
2	Lines identified for unique traits	Source material identified for traits of interest	Germplasm lines identified for utilization in breeding programme	Number of lines identified	Number of lines for desired traits may not exist in the germplasm lines evaluated
3	Entries contributed for multilocation trial	Promising breeding lines developed at centres	Promising lines identified for trait of interest for which it is bred	Number of entries evaluated	
4	Varieties identified for release	Breeding lines tested along with checks at multilocations through All India Coordinated Research Projects and the best performing entries compared to checks are identified and released	Best performing entries identified as a new variety for release	Number of such varieties released	Targets for varieties identified in Section 2 and their respective trend values in Section 3 may vary as the identification of varieties depend upon the availability of superior material with respect to yield, biotic and abiotic resistance/ tolerance over the existing varieties
5	Mapping population and mapping panels developed	Trait specific mapping population and genetic resources generated for gene mapping	Populations derived from divergent parents showing variation for the traits of interest	Number of mapping population developed	
6	Breeder seed produced	Breeder seed is the starting point in seed chain which is multiplied/ converted into foundation/certified seed	Produce from nucleus seed is the breeder seed	Quantity produced (Quintal)	Quantity may vary as per indent from DAC
7	New technologies tested/validated	Developing technologies for maximizing production and minimizing crop losses due to stresses	Technology refers to optimum use of natural resources and input and management of stresses	Number of crop production & protection technologies developed	These will increase the production
8	Strains identified	Beneficial micro organisms that interact with plant system and help plants in with standing biotic and abiotic stresses	Beneficial micro organisms either fungal or bacterial, that occur near rhizosphere of the crop	Number of beneficial strains identified	Number of desired micro organisms may not be available in the strains evaluated
9	Frontline demonstrations conducted	Demonstration of improved technologies conducted to showcase the potential of technologies	Demonstrations conducted in the farmers fields under the supervision of scientists	Number	
10	Trainings/fairs organized	Capacity building activities related to knowledge and skill improvement/development programmes conducted for farmers, rural youth and extension personnel	Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation or improving productivity in an organization or enterprise	Number	

Section 5 : Specific performance requirements from other departments that are critical for delivering agreed results

Location Type	State	Organisation Type	Organisation Name	Relevant Success Indicators	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this Organisation	What happens if your requirement is not met
Central Government	-	Department	Department of Agriculture & Cooperation	Breeder seed produced	Indent for quantity of breeder seed to be produced	Variety wise indent for the breeder seed	Quantity of breeder seed is produced as per the indent	Less or more quantity of breeder seed will be produced
Central Government	-	Department	Department of Agriculture & Cooperation	Frontline demonstrations conducted	Funds	For effective implementation of the Frontline Demonstrations	Amount	Ineffective implementation
Central Government	-	Department	Department of Extension	Trainings/fairs organized	Funds	Dissemination of technology	Amount	Less number of trainings organised

Section 6: Outcome/Impact of activities of Department/Ministry

S.No.	Outcome / impact	Jointly responsible for influencing this outcome/impact with the following organization (s) Department(s)/ Ministry(ies)	Success Indicator (s)	Unit	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
1.	Enhanced productivity of sunflower, safflower and castor	Department of Agriculture & Cooperation, Department of Extension, State Government	Increase in productivity	%	0.85	0.48	0.54	0.56	0.58

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch

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