भाकृ अनुप
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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
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ICAR-Indian Institute of Soybean Research

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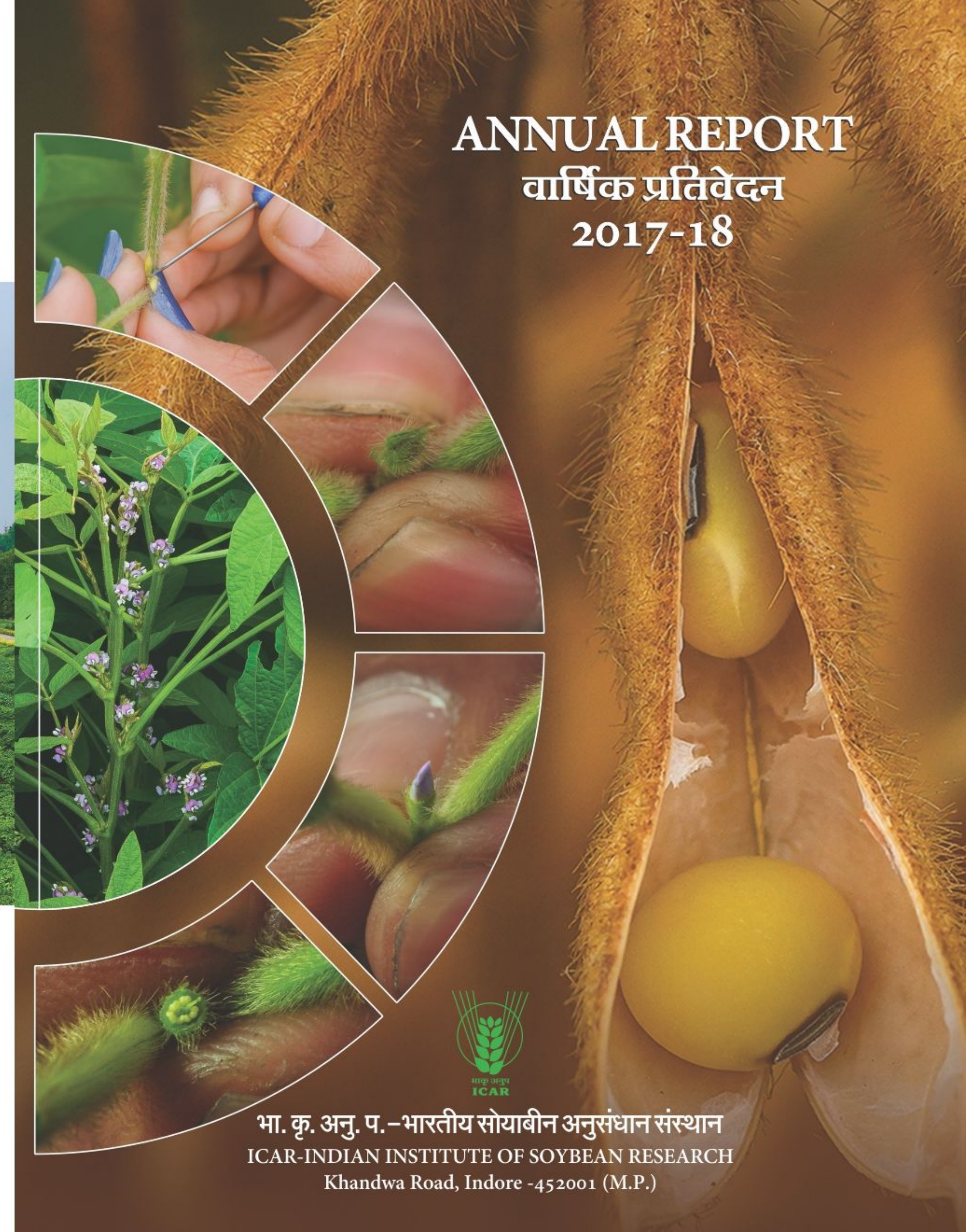

ANNUAL REPORT
वार्षिक प्रतिवेदन
2017-18

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ICAR-INDIAN INSTITUTE OF SOYBEAN RESEARCH

Khandwa Road, Indore -452001 (M.P.)

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खण्डवा रोड, इन्दौर — ४५२ ००१ (म.प्र.)

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P R E F A C E

It is a matter of great honour and pride for me to present the Annual Report (2017-18) of ICAR-Indian Institute of Soybean Research, Indore. The research accomplishment and technological competence of the institute can be judged by the fact that the soybean was introduced for commercial cultivation in late 60's, and in a span of 5 decades the soybean has become the most important oilseed crop of India. At present, the crop is grown in ~ 11.0 million ha with a production of ~12-13 million tones. Its contribution to total oilseeds and edible oil produced in the country is 42 and 22 percent, respectively. Soybean seed contains 40% protein and 20% oil and it is one of the most economical sources of good quality protein. The crop has a potential to provide nutritional security and eradicate rampant protein malnutrition in the country. However, its productivity has remained low compared to other countries, which is the main cause of concern.

Among the major reasons of poor productivity in soybean is its rainfed nature. The climatic variability for the last 5-6 years, which include the late arrival of monsoon, prolonged drought spells particularly at seed filling stage, heavy rains in short span of time leading to water logging conditions and above normal temperatures has led to lots of fluctuations in productivity and production of soybean. The repeated dry spells and above normal temperatures have resulted in increased infestation by number of insects and disease to soybean crop. The scientists of Indian institute of Soybean Research, Indore are aware of the problem and have launched the focussed programme to address these challenges. The strategies include development of varieties and production and protection technologies to overcome the problem of drought, water logging, high temperature and infestation by insects and disease.

The most significant result of 2017-18 includes the release of first-ever Kunitz trypsin inhibitor free soybean variety NRC 127 in India. The soybean industry would benefit hugely by this variety. In addition, climate resilient soybean genotypes, with shorter duration (< 85 days) and YMV resistant genotypes have also been developed and are in various stages of testing under All India Coordinated trials. To promote food uses soybean, genotypes free from both Kunitz trypsin inhibitor and lipoxygenase-2 have been developed by pyramiding null alleles of these undesirable traits through marker assisted breeding.

I am glad to present the Annual report for the year 2017-18 which would give a panoramic scenario of R&D activities undertaken by Indian Institute of Soybean Research, Indore. I would like to congratulate the entire team of scientists and other staff of the institute for carrying out R&D activities and bringing out the results in time. I would also thank Chairperson and members of RAC who guided us and gave direction to the research activities. I take this opportunity to state my deep sense of gratitude to Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for guidance, and consistent support to soybean research and development. I gratefully acknowledge the help and valuable guidance provided by Dr. A.K. Singh, Deputy Director General (Crop Science), for the progress of the Institute. I sincerely thank Dr. P.K. Chakrabarty Assistant Director General (O&P) for his support and guidance for the growth and development of the Institute. Thanks are also due to the members of editorial committee for making this report crisp, comprehensive and informative. All the scientific, technical, administrative, account and service staff of the institute who have contributed in bringing out this report are worthy of appreciations. I extend my hearty thanks and congratulations to each of them.

V.S.Bhatia

(V.S. Bhatia)
Director

CONTENTS

EXECUTIVE SUMMARY

- NRC 127 first Kunitz trypsin inhibitor free variety developed has been identified for release in Central Zone
- NRC 128 entry ranked I in Northern Plain Zone (3370 kg/ha), ranked II in North Eastern Hill Zone (1665 kg/ha) and Eastern Zone (1981 kg/ha) in IVT trial
- Two extra early maturing genotypes were developed with yield potential of 1925 and 1983 kg/ha and maturity duration of 76 and 84 days
- Two mass-array based multi-trait functional marker assays (MTFMA) has been developed for high-throughput genotyping of soybean germplasm accessions and breeding populations
- The two MTFMA multiplex panels were used for genotyping of 280 soybean genotypes and several germplasm sources have been identified with rare alleles of agronomic and quality traits
- Genome-wide identification of InDels from the rust resistant accession EC 241780 was performed. Genomic annotation of InDels in this genotype revealed that majority of InDels falls in the inter-genic region. InDels associated with NBS-LRR rust resistant genes were identified
- Screening of 541 pre-breeding lines at Ludhiana and Delhi led to identification of 74 and 126 lines resistant to YMV disease, respectively
- An elite drought tolerant high yielding breeding line NRC 137 was promoted to AVT-I of North Eastern Hill Zone (NEHZ) and Eastern Zone (EZ)
- Two advanced breeding lines, namely, NRC 140 and NRC 141 exhibiting high oleic acid (about 60%) content have been developed
- Kunitz trypsin inhibitor free lines NRC 144 and NRC 145 with clear hilum have been developed
- Soybean genotypes NRC 142 and NRC 143 free from both Kunitz trypsin inhibitor and lipoxygenase-2 have been developed by pyramiding null alleles for these undesirable traits through Marker Assisted Forward Breeding
- Estimation of Kunitz trypsin inhibitor (KTI) and Bowman-Birk inhibitor (BBI) through densitometry and enzyme-linked immunosorbent assay (ELISA), respectively, was standardized and total trypsin inhibitor estimated through regular spectrophotometric method was found significantly higher than the summation of KTI and BBI
- Estimation of Kunitz trypsin inhibitor (KTI) through densitometry and ELISA in soybean seeds was standardized. Densitometry of protein profile of 102 soybean varieties revealed wide genetic variation for KTI activity, and its contribution to total trypsin inhibitor activity. ELISA of low- and high-KTI genotypes exhibited 8-fold genetic variation for Bow-man Birk inhibitor (BBI)

- Survey of 90 soybean germplasm accessions using dCAPS marker for recessive allele of E2, which confers early maturity, resulted in identification of early maturity genotype IC 15089
- High lignin varieties (VL Soya 1, MACS 450) were crossed with bold seeded genotypes (NRC 7, EC 538828, PS 1029, JS 95-60) and vegetable type (Karune) with the objective of strengthening the seed coat in the segregating lines
- Lignin content of seed coat of advanced breeding lines of cross VL Soya 1 × EC 538828 showed a variation of 1.38-3.28, 1.22 - 5.028 and 1.35 - 4.04 mg/g seed coat in yellow, brown and black seeded lines, respectively
- Nano zinc and magnesium application @ 100, 150 and 200 mg/kg of soybean seed improved seedling growth and vigour over control. Increase in seedling dry weight to the magnitude of 22-24% was recorded due to nano zinc and magnesium application @ 200 mg/kg seed
- Among the different substrate combinations, soil-sand mix amended with soybean hulls and vermi-compost was found to be the most optimum substrate sustaining higher production of Arbuscular Mycorrhizal Fungi (AMF), thereby indicating that this combination has the potential for mass production of AMF using sorghum as trap plant.
- Cropping sequence of soybean-chickpea maintained significantly higher microbial biomass carbon and AMF biomass over soybean-wheat and soybean-mustard
- Study on factors determining farm yield variability of soybean indicated that farmers having higher yield (> 21.7 q/ha) followed the recommended production practices, procured seeds from government /cooperative sources and were also in constant contact with extension agencies
- ICAR-IISR started a quarterly publication "Soybean Market Monitor" covering soybean production scenario in India and world, domestic and international price movements of soybean and products, import and export of soybean and products from India
- Soybean Gyan- A Mobile App for soybean farmer's has been developed by this Institute. The App gives information on different aspects of cultivation viz agronomic practices, production technology, crop management, insect management, disease management, weeds management, food uses and health benefits and farm machinery. It also provides expert's recommendations about farm preparation, suitable selection of soybean varieties, seed treatment, fertilizer doses, sowing, seed-rate, harvesting, seed storage. Through this app the farmers can submit their queries along with photos about the problems faced by them in field conditions

1. INTRODUCTION

The ICAR-Indian Institute of Soybean Research (IISR) was established by Indian Council of Agricultural Research in the year 1987 at Indore in the state of Madhya Pradesh to take up the centralized research to support soybean production systems with basic information and breeding material. Coordinating unit of All India Coordinated Research Project on Soybean (AICRPS), Soybean Breeder Seed Production (BSPS) and National Active Germplasm Site (NAGS) for soybean germplasm are also situated at IISR.

1.1. Physiography

IISR campus is situated in the village Piplyarao of district Indore, which lies in Vidhyanchal range of Malwa Plateau at 22° 4'37"N latitude and 75° 52'7"E longitude. It is positioned at an altitude of 550 meter above the mean sea level. The Institute with an area of 56.7 hectare is situated at a distance of 4 km from the heart of Indore city and 6 km from Railway station.

1.2. Soil

The soil of ICAR-IISR research farm is deep black cotton soil with pH 7.6 to 8.1 (basic / alkaline), low to medium in organic carbon and available phosphorus and high in potassium. Taxonomically it is classified as fine, montomorillonitic, hyperthermic family of Typic Chromusterts and fine clay loam, montmorillonitic family of Lithic Vertic Ustochrepts.

1.3. Climate

The climate of the Malwa Plateau of Madhya Pradesh is semi arid with a growing period of 150 180 days. As such, the climate of this region is characterized by 3 distinct agricultural seasons. These are: (a) rainy season, also known as Monsoon or *kharif* season, usually begins from mid June and extends up to early October. Generally duration of monsoon is approximately 100 days with about 800 mm mean annual rainfall. Soybean is generally grown during this season as rainfed crop, (b) post-rainy season which runs from mid October to March, also known as *rabi*, is dry, cool and (c) warm and dry season, which begins in February and lasts until April May/June is called *zaid* or summer/spring. Any crop grown during this season requires irrigation.

1.4. Past Achievements

Major achievements of this Institute include a vast collection of soybean germplasm including exotic, indigenous, breeding lines and wild species. Currently, a total of 4097 germplasm accessions are present with ICAR-

IISR and ICAR-NBPGR. Further for better management of genetic resources and to enhance germplasm utilization core-collection of germplasm has been developed successfully. A number of genetic resources have been identified for various traits like photoperiod insensitivity, drought tolerance, diseases such as rust and YMV and insect resistance. High oleic acid (NRC 106, IC 210), low linolenic acid (VLS 59), vegetable soybean genotype (NRC 105) and null Kunitz trypsin inhibitor (NRC 101, NRC 102) genotypes have been developed at this Institute. A number of high yielding varieties possessing resistance to various biotic and abiotic stresses (NRC 7, NRC 37, NRC 86, JS 97-52) were bred and have been released for cultivation in different agro-ecological regions of the country. A null KTI genotype NRC 127 has also been identified for release in the Central Zone.

In the field of crop production, *in situ* moisture conservation technologies and the associated mechanization for soybean-based cropping system (BBF, FIRBS R&F) have been developed and commercialized. Integrated management for soybean-wheat and soybean-chickpea, and integrated weed management for soybean have been developed. Microbes that enhance soil health including Zn & Fe solubilizing bacteria, and *Rhizobia* have been identified. In the field of plant protection, integrated management schedule for major soybean insects pests has been worked out. Studies on epidemiology of rust occurrence in soybean revealed that the source of rust inoculum for south India is lying in the Krishna valley. Web-based expert systems for varietal and disease identification and data management systems for AICRPS have been developed. Consequently, the Institute has emerged as a catalyzing force to facilitate rapid increase in acreage and production of soybean from last 25 years. It has also been instrumental in providing sustainability to soybean cultivation in different regions of the country. The transfer of research emanated improved production technology has led to increase in national productivity from 700 to 1300 kg/ha during past 25 years.

1.5. Mandate

Following is the mandate of the institute:

- Basic, strategic and adaptive research on soybean for improving productivity and quality
- Provide access to information, knowledge and genetic material to develop improved technology and enhanced soybean production
- Coordination of applied research to develop location specific varieties and technologies
- Dissemination of technology and capacity building

1.6. Organizational Set-up

For efficient functioning of the centre and to achieve the mandate and objectives, the organizational pattern of the Institute has been evolved and depicted in Fig.1.

1.7. Library

The Institute has developed a reasonably good library equipped with relevant books, journals, etc. to provide the research needed support to the scientists. At present the library is equipped with 3269 books and subscribing 01 international and 39 national journal. The library is also a beneficiary of CERA for accessing more than 2000 scientific journals on-line.

1.8. Staff and Budget

The total sanctioned staff position of ICAR-IISR as on 31 March 2018 is 82 comprising 37 scientific, 22 technical, 23 administrative and supporting positions. Out of which a total of 71 are in positions as on 31 March 2018 (Details given in Chapter 12). The budget allocation and expenditure of the ICAR-IISR for 2017-18 is shown in Table 1.

Table 1: Budget and expenditure of ICAR-IISR for the year 2017-18 (₹ in lakhs)

Head	IISR Grant	
	R. E.	Actual Exp.
Pay & Allowances	890.00	887.33
Wages	12.00	11.16
T.A.	16.00	13.34
Other Charges Recurring	363.18	350.19
(a) Information Technology	6.00	5.05
(b) Equipments	12.20	11.72
(c) Works	5.80	5.49
(d) Library	5.00	4.96
(e) Furniture & Fixures	2.00	1.60
(f) others Items	-	-
(g) HRD	7.00	6.58
(h) Pension & Retirement Benefits	82.00	82.00
(i) Loans & Advances	6.00	6.00
Total	**1407.18**	**1385.42**

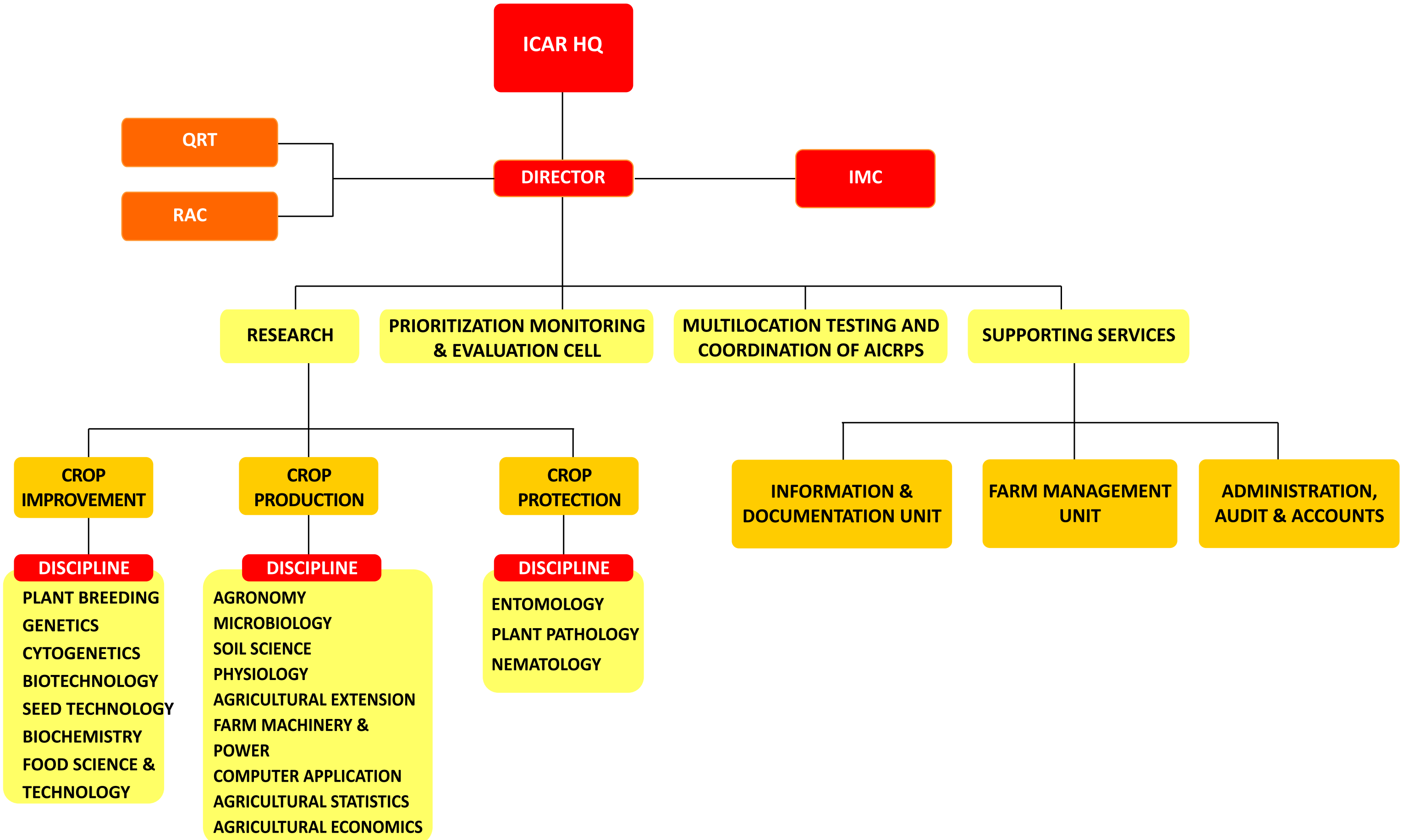


Fig. 1: Organogram of ICAR-IISR

2.0 GENETIC RESOURCES

- **Germplasm augmentation, evaluation and maintenance**
- **Germplasm evaluation for resistance to biotic/abiotic stresses**
- **Development of multi-trait functional marker assays (MTFMA) for characterization of germplasm accessions**
- **Genetic relationship and population structure analysis among Indian soybean landraces**
- **Identification of a triple recessive mutant of flowering and photoperiod sensitivity genes**
- **Distribution of germplasm and segreggating material**

2.0 GENETIC RESOURCES

2.1 Germplasm augmentation

One hundred forty six (146) accessions have been procured from AVRDC, Taiwan, and are under quarantine at ICAR-NBPGR, New Delhi. Sixty one germplasm accessions imported from Canada by NBPGR have been received for multiplication and submission to Long Term Storage (LTS) of ICAR-NBPGR. Four accessions collected by NBPGR from Arunachal Pradesh and one accession from Taiwan have been received for multiplication and subsequent submission to LTS. One thousand seventy one (1071) germplasm accessions were received from LTS of ICAR-NBPGR and 605 accessions were received from Bhowali centre of ICAR-NBPGR.

One thousand four hundred ninety (1490) germplasm accessions have been sent to LTS for long term conservation. Presently, ICAR-IISR in collaboration with ICAR-NBPGR, New Delhi is maintaining 4097 accessions of *G. max* including wild species in medium term storage (MTS).\

2.2 Germplasm evaluation and maintenance

Six hundred five (605) accessions were grown for periodic multiplication of conserved germplasm of MTS. A set of 125 accessions which formed the part of core collection, were evaluated across 7 locations, namely, Palampur, Pantnagar, Imphal, Raipur, Indore, Parbhani and Pune for 8 morphological traits, namely, days-to-flowering, days-to-maturity, plant height (cm), branches/plant, pods/plant, 100-seed weight and yield/plant. Mean performance of promising germplasm accessions of different locations is given in Table 2 and promising accessions over locations are given in Table 3.

2.3 Germplasm evaluation for resistance to biotic stresses

Fifty germplasm accessions were evaluated at different locations, namely, RVSKV, Sehore and Vasantrao Naik Marathwada Krishi Vidyapeeth; PAU, Ludhiana; JNKVV, Jabalpur, Palampur; Dharwad for insect resistance, YMV resistance, Charcoal Rot (CR) resistance,

Frog-eye Leaf Spot (FLS), Rust and Purple seed stain (PSS) respectively. Results of screening are given in Table 4. None of the entries was resistant to rust and PB(ct) at Dharwad. The line P 501 showed AR reaction to FLS (Frog Eye Leaf Spot) and CR, MR reaction to rust and HR reaction to PSS. GPC 32 and KB 17 showed promising reaction against defoliators, stem fly and girdle beetle.

Table 2: Promising accessions in multilocation trial

Locations	Days-to-flowering	Days –to-maturity	Pods/plant	100-seed weight (g)	Yield /plant (g)
Pune	**WT 35*,EC 34092, B 160-3, EC 242091, EC 34395 (up to 33 days)**	**EC 34092, EC 34395, WT 35, EC 242091, AGS 158, EC 481571, EC 685256,** VP 1162 (up to 87 days)	TGX 849-380, **EC 171536, TGX 855-32E,** DS 203, **EC 456610,** TGX 849-25D, **TGX 849-D-13-4 (>80 pods)**	**EC 175321, P 501,** VP-1181, **G 110,** EC 251776, **TRAIT SP. HARDER, VP 1177 A,** EC 357990 **(>16 g)**	**TGX 849-380,** EC 467295, TGX 849-25D, **P 501,** EC 934413, TGX 855-32E, DS 203, IC 24065 (> 19 g)
Imphal	EC 34092, EC 30942, WT 191, EC 242091, B 160-3, EC 175321, ICS 84/86-85B-41, EC 685256 (up to 40 days)	EC 456647, EC 685256, EC 30942, TGX 996-4F6, ICS 84/86-85B-41, WT 35 (up to 96 days)	UPSL 293, EC 357990, EC 287454, VP 1177 B, TGX 855-32E, EC 358002, VAM SAW (> 95)	EC 175321, G 110, VLS 12, EC 343311, EC 357990, P 501 (>15 g)	EC 357990, EC 287454, VP 1156 A, EC 241778 A, VP 1177 B (>15 g)
Indore	DN 290, EC 242091, EC 34395, WT 35, EC 34092 (up to 31 days)	EC 34395, WT 35, EC 481571, DN 290, EC 34092, EC 175321, VP 1168, EC 457157, EC 456647, EC 39751, ICS 84/86-85B-41 (up to 89 days)	TGX 849-D-13-4, EC 934413, EC 280149, AGS 31, GC 84058-18-4, EC 456613, EC 287454 (>60 pods)	EC 34395, EC 456647, JS 20-80, UPSL 229 (>11 g)	VLS 11 (10g), JS 20-80 (8g), EC 456613, GC 84058-18-4, AGS 31, VP 1177 B, TRAIT SP. HARDER, P 501, TGX 849-D-13-4 (>5 g)
Pantnagar	ICS 84/86-85B-41, EC 242091, DN 290, WT 187B, WT 35, EC 34395, EC 685256, EC 34092, VP 1162 (up to 38 days)	EC 481571, EC 175321, PS 1343, V 43, V 55, ICS 84/86-85B-41, EC 39751, EC 30942, EC 333860, EC 280149 (up to 98 days)	WT 187B, TGX 855-32E, VLS 12, AGS 76 EC 456610, EC 287469 (> 92 days)	TRAIT SP. HARDER, VP 1177 B, EC 175321, EC 23001, TGX 825-1E, EC 685256, EC 34395, EC 343311, VLS 12, JS 20-80 (>10.5g)	VLS 12, TGX 855-32E, EC 357990, EC 341115, VP 1156 A, GC 12 (> 15 g)
Raipur	EC 358002, WT 35, ICS 84/86-85B-41, B 160-3, VP 1168, DN 290, EC 481571, EC 175321 (up to 36 days)	ICS 84/86-85B-41, TGX 996-4F6, EC 34092, EC 34395, AGS 158, WT 35, VP 1168, DN 290, EC 175321, EC 242091, EC 39751, (up to 85 days)	TGX 849-813, EC 456613, EC 456610, AKSS 143, P 501, AGS 31, AGS 76 (>65 pods)	EC 456647, EC 175321, B 160-3, EC 602272, EC 685256, GPC 32, VP 1177 A, VP 1162, EC 242091 (>11.5g)	EC 456647, P 501, VP 1156 A, EC 251776, EC 456610, EC 456613, TGX 849-813 (>14 g)

Table 2 Contd.

Locations	Days-to-flowering	Days –to-maturity	Pods/plant	100-seed weight (g)	Yield/plant (g)
Parbhani	TGX 996-4F6, GC 22, ICS 84/86-85B-41, PPI 72-2-5-6, EC 242091, EC 39751, EC 34395, EC 457157 (up to 36 days)	ICS 84/86-85B-41, PPI 72-2-5-6, EC 30942, TGX 996-4F6, EC 242091, EC 34395, GC 80, M 486, EC 481571 (up to 95 days)	WT 89, Pb 1(S) B, EC 171536, M 486, TGX 849-D-13-4, VP 1156 B, VP-1180, GC 17 (>102 pods)	WT 89, B 160-3, EC 456647, TK 5, EC 34395, EC 23001 (>15 g)	WT 89, Pb 1(S) B, VP 1156 B, EC 171536, M 486, GC 17 (>8 g)
Palampur	EC 175321, ICS 84/86-85B-41, B 160-3, TGX 85B -48, TGX 996-4F6, GC 84058-18-4, M 108, VP 1162, VP 1165, VP 1168, EC 481571, EC 242091, AGS 158, EC 685256, JS 20-80 (up to 55 days)	TGX 85B-48, B 160-3, EC 60020-8-7/18, ICS 84/86-85B-41, EC 685256, JS 20-80, EC 457157, EC 41318, TK 5 (up to 127 days)	EC 241778 A, EC 171536, GPC 32, GP 448, PS 1343, EC 456613(> 30 pods)	EC 358002, PPI 72-2-5-6, TGX 849-380, UPSL 595, EC 109540, B 160-3, EC 23003, ICS 84/86-85B-41, EC 343311, EC 377883, WT 89 (>16 g)	EC 241778 A, VP 1156 B, EC 171536, DS 327, EC 358002, VP 1168, EC 109540, TGX 849-380, EC 60020-8-7/18 EC 390981, M 486, VP 1170, V 43, VP -1181, EC 30942 (> 33 g)

***Accessions in bold are identified in other locations also.**

Table 3: Promising germplasm lines identified on the basis of mean performance across locations

Accession	Days-to-flowering	Accession	Days –to-Maturity	Accession	Pods/ plant	Accession	100-seed weight (g)	Accession	Yield/ plant (g)
ICS 84/86-85B-41	37.0	EC 34092	95.0	TGX 849-D-13-4	65.0	B 160-3	13.5	P 501	13.5
EC 242091	37.1	EC 34395	92.9	WT 89	66.8	EC 175321	13.4	VLS 12	13.5
EC 34092	34.5	JS 95-60	93.8	EC 171536	70.8	EC 456647	13.5	VP 1156	13.8
JS 95-60	35.4	JS 20-34	90.4	EC 456610	63.6			EC 241778	13.8
JS 20-34	27.2	JS 93 - 05	87.8	EC 456613	64.1				
JS 93 -05	34.2			JS 97-52	64.8				

Table 4: Evaluation of germplasm accessions for insect-pest and disease resistance

Location	Disease and/or insect	Resistant/tolerant accession
Palampur	FLS	P 501, TGX 855-32 E, and PS 1347
	Pod Blight (Ct)	PLSO 57, TGX 849-D-13-4, V 1, DB 1588, EC 241768, EC 241807, EC 245986
Jabalpur	Charcoal Rot	P 501, PR 35, TGX 849-D-13-4, TGX 854-42 D, TK 5 EC 18594, EC 241778, EC 241807, EC 250591, EC 1619, NRC 78, SQL 89
Ludhiana	YMV	PR 35, PS 1347 and VP 1162
Dharwad	Rust	P 501, EC 241778, EC 250591, DSb21 (HR), JS 20-42
Sehore	Defoliator tolerance	PPI 72-2-5-6, GPC 32, KB17, NRC 67 and VP1165
	Girdle Beetle	GPC 32, EC 241778 and KB 17

2.4 Development of Multi-Trait Functional Marker Assays (MTFMA) for characterization of germplasm accessions

Multiplexed allele-specific functional DNA markers are important to precisely select multiple traits from multiple parents without phenotypic screening. Two mass-array based multi-trait allele-specific SNP/Indel panels were developed for high-throughput genotyping of soybean germplasm accessions. A total of 15 well-characterized genes for 11 different agronomic and quality traits, namely; flowering and maturity, pod shattering, hard-seededness, growth habit, long juvenile, phosphorous use efficiency, salt tolerance, seed weight, oleic acid content and fragrance, were selected. A total of 31 alleles known to be associated with phenotypic variance among these 15 genes were incorporated in two multiplex panels comprising of 19 and 12 alleles for genotyping using matrix-assisted laser desorption ionization-time of flight mass spectrometry. The two multiplex panels were used for genotyping of 280 genotypes comprising germplasm accessions selected from core set, trait specific genotypes, eight parental genotypes of a multi-parent advance generation inter-cross (MAGIC) population and one accession of *Glycine soja.* The results indicated an overall genotyping success rate of 98%. Genotypes with rare alleles were identified for all the traits except seed weight and phosphorous efficiency (Table 5). Genotypes with rare alleles were validated phenotypicaly for flowering and maturity, growth habit and pod shattering characters. These two novel multi-trait functional marker assays (MTFMA) facilitated identification of genotypes with rare alleles without phenotyping and genetic analysis of a number of traits, thus greatly saving the resources and cost. The identified germplasm accessions would serve as donors in breeding programmes for multiple traits.

Table 5: Germplasm sources with rare alleles of desirable traits identified by genotyping with two MTFMA

Assay allele	No. of genotypes characterized	Common	Heterozygous	Rare
E1-as_SNP44	280	258	10	12
E1fs_Indel46	280	280	0	0
E2_SNP15056	280	259	6	15
E3-fs_Indel1272	280	274	0	6
E3-ns_SNP3826	280	278	1	1
E3ft_SNP3835	280	275	2	3
E4-kam_Indel3081	280	279	0	1
E4-kes_Indel3270	280	279	0	1
E4-oto_Indel339	280	280	0	0
E4-tsu_Indel2653	280	280	0	0
DT_SNP1130	280	244	13	23
DT_SNP1181	280	280	71	0
DT_SNP1288	280	280	82	0
FAD2-1A_Indel544	280	280	0	0
FAD2-1B_SNP_410	280	279	0	1
FAD2-1B_SNP428	280	280	0	0
FG_Indel2139	280	279	0	1
FG_SNP2213	280	280	0	0
HS_SNP3381	280	250	10	20
Pdh1_SNP91	280	171	19	90
PE_Indel170	280	203	19	66
PE_SNP1688	184	183	1	0
PE_SNP432	184	184	0	0
SALT_SNP-20	280	206	35	39
SALT_SNP11409	280	208	25	47
E9_Indel47	280	241	3	36
E9_SNP398	280	276	0	4
LJ_Indel1282	280	280	0	0
LJ_Indel1352	280	280	0	0
LJ_Indel587	280	278	1	1
LJ_SNP143	280	280	0	0
SW_SNP111	280	280	0	0

2.5 Genetic relationship and population structure in Indian soybean landraces

A set of 90 Indian soybean landraces were analysed for polymorphism at 43 SSRs. A total of 42 polymorphic SSRs had amplified 126 alleles which were used for estimation of genetic relationship and population structure. The number of alleles amplified at a locus ranged from 2 to 4 with an average of 3 alleles per SSR locus. Two accessions, IC 18768 and IC 15089 were identified as rich source of rare alleles. Gene diversity in the population varied from 0.717 (Satt328) to 0.065 (Satt164) with a mean value of 0.411. Hierarchical clustering based on neighbour-joining method identified three major clusters among 90 soybean accessions (Fig. 2).

Population structure analysis divided the 90 soybean accessions in to four populations (K = 4) (Fig. 3). Mean value of Wrights fixation index (Fst) ranged between 0.7239 (highest) for pop2 and 0.4143 (lowest) for pop1 with a mean value of 0.50, while observed mean value of alpha (α) was 0.1205. Cluster analysis revealed that majority of accessions collected from Eastern region were clustered in pop1 (19 out of 31) and pop4 (12 out of 31), while majority of accessions collected from Northern part were clustered in pop2 (13 out of 29), accessions collected from North-Eastern region were clustered in pop1 (14 out of 22). Similarity was observed between clustering pattern of hierarchially constructed clusters and model based populations in which majority of the landraces were clustered according to their geographical origin.

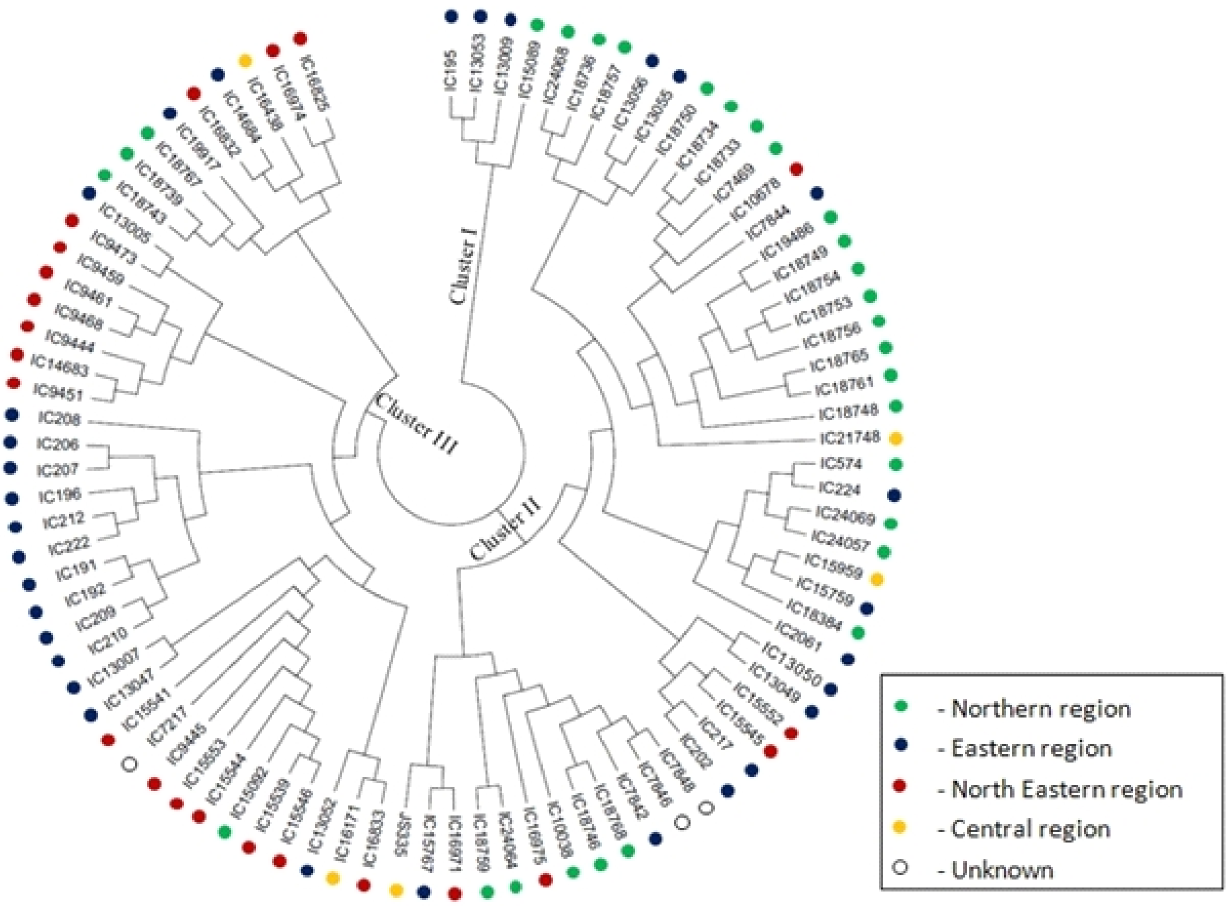


Fig. 2 SSR marker based NJ tree of 90 soybean accessions. The colored dots represent geographical origin of the accession.

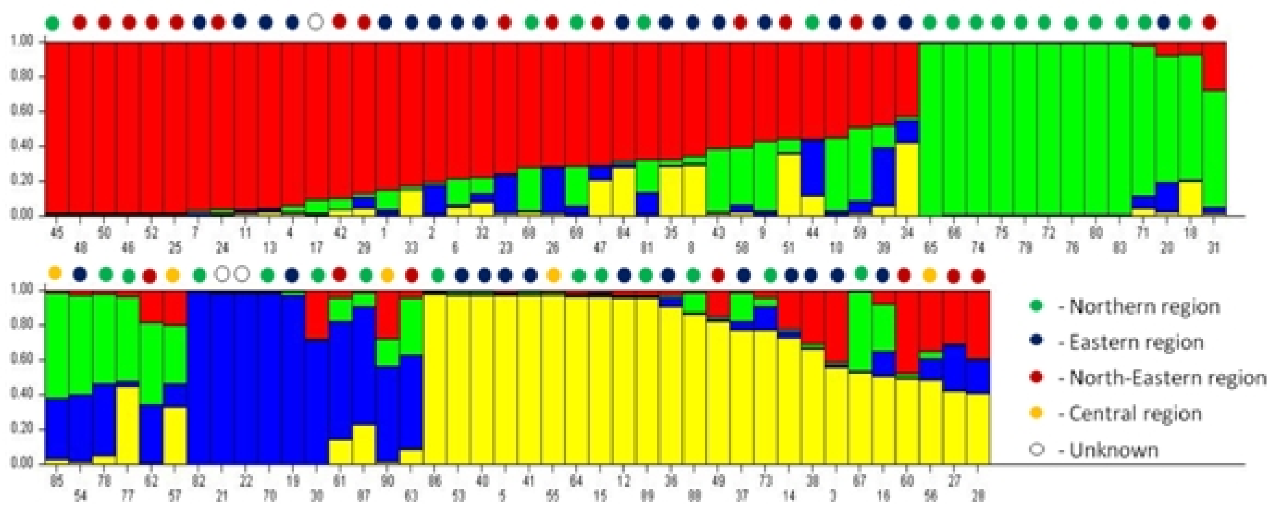


Fig. 3 Inferred population structure of 90 Indian soybean landraces based on SSRs

2.6 Identification of a triple recessive mutant for flowering and photoperiod sensitivity genes

Allele specific dCAPS marker genotyping of 90 Indian soybean landraces for E1 gene led to the identification of two accessions with recessive e1-as allele (IC 15089, IC 10038), whereas dCAPS analysis of E2 gene resulted in the identification of one accession having recessive e2 (IC 15089). Allele specific FLP genotyping of 90 accessions for E3 gene had identified recessive allele e3-tr in accession IC15089. These results identified that accession IC15089 is a triple recessive for flowering genes E1, E2 and photoperiod sensitivity gene E3. Phenotypic observations of IC 15089 for flowering and maturity time were recorded as 26 days and 88 days, respectively. The phenotype of IC 15089 for photoperiod insensitivity was confirmed by phenotyping in extended photoperiod with fluorescent light.

2.7 Distribution of germplasm and segregating material

Nine hundred fifty five accessions were distributed to different research organizations (Table 6)

After signing MoU between ICAR-IISR and ICAR-IARI, seed material of two novel mapping populations viz., Nested association mapping population and multiparent advanced generation intercross population have been sent to ICAR-IARI for research and academic purpose. Similarly, breeding lines were also supplied to AICRP centre ARS, Adilabad, Telangana and AICRP centre UAS Bangalore.

Table 6: Germpalsm distributed to different research organization

Name of organization	No of accessions supplied	Purpose
Tamil Nadu Agricultural University	05	Development of MAGIC population
University of Kerala	604	Water logging and salinity tolerance
University of Agricultural Sciences, Raichur	130	Trait specific accessions for strengthening breeding programme
Regional Sugarcane and Rice Research Station, Rudrur, Telengana	08	Initiating soybean research programme
IIHR, Bangalore	04	Rust resistant
NRCPB, New Delhi	08	For biotechnological research work
Agricultural Research Station, K. Digraj, Sangli	08	Photoinsensitivity, long juvenility, rust differentials
PDKV Akola	02	long juvenility

3.0 YIELD ENHANCEMENT, WIDER ADAPTIBILIY AND FOOD-GRADE CHARACTERS

- **Evaluation of advance breeding lines**
- **Hybridization and generation advancement**
- **Deployment of MTFMA in breeding populations for simultaneous selection of desirable alleles for multiple traits**
- **Characterization of a *Glycine soja* derived advanced backcross population of soybean for yield component traits and yellow mosaic disease resistance**
- **Breeding for wider adaptability using photoperiod response and growth habits**
- **Performance of notified soybean varieties during *kharif* 2017**
- **Breeding for food grade characters and high oil content**
- **Mapping QTLs for oleic acid and development of high oleic acid soybean**
- **Screening of germplasm for vegetable type soybean**

3.0 YIELD ENHANCEMENT, WIDER ADAPTIBILIY AND FOOD-GRADE CHARACTERS

3.1. Evaluation of advance breeding lines

A total of 132 advanced progenies (F_6/F_7) of different crosses were evaluated in two separate trials along with checks JS 20-29, NRC 86 and JS 20-34. Some of the lines (6A-58, 6A-26-1, 6A-47) yielded approximately 2500 kg/ha. The highest yield was obtained in entry 6A-58, which matured in 101 days. Two more entries viz., 6A-47 (2474 kg/ha) and 3A-44-1 (2271 kg/ha) performed better than checks with maturity of 97 and 94 days. Two entries, namely, MACS 330 × NRC 86-1-7-2 and MACS 330 × NRC 86-1-6-1, found to be extra early with maturity of 76 days, yielded 1925 kg/ha and 1533 kg/ha, respectively (Table 7).

Table 7: Performance of selected advanced breeding

Entry	Yield (kg/ha)	Days-to-maturity	Per day productivity (kg/ha/day)
6A-58	2585	101	25.6
6A-47	2474	97	25.5
3A-44-1	2271	94	24.2
3A-60	2021	97	20.8
MACS 330 × NRC 86-1-7-2	1925	76	25.3
MACS 330 ×NRC 86-1-13-4	1955	84	23.3
MACS 330 × NRC 86-1-10-1	1983	84	23.6
MACS 330 × NRC 86-1-6-1	1533	76	20.2
6A-26-1	2580	97	26.6
3A-17	1848	94	19.7
3A-44-A	2042	95	21.5
8-24	1672	94	17.9
NRC 86 (Check)	1071	101	10.6
JS 20-29 (Check)	2020	108	18.7
JS 20-34 (Check)	1858	90	20.6

3.2 Hybridization and generation advancement

Hybridization was carried out for earliness and YMV resistance by crossing among JS 95-60 and early germplasm accessions EC 34398, EC 34395 and EC 39230. Pre-breeding lines developed from backcrosses of NRC 37 × *G. soja*, NRC 86 × *G. soja*, JS 95-60 × *G. soja* and JS 335 × *G. soja* were advanced to next generation. Eight parent-based intercross population was advanced to F_3 generation. Similarly, Nested association populations consisting of 20 crosses were advanced to F_4 generation. The crosses among the eight way hybrids with JS 20-29, SL 958, SL 979 and JS 20-69 were advanced to F_2 generation.

3.3 Deployment of MTFMA in breeding populations for simultaneous selection of desirable alleles for multiple traits

Two mass-array based multi-trait functional marker assays (MTFMA) has been developed for high-throughput genotyping of soybean germplasm accessions and breeding populations. Genotyping of parental genotypes of an eight way multi-parent advance generation inter-cross (MAGIC) population with two MTFMA of 19 allele and 12 alleles had identified polymorphism among 5 alleles. These 5 polymorphic alleles were present in the genes for growth habit, flowering, pod shattering, oleic acid content and phosphorous use efficiency. Genotyping of 116 eight way MAGIC lines was performed with 19-plex assay and an allelic matrix was prepared. The allelic matrix identified several breeding lines comprising upto four desirable alleles associated with five traits from different parental genotypes (Table 8). Genotyping of parental genotypes of three recombinant inbred lines (RILs) population, which were segregating for 100-seed weight and number of seed per plant, identified polymorphism among 7 alleles of growth habit, flowering, maturity, pod shattering, salt tolerance and phosphorous use efficiency. An allele matrix developed by genotyping of 63 high yielding RILs with 19-plex MTFMA and one FLP marker (E3/e3) had identified breeding lines comprising upto 5 desirable alleles (Table 9).

Table 8: Allelic matrix of MAGIC lines representing different combination of desirable alleles

Genotype Id.	DT_SNP12 88	E1as_SNP 44	FAD21B_SNP_410_4281	Pdh1_SN P91	PE_Indel 170
7-122	T	C	G	T	DEL
7-123	T	C	G	T	AACAAAC
9-41	A	C	G	T	AACAAAC
A 29	A	C	G	T	AACAAAC
2-126	A	C	G	A	AACAAAC
2-118 (Wild type)	T	G	C	A	AACAAAC

Table 9: Allelic matrix of RILs representing different combination of desirable alleles

RIL Id.	DT_SNP11 81	DT_SNP12 88	E2_SNP15 056	E3/e3	Pdh1_SNP 91	PE_Indel 170	SALT_SNP20	SALT_SNP11 409	Days-to-maturity
8-24	C	A	T	e	T	AACAAAC	G	G	90
8-93	C	A	T	e	T	AACAAAC	G	G	90
8-94	C	A	T	e	T	DEL	G	G	96
3A-33	C	A	T	e	T	AACAAAC	G	G	94
3A-60-2	T	T	T	-	T	AACAAAC	G	G	92
5A-5	C	A	T	E	T	AACAAAC	C	T	100
5A-7	C	A	T	e	T	AACAAAC	C	T	97
6A-2 (Wild type)	C	A	A	E	A	AACAAA	G	G	105

3.4 Characterization of a *Glycine soja* derived advanced backcross population

An advanced backcross population of soybean was developed from wild species *Glycine soja* (Sieb. and Zucc.) and Indian soybean cultivar JS 335. The BC_2 advanced backcross population was characterized for three yield component traits, namely 100-seed weight, number of seeds per plant and seed yield per plant phenotyped over three years. Six quantitative trait loci (QTL) regions on the soybean genome associated with 100-seed weight were selected for QTL validation. SSR markers linked with two major QTLs were validated successfully over two year's phenotyping data. One QTL for 100-seed weight identified between Satt580 and Satt179 on linkage group D1a had explained >19% of phenotypic variance for combined phenotyping data of three years. The advanced backcross population was also screened for yellow mosaic disease resistance. Screening of BC_2F_4 population for yellow mosaic disease (YMD) resistance at hot spot location identified two pre-breeding lines SS131 and SS147 as YMD resistant over all the three years of testing. The results of this study will be an important milestone towards exploiting wild species in soybean breeding for the development of high yielding and disease resistant cultivars.

3.5 Breeding soybean for wider adaptability using photoperiod response and growth habit

3.5.1 Soybean promising cultures in AICRP breeding trials

NRC 130 and NRC 131 from photoinsensitivity trials were evaluated in IVT against the earliest maturing check JS 20-34. Both of these entries had on par maturity duration as that of JS 20-34 but out-yielded it by 27% and 15% in Central Zone where early maturing entries are highly required. Other two entries having equivalent maturity to that of JS 20-34 were inferior to it in yield (Table 10).

Table 10: Mean performance of early maturing entries in Central Zone

Entry	Maturity (days)	Yield (kg/ha)
NRC 130	88	1712
Shalimar Soybean 1	89	1024
SKF 1050	89	856
NRC 131	90	1555
JS 20-34 (early check)	88	1305

3.6 Performance of notified soybean varieties

Hundred and twelve released and notified soybean varieties were maintained under DUS Testing Project at ICAR-IISR, the nodal centre during *kharif* 2017. The morphological characters were recorded and it was found that plant height was reduced as compared to *kharif* 2016 due impact of adverse climate during early vegetative stage. The reproductive phase was affected more and seed size was drastically reduced. Unfavorable climatic conditions in India during *kharif* 2017 caused appearance of several diseases like *Rhizoctonia* aerial blight, charcoal rot and anthracnose. The severe infestation of these diseases caused high scale loss of yield in most of the soybean varieties. The resistance capacity of some varieties was reflected with their higher productivity as compared to other varieties. Out of 117 varieties only four viz., JS 20-69, Hara Soya, PS 1029, JS 20-98 (3.5%) varieties yielded more than 20 q/ha, eight varieties yielded 10 to 20 q/ha, and twenty varieties yielded 5 to 10 q/ha and rest of 85 varieties yielded less than 5 q/ha (Fig. 4). The maximum air temperature and rainfall during soybean cropping season in *kharif* 2017 is shown in Fig. 5.

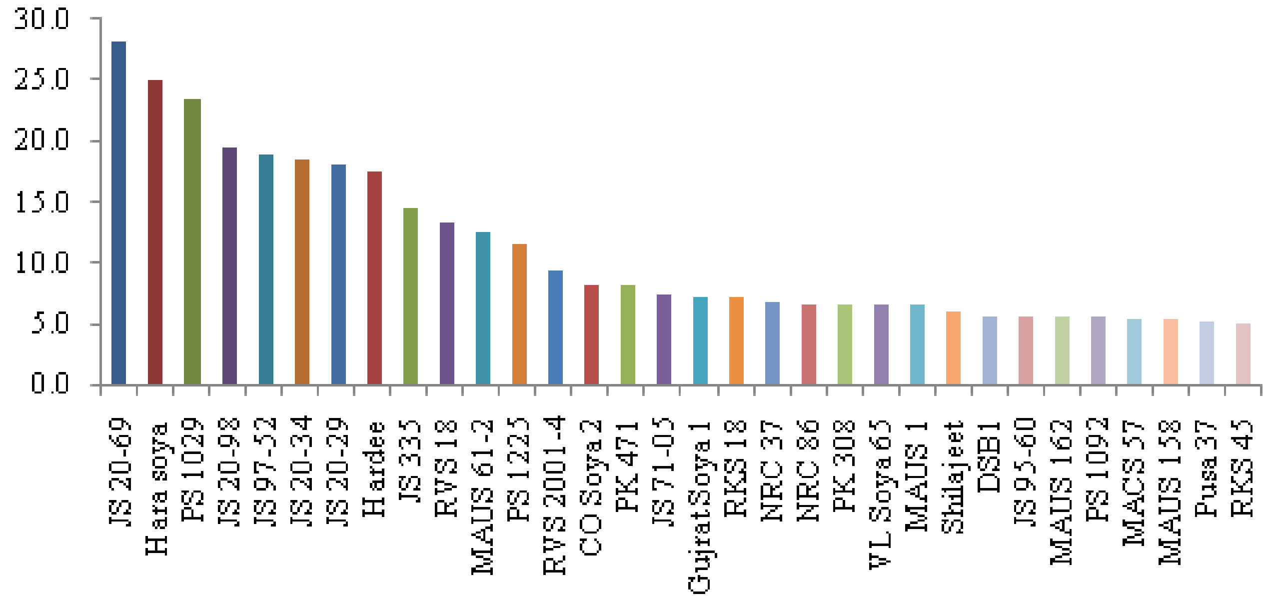


Fig. 4: The yield performance of notified soybean varieties having productivity more than 5 q/ha during *kharif* 2017

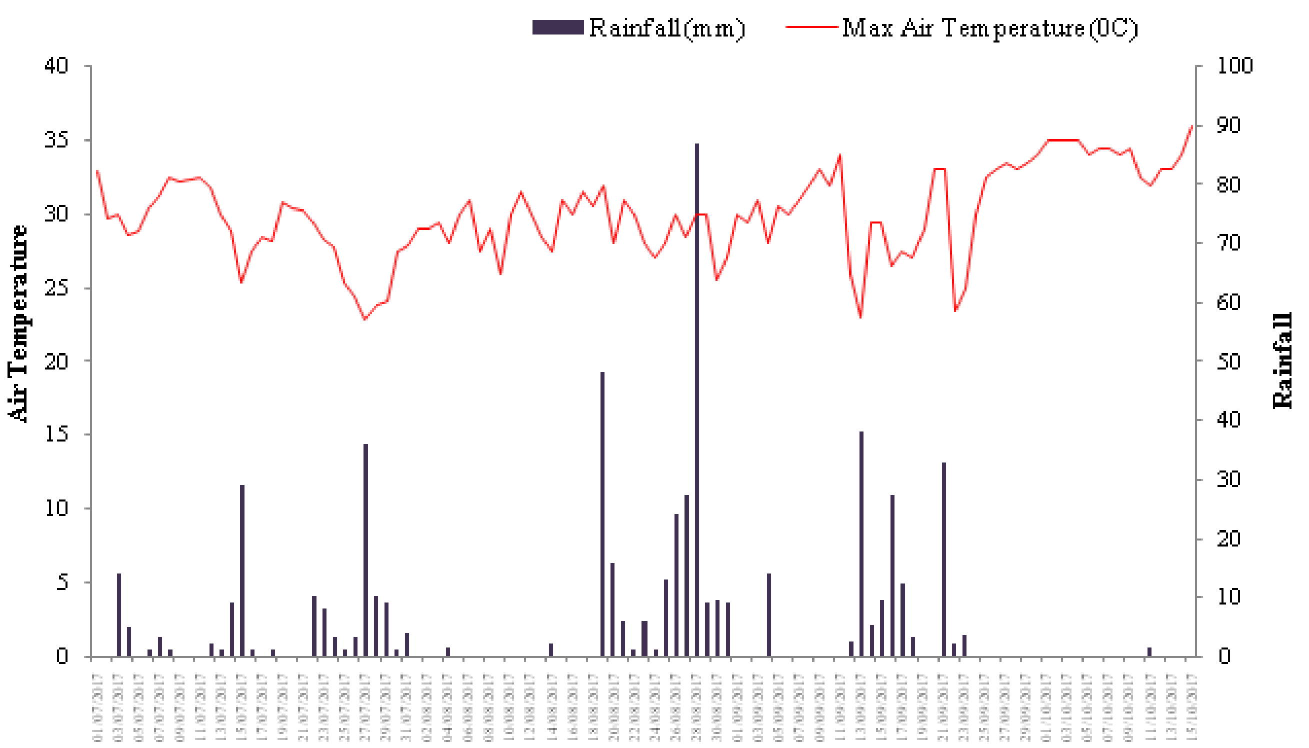


Fig. 5: The maximum air temperature and rainfall during soybean cropping season in *kharif* 2017

3.7 Breeding for food grade characters and high oil content

Following crosses were attempted to incorprate null alleles of lipoxygenases, Kunitz trypsin inhibitor into high yielding background and vegetable type soybean, to pyramid null alleles of both the character in same genetic background and to develop high oil genotypes.

- F_1 (derived from JS 97-52 × NRC 101) × NRC 109 × (SL 958 × NRC 94)
- High protein line derived from Hardee × AGS 191 × Da cha ma-me × NRC 101 (titi and clear hilum)
- JS 335 × BC_2F_1 (JS 335 × NRC 101)
- SL 525 × BC_2F_1 (SL 525 × NRC 101)
- JS 95-60 × BC_1F_1 derived from JS 95-60 × NRC 101
- JS 97-52 × PI 596540 (lx2lx2) × PI 542044 (titi) × Dada cha ma me × NRC 101
- Hardee × NRC 7 (High oil line) × high oleic line derived from LSb1× IC 210
- High oleic line derived from LSb1 × NRC 7 × NRC 132 (lx2lx2)
- KHSb 2 × JS 97-52 × PI 542044 (titi)
- KB 79 × JS 97-52 × PI 542044 (titi)
- EC 456548 × JS 97-52 × PI 596540 (lx2lx2) × PI 542044 (titi)
- EC 456548 × high oil line derived from Hardee × NRC 7
- F_6 line derived from NRC 105 × NRC 101 × JS 97-52 × PI 542044 × PI 596540
- NRC 37 × JS 97-52 × NRC 101

Four hundred advanced and segregating lines developed for high oil content were analysed for oil and protein content. Some of the lines with best combination of protein and oil content are given in Table 11.

Table 11: Advanced and segregating lines with best combination of protein and oil content

Line No.	Pedigree	Oil content (%)	Protein content (%)
NAG 145	NRC 7 × AGS 191	23.0	36.8
HG 11	Hardee × G 76	24.1	38.4
JG 8	JS 93-05 × G 688	24.7	35.4
JG 34	JS 93-05 × G 76	23.4	37.8
HN 92	Hardee × NRC 7	24.7	38.8
NG 101	NRC 7 × G 76	24.6	40.1
HNAG 390	(Hardee × NRC 7) × AGS 191	24.2	36.1

3.7.1 Development of null KTI and null lox2 genotypes

Advanced breeding lines NRC 142 and NRC 143 pyramided for null KTI allele and null lox2 allele were analysed using gene specific and linked marker (Fig. 6 & Fig. 7)

Fig. 6: PCR amplification of null Lox2 specific primer in lines pyramided for null KTI and null lipoxygenase-2

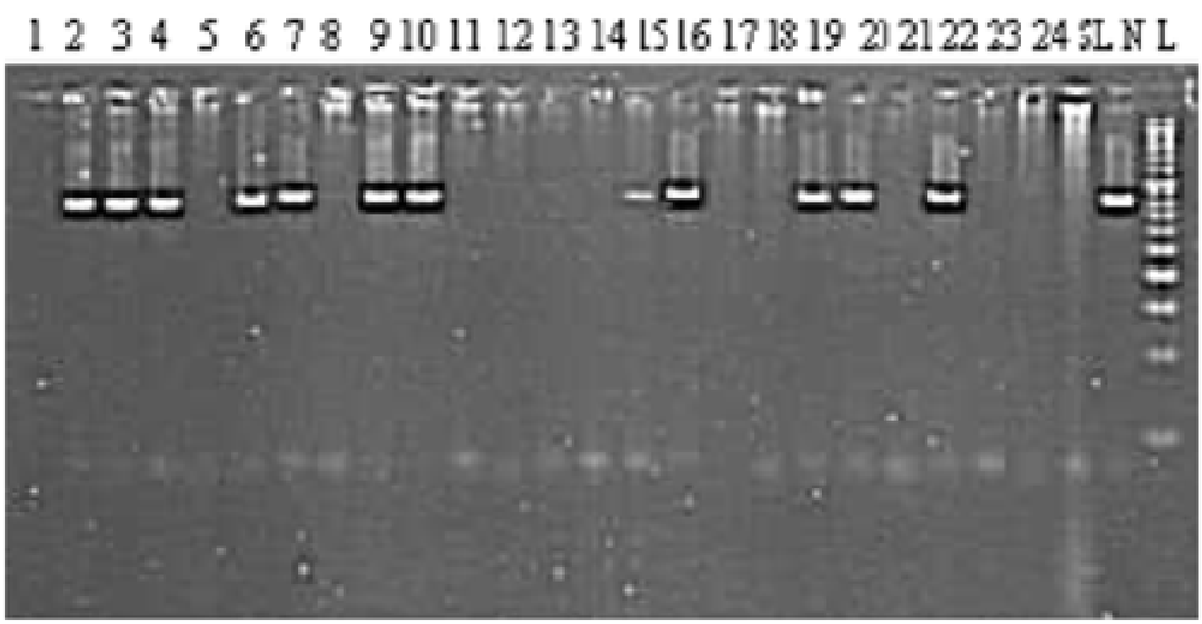


Fig. 7: PCR amplification of null KTI specific primer in lines pyramided for null KTI and null lipoxygenase-2

NRC 132 (Lox2 free) and NRC 133 (Kunitz trypsin inhibitor free) have entered in IVT of AICRPS, 2017. An memorandum of understanding (MoU) has been signed between ICAR-Indian Institute of Soybean Research (ICAR-IISR), Indore and M/S Nature Bio Foods Limited, New Delhi- 110017 for commercialization of NRC 109 (lipoxygenase -2 free soybean line) developed by ICAR-IISR, Indore on 14th August 2017. As per the terms and conditions of MoU, a non-exclusive license for 5 years has been extended to M/s Nature Bio Foods Limited, New Delhi for commercialization of lipoxygenase -2 free soybean line (NRC 109). M/s Nature Bio Foods Limited, New Delhi is a leading company involved in organic grain production, processing, packaging, storage, sales and distribution of organic products across the world.

Scientists from ICAR-IISR and representative of M/s Nature Bio Foods Limited, New Delhi displaying the MoU signed for commercialization of NRC 109 (lipoxygenase -2 free soybean)

3.7.2 Marker assisted elimination of off-flavour generating lipoxygenase-2 from Kunitz trypsin inhibitor free soybean genotypes

- Parental polymorphism survey was carried out using 364 new SSR markers for 4 parental combinations viz., NRC 7 × NRC 109, JS 97-52 × NRC 109 and JS 93-05 × NRC 109, MACS 450 × NRC 109. Total number of SSR marker surveyed across the genome for NRC 7 × NRC 109, JS 97-52 × NRC 109, JS 93-05 × NRC 109 and MACS 450 × NRC 109 is 600, 604, 594, and 576, respectively, exhibiting 39.83, 40.06, 35.52 and 34.37% polymorphism. Hybridity of putative F_1 seeds of JS 97-52-derived Kunitz trypsin inhibitor free line × NRC 109 and NRC 7 -derived KTI free line × NRC 109, respectively was confirmed using Satt 656 (SSR marker linked to Lox2 locus (Fig. 8) and null lipoxygenase-2 allele specific marker (Fig. 9). True F1 plants from both the parental combinations were backcrossed with recurrent parents to obtain BC_1F_1 seeds.

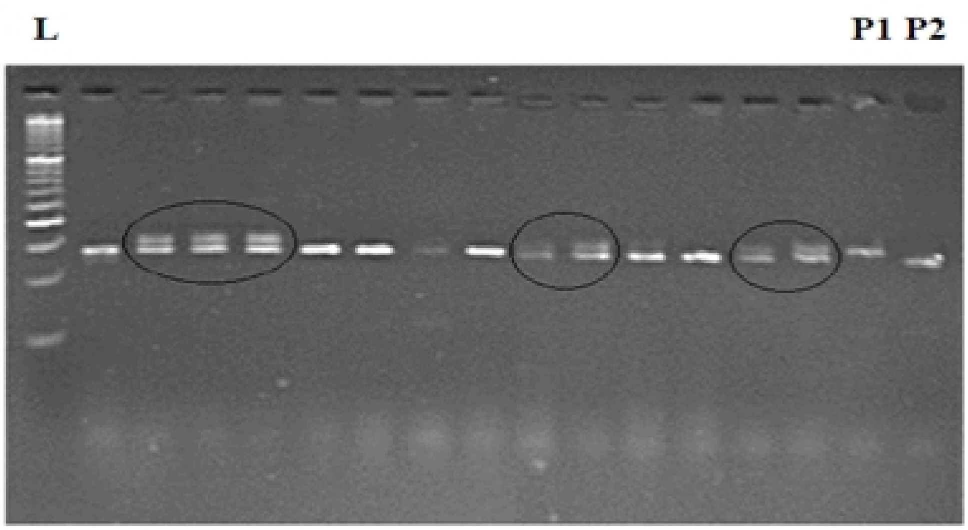


Fig. 8: Amplification of lox2 linked marker Satt 656 in putative F_2 plants of NRC7-derived KTI free line (P1) × NRC109 (P2). Lane L corresponds to 50 bp DNA ladder. P1 and P2 corresponds to NRC109 and NRC7, respectively. Encircled Lanes correspond to true F1 plants, with amplified products from both the parents (P1 and P2).

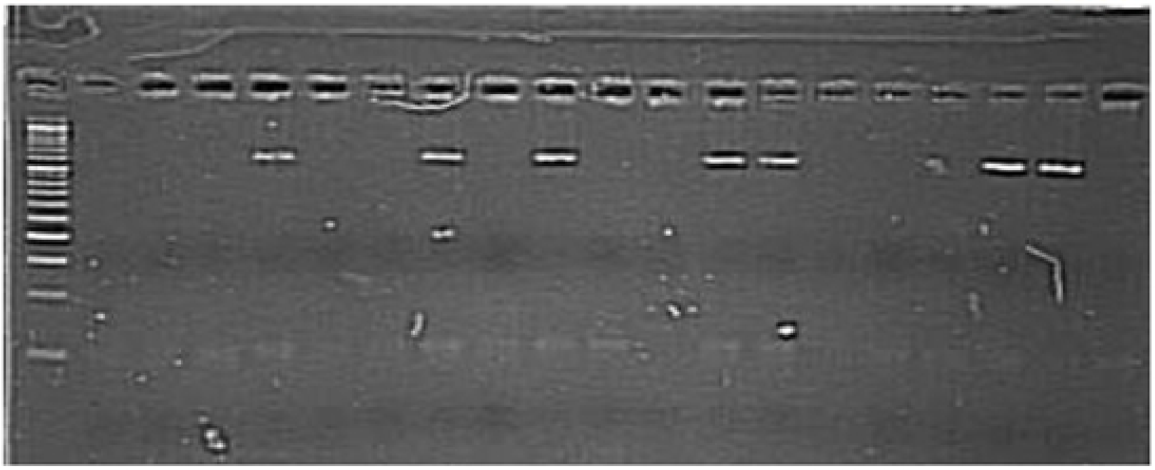


Fig.9: Amplification of null lox2 specific marker in putative F_1 plants of NRC 7-derived KTI free line × NRC 109. Lane L corresponds to 50 bp DNA ladder. P1 and P2 corresponds to NRC 109 and NRC 7, respectively; and lanes showing amplification corresponds to true F_1 plants.

3.7.3 Mapping QTLs for oleic acid and development of high oleic acid soybean

F_5 generations of population LSb 1 × NRC 7 × IC 210, LSb 1 × IC 210, IC 210 × LSb 1 × NRC 7 and Hardee × NRC 7 × AGS 191 were advanced and $F_{5:6}$ seeds tested for oleic acid through Gas chromatography and several of these lines have been found to contain oleic acid content about 60%. Two of these lines have been assigned identification number, namely, NRC 140 and NRC 141 for submission for registration.

3.7.4 Kunitz trypsin inhibitor and phytic acid in soybean: Assessment of methods of estimation and profiling of commercial varieties, germplasm and soy-based products in India

- Standard spectrophotometric protocol widely followed for estimation of trypsin inhibitor activity (TIA) is cumbersome and does not distinguish Kunitz trypsin inhibitor (KTI) from Bow-man-Birk Inhibitor (BBI). Extraction conditions for KTI were optimized (Fig. 10) and different forms of this polypeptide were resolved in 180 soybean genotypes of Indian and exotic origin through native PAGE. This led to the identification of 3 KTI alleles, namely, Tia, Tib and Tic, with Tia occurring in Indian genotypes (Fig. 11).
- Selected genotypes were subjected to estimation of KTI and BBI activity through densitometry and enzyme-linked immunosorbent assay, respectively; and total TIA through standard spectrophotometric protocol. Summation of KTI and BBI was significantly ($P<0.05$)

lower than TIA determined through spectrophotometric method.

- Kunitz trypsin concentration was determined in 102 soybean varieties using densitometry.

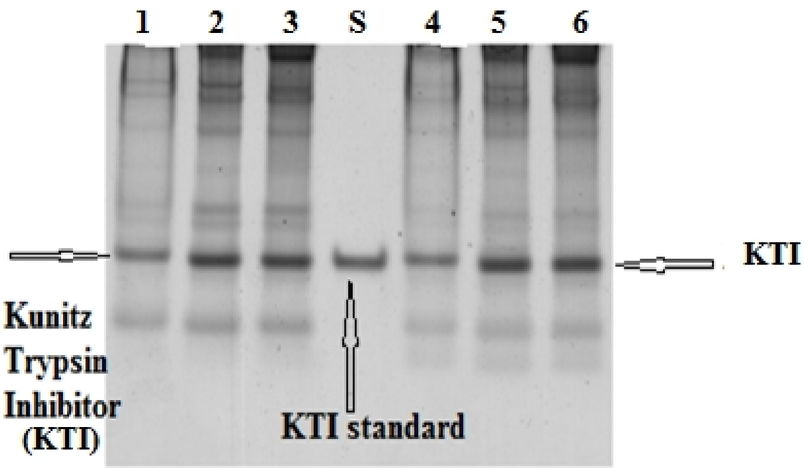


Fig. 10: Kunitz trypsin inhibitor polypeptide extracted using different solvents. Lane 1, 2, 3 & 4, 5, 6 correspond to kunitz trypsin inhibitor polypeptide in the seeds of JS 97-52 & JS 95-60 extracted from 1.5M Tris Buffer (pH 8.0), double distilled water (ddH$_2$O), 0.01N NaOH, respectively, and resolved on 10% Native Polyacrylamide gel electrophoresis. Lane S corresponds to Kunitz trypsin inhibitor standard (2 µg).

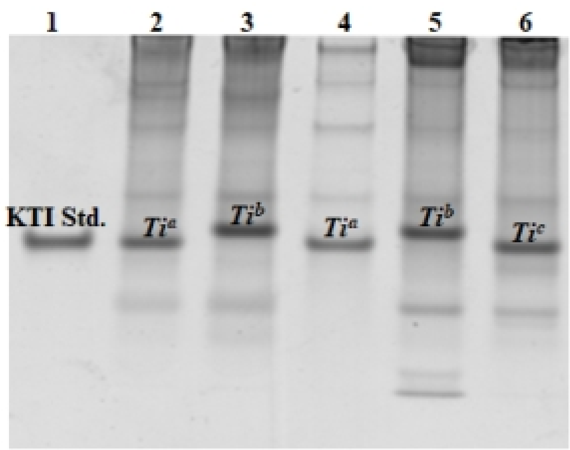


Fig. 11: Different isoforms of KTI through PAGE. Lane 1 represents standard KTI (20KD). Lanes 2, 3, 4, 5 and 6 represents the KTI polypeptide with varying Rf value in JS 20-34, advanced breeding line derived from JS 335 × PI 133226, Boiling-type, NRC 121 and Karune,respectively. Lanes 2 and 4 represent the Tia isoform of KTI in two soybean genotypes JS 20-34 and Boiling-type, which has same Rf value as that of KTI standard. Lanes 3 and 5 represent Tib isoform in two soybean genotypes, namely, advanced breeding line from JS 335× PI 133226 and NRC121 at a slightly low RF value. Lane 6 represents the Tic isoform in genotype Karune which shows the slightly higher Rf value

3.8 Screening soybean germplasm for vegetable type characteristics and processing of green pods of NRC 105

Organoleptically superior lines selected from the screening of 2200 germplasm lines in the previous year were again evaluated at R_6 stage in *kharif* 2017. The pods of vegetable type soybean NRC 105 were picked at R_6 stage from field, blanched and effect of different drying methods was studied. In tray drying method, samples were dried in tray dryer at 60 ± 2 °C and 80 ± 2 °C for 24 hours to reduce moisture to 4.0-6.0%. The drying rate was more at 80 °C while appearance of sample was more desirable at 60 °C. In microwave drying, the effect of microwave drying on appearance and moisture reduction rate of green beans at different power viz., 270 W, 540 W and 810 W was studied. The results showed that as power increased the drying rate increased. In osmotic dehydration method, the changes in green seeds as affected by sugar concentration (20, 30, 40, 50, 60, 70%) and time of treatment was studied. The least change in appearance as well as faster rehydration rate was found in osmo-dried sample treated with 40% sugar solution.

4.0 SEED QUALITY CHARACTERISTICS

- **Application of nano particles to seed to improve seed germination**

- **Improvement in soybean seed viability and strength of seed coat by genetic amelioration of seed coat traits**

4.0 SEED QUALITY CHARACTERISTICS

4.1 Application of nano particles to seed to improve seed germination

Seeds of JS 20-34 were treated with nano zinc and nano magnesium @ 100, 150 and 200 mg/kg seeds and with nano rock phosphate @ 200, 300, 400, 500, 600 and 700 mg/kg seeds with synthetic polymer to study field emergence, growth and yield. Increase in emergence percentage was maximum 10% over control in case of nano Mg (@ 200 mg/kg). Increase in field emergence (8%) was observed in most of the treatments. The application of nano rock phosphate was not effective to increase field emergence and was at par with control. There was significant improvement in seedling growth and vigour due to nano Zn and Mg treatment. The seedling length was 14.42 and 14.17 cm in nano Mg and Zn (@ 200 mg/kg seed) as compared to control 11.83 cm. seedling dry weight in these treatments were 847.7 and 838 mg as compared to control 682.4 mg.

The effect of nano Zn and nano Mg was compared with the effect of non nano forms of zinc and magnesium. The research grade zinc sulphate and magnesium sulphate was applied to seed in the same dose of 100, 150 and 200 mg/kg seeds through polymer coating. The improvement was found with $ZnSO_4$ and $MgSO_4$ treatment but the improvement was less than nano forms and was not statistically significant. The seed yield was increased due to nano particles of Zn and Mg as well as non nano form of Zn and Mg, seed yield was significantly improved with the dose of 200 mg/kg seeds in all the forms of Zn and Mg treatment on seeds. With the result of these experiments, it can be hypothesized that the soybean seed responds to these elements and there is scope to improve seed quality by increasing Zn and Mg content in seeds through nutrition supplements (Fig. 12 & Fig. 13).

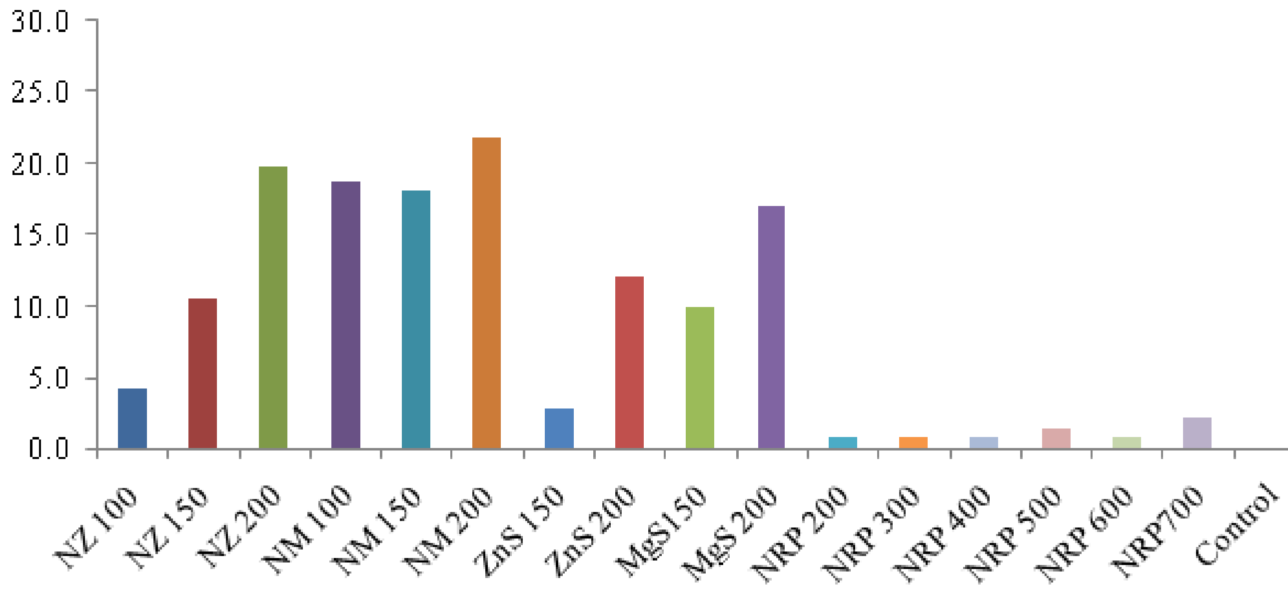


Fig. 12: Increase (%) in seedling dry weight due to nano Zn and Mg seed treatment

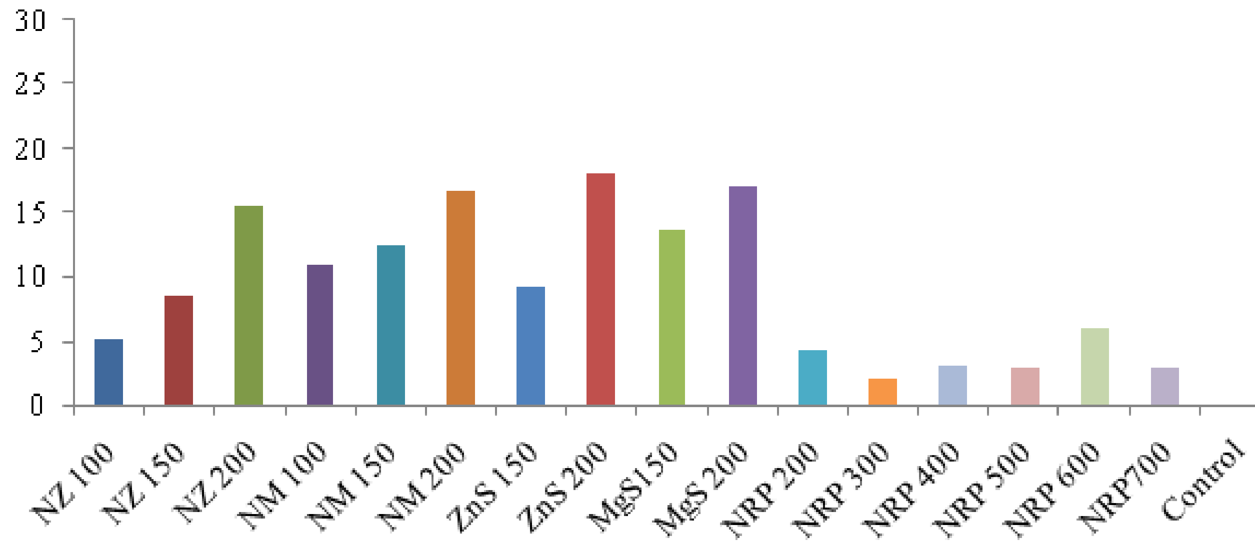


Fig. 13: Increase (%) in seed yield over control due to nano and non-nanoforms of Zn and Mg

4.2 Genetic improvement of seed viability and seed coat strength

The seed coat is one of the main determinants of seed quality and longevity potential. Susceptibility of soybean seed coat to mechanical damage is related to lignin content. High seed coat lignin content imparts better longevity and tolerance to field weathering. The bottleneck of soybean cultivation in India is still being loss of seed quality. The factors affecting seed quality loss of soybean is its delicate nature of seed and seed coat. Work has been undertaken to find variability among soybean cultivars for its susceptibility to mechanical forces and seed coat compositional variation. The findings need to be exploited for genetic improvement of seed coat traits for better storer soybean varieties. This work is aimed to develop the RILs from cross between bold seeded lines having higher seed coat lignin content with high yielding cultivars having low seed coat lignin content and to improve seed coat traits. Following crosses were made during *kharif* 2017.

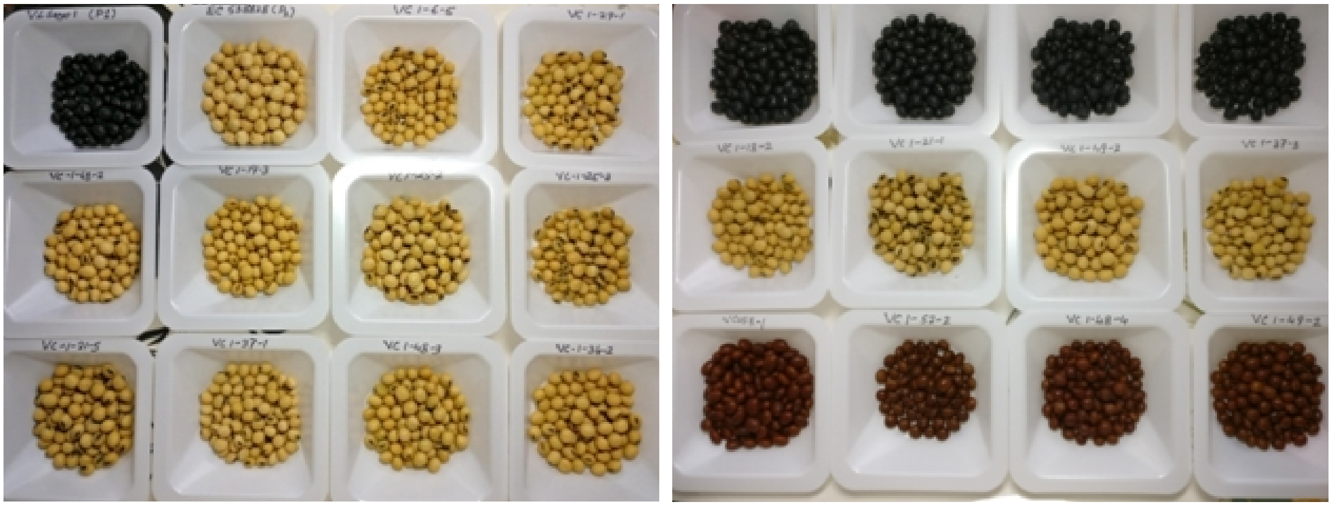
- NRC 7 × EC 538828
- F_1 (VL Soya 1 × EC 538828) × MACS 450
- Karune × EC 538828
- VL Soya 1 × JS 9560
- JS 20-29 × VL Soya 1
- PS 1029 × MACS 450
- CN 1(F_1) × Karune

One hundred fifty advanced and segregating lines developed from the cross VL Soya 1 × EC 538828 were analyzed for seed coat lignin content (Fig. 14). Three types of seed colour i.e. yellow, brown and black were obtained in the segregating lines from this cross. The black seeds of VL Soya1 was found to have higher mechanical strength due to higher lignin content in seed coat. The cross between VLSoya 1 and EC 538828 was intended to transfer the positive seed parameters of black seeded VLSoya 1 into the segregating yellow seeded lines with larger seed size. The variation in lignin content in yellow seeded advanced line ranged from 1.38-3.28 mg/g seed coat, in brown seeded lines from 1.22-5.028 mg/g seed coat and in black seeded advanced line ranged from 1.35-4.0428 mg/g seed coat (Table 12).

Table 12: Variation in lignin content (mg/g seed coat) of advanced segregating lines of cross VLS 1 X EC 538828

Seed coat colour	Line No.	Seed coat lignin content	Seed coat colour	Line No.	Seed coat lignin content	Seed coat colour	Line No.	Seed coat lignin content	Seed coat colour	Line No.	Seed coat lignin content
Yellow	VC 129	3.28	Brown	VC 3	5.00	Black	VC 119	4.04	Yellow	VC 16	2.19
Yellow	VC 21	2.89	Brown	VC 82	4.82	Black	VC 20	3.81	Yellow	VC 145	2.19
Yellow	VC 68	2.78	Brown	VC 62	4.77	Black	VC 103	2.71	Yellow	VC 128	2.18
Yellow	VC 17	2.77	Brown	VC 43	4.33	Black	VC 46	2.68	Yellow	VC 130	2.18
Yellow	VC 28	2.70	Brown	VC 44	4.09	Black	VC 53	2.50	Yellow	VC 139	2.15
Yellow	VC 25	2.69	Brown	VC 131	4.09	Black	VC 24	2.28	Yellow	VC 133	2.15
Yellow	VC 132	2.68	Brown	VC 13	3.96	Black	VC 117	1.97	Yellow	VC 58	2.14
Yellow	VC 27	2.61	Brown	VC 39	3.84	Black	VC 120	1.90	Yellow	VC 10	2.10
Yellow	VC 135	2.52	Brown	VC 78	3.73	Black	VC 146	1.59	Yellow	VC 90	2.10
Yellow	VC 64	2.44	Brown	VC 1	3.61	Black	VC 115	1.53	Yellow	VC 89	1.82
Yellow	VC 14	2.41	Brown	VC 76	3.05	Black	VC 118	1.48	Yellow	VC 144	1.81
Yellow	VC 31	2.33	Brown	VC 55	2.87	Black	VC 150	1.35	Yellow	VC 100	1.78
Yellow	VC 148	2.32	Brown	VC 32	2.71	Yellow	VC 5	2.09	Yellow	VC 123	1.77
Yellow	VC 56	2.26	Brown	VC 50	2.41	Yellow	VC 136	2.06	Yellow	VC 65	1.73
Yellow	VC 66	2.24	Brown	VC 104	2.34	Yellow	VC 141	2.02	Yellow	VC 134	1.71
Yellow	VC 67	2.21	Brown	VC 71	2.20	Yellow	VC 140	2.00	Yellow	VC 86	1.71
Yellow	VC 122	1.71	Brown	VC 110	2.05	Yellow	VC 137	1.97	Yellow	VC 4	1.66
Brown	VC 93	1.90	Yellow	VC 60	1.97	Yellow	VC 109	1.63	Brown	VC 116	1.67
Yellow	VC 57	1.96	Yellow	VC 63	1.60	Brown	VC 112	1.58	Yellow	VC 61	1.93
Yellow	88	1.45	Brown	VC 19	1.56	Yellow	VC 101	1.89	Yellow	125	1.41
Brown	VC 49	1.55	Yellow	VC 121	1.86	Yellow	87	1.39	Brown	VC 113	1.52
Yellow	VC 142	1.86	Yellow	85	1.38	Brown	VC 54	1.22	-	-	-
Brown	VC 81	2.14	Yellow	VC 59	1.99	Yellow	VC 138	1.84	-	-	-

Fig. 14: Advanced lines of cross VL Soya 1 × EC 538828 having good mechanical strength, with high lignin content



The seed coat cracking in soybean during maturation, drying and storage is an undesirable trait which affects seed quality and germination. The stronger seed coat resists cracking during these critical stages and is a desirable trait in improved varieties to perform better in farmer's field. The black seeded VLSoya 1 is resistant to cracking during maturation drying and storage. This positive trait was used in hybridization and developed several yellow seeded lines with bold seed size (Fig. 15)

Fig. 15: Lines with stronger seed coat

5.0 ABIOTIC STRESS

- **Hybridization and early generation advancement**
- **Evaluation of recombinant inbred lines (RILs) for water-logging tolerance**
- **Evaluation of recombinant inbred lines (RILs) for drought tolerance**
- **Multilocation evaluation of elite drought tolerant breeding lines**
- **Evaluation of advance breeding lines and germplasm accessions for drought tolerance**
- **Multi-tiered screening for delayed senescence and drought susceptibility index**
- **Identification of drought tolerant soybean *Rhizobia***

5.0 ABIOTIC STRESS

5.1 Hybridization and early generation advancement

Three BC_2F1s were realized by crossing 3 drought tolerant genotypes, namely, 70-4, Hardee, AGS 25 with JS 71-05, JS 90-41, PK 472, respectively, and 3 BC_1F_1 by crossing two drought tolerant genotypes Young, PI 416937 and one water logging tolerant PK 472 with JS 335. Further, 23 three-way and 6 biparental crosses were achieved to combine drought tolerance and earliness. In on-season trial at ICAR-IISR, Indore 2 BC_2F_2s; while in off-season trial at AICRPS Centre GKVK, Bengaluru, 3 BC_2F_1s, 2BC_1F_1s, 1 four-way cross, 7 three-way crosses, 3 bi-parental crosses and an F_2 breeding population (Young × Kaeri 651-6) were advanced.

5.2 Evaluation of recombinant inbred lines (RILs) for water-logging tolerance

A RILs population (92 lines) derived from a cross JS 90-41 × JS 97-52, was evaluated under 15 days water logged condition at R_1 stage in an artificial pond like structure. Percentage reduction in seed yield per plant, under high moisture stress condition in relation to normal field condition, was recorded to be less in cultivar PK 472 (26.8%) followed by JS 97-52 (28.7%). Four lines of RILs population recorded less percentage reduction in seed yield per plant under water logged condition, were 104-10 (3.1%), 104-11 (7.1%), 104-8 (7.8%), 104-2 (7.9%).

5.3 Evaluation of recombinant inbred lines (RILs) for drought tolerance

A RILs population (162 lines) derived from a cross JS 97-52 × NRC 37, was evaluated under low moisture stress at R_5 in rainout shelter in relation to normal field condition. Drought resistance index (DRI) was estimated to determine drought tolerance of the population. DRI is ratio of yield reduction due to stress in a given genotype as compared to the mean reduction over all genotypes in a given test. Among the cultivars, JS 97-52 estimated high drought resistance index (DRI 1.46) whereas JS 90-41 estimated low drought resistance index (DRI 0.62). Nine lines of RILs population, estimated with higher DRI were 107-33 (3.10), 107-43 (3.06), 107-44 (3.02), 107-186 (2.98), 107-14 (2.97), 107-9 (2.92), 107-6 (2.74), 107-45 (2.74) and 107-1 (2.69) as compared to JS 97-52.

5.4 Multilocation evaluation of elite drought tolerant lines

An elite breeding line NRC 137 was evaluated in IVT of *kharif* 2017 and was promoted to AVT-I of North East Hill Zone and Eastern Zone. NRC 137 derived from a cross (JS 97-52 × NRC 37) was a drought tolerant lines with DSI of

0.7. Another elite breeding line NRC 136 derived from a cross (JS 97-52 × NRC 37) with drought tolerance was entered in the IVT of *kharif*, 2017.

5.5 Evaluation of advance breeding lines and germplasm accessions for drought tolerance

Thirty three advance breeding lines and 6 accessions along with drought tolerant check JS 97-52 and susceptible check JS 90-41 were evaluated in water stress in rainout shelter and well watered condition in a field trial. Five breeding lines were found to possess drought tolerance based on drought resistance index (DRI) ≥1.0 viz. Drt17-27-5/2, 32-15/1-3, 20-105-2, 21-105-13, 50-1012(1) 63-74-13. These lines produced more than 5% higher seed yield (kg/ha) than the check JS 97-52 and therefore have potential for sustaining soybean improvement under low moisture stress scenario (Table 13). These lines have been promoted to station trial for yield evaluation.

Table 13: Elite breeding lines for drought tolerance in soybean

Accessions	Well watered seed yield (kg/ha)	Well watered harvest index (%)	Drought resistance Index
Drt 17-27 5/2	1317	32.0	1.2
32 15/1 -3	1313	34.2	1.0
20 105-2 M	1188	33.3	1.2
21 105-13	1118	26.9	1.3
50 1012 (1) 63-74-13	1098	21.2	1.1
JS 97-52 (T)	991	22.4	1.5
JS 90-41 (S)	37	8.8	0.6

For root parameters, line Drt 17-27 5/2 was identified to possess prominent root system architecture traits like root angle (33°), root thickness (avg. dia. 0.4359 mm) and rooting depth (109.3 cm). Among germplasm accessions EC 291448 (46°), EC 107407 (43°) and MACS 345 (41°) showed drought tolerance with root angles >410 (Table 14). Accessions viz., PI 159923, TGX 709-50E and J 732 expressed drought tolerance in terms of DRI (>1.0), and root thickness (average diameter 0.4052 mm) in comparison to drought tolerant check JS 97-52.

Table 14: Drought tolerance in germplasm accessions for above and below ground traits

Accessions	DRI	Av. Dia (mm)	Av. Root angle	Rooting depth (cm)	Nodes/plant (water stress)
PI 159923	2.1	0.41	36	140.0	15.5
TGX 709-50E	1.6	0.48	36	87.6	13.2
J732	1.6	0.45	26	115.7	13.2
MACS 345	1.1	0.40	41	166.8	13.1
EC 291448	2.5	0.40	46	180.2	12.0
EC 107407	2.4	0.49	43	104.3	13.3
JS 97-52 (T)	1.5	0.40	41	137.9	11.8
JS 90-41 (S)	0.6	0.38	30	104.3	9.4

5.6 Multi-tiered screening for delayed senescence and drought resistance index

In a field screening during summer 2017, 198 accessions and 155 advanced lines were selected for delayed senescence trait. During *kharif* season, these accessions and advanced lines were further field screened under chemical desiccation (KI 0.2%) stress at R_5 plus 8-10 days stage and DRI was calculated. Fifteen accessions and 19 elite lines were identified with high drought resistance index (DRI $\geq$ 1) (Table 15).

Table 15: Elite lines and accessions screened for DRI under chemical desiccation stress

Lines	Gen.	DRI	Accessions	DRI
21 SPD Sel 105 13	F_8	2.3	EC 308312	2.3
37 DrtSel 5/4 44	F_9	2.3	EC 389174	2.3
11 104-42	F_8	2.2	EC 389148	2.2
KH-16 RIL 107 153	F_7	2.1	PI 307863	2.2
5 8-95 Drt	F_6	2.1	TGX 709-7E	2.2
KH-16 RIL 107 109	F_7	2.1	P 426	2.1
KH-16 RIL 107 2	F_7	2.1	EC 84051-32-1	2.1
107-4	F_7	2.1	ELGIN(S)	2.1
KH-16 RIL 107 157	F_7	1.9	AGS 96	2.1
10 104-10	F_8	1.9	IC 47392	2.1
27 DrtSel 5/2 1	F_9	1.9	EC 274741	2.0
8 104-51	F_8	1.8	Lee-1	2.0
53 1012(1) 1	F_8	1.8	EC 389158	1.8
KH-16 RIL 107 80	F_7	1.8	EC 389157	1.7
33 8-66 Drt	F_6	1.8	EC 3262	1.7
108-86	F_8	1.8	EC 602288 (T)	1.1
KH-16 RIL 107 127	F_7	1.8	JS 71-05(T)	1.0
25 DrtSel 8/12	F_6	1.8	JS 97-52(T)	1.0
26 8-28 Drt	F_6	1.7	NRC 2(S)	0.0

5.7 Identification of drought tolerant soybean *Rhizobia*

The potential *Rhizobial* strains recovered from high trehalose accumulating lines were tested for their nodulation abilities and overall growth of soybean and compared their efficacy with available PGPR strains and one conventional/commercial during *kharif* 2017.

- In terms of nodulation, in general, all the *Rhizobial* strains performed well (*Burkholderia arboris* showed comparatively higher nodule number), although inoculation of D-4A (*Bradyrhizobium daqingense* - PK 472) and D-4B (*Bradyrhizobium liaoningense*- PK 472) strains were found to have higher leghaemoglobin and acetlylene reduction assay (ARA) in nodules than commercial inoculum.
- The inoculation of *Rhizobia* and other PGPR strains in soybean tested under normal and stressed (imposed for 15 days at R_5 stage) conditions. Under normal conditions, the inoculation with *Bradyrhizobium daqingense* and *Burkholderia arboris* found to have higher nodulation then other strains. The leghaemoglobin content was also higher in inoculated plants of *Burkholderia arboris* and consortia of *Pseudomonas, Burkholderia arboris* and AMF compared to other treatments (Fig. 16). Overall, plants inoculated with *Bradyrhizobium liaoningense*, *B. daqingense* showed higher chlorophyll and nitrogen content in roots, nevertheless, PGPR strains *B. subtilis*, *Psuedomonas* sp. , *B. arboris* were also found good. (Table 16).
- Under stressed conditions, the inoculation of *Bradyrhizobium daqingense* and *Bradyrhizobium liaoningense* significantly increased both nodule biomass and leghaemoglobin as compared to other treatments (Fig. 17). However, with regard to Relative Water Content (RWC), inoculation of *B. japonicum* performed better whereas, chlorophyll content increased in *Burkholderia arboris* plants.

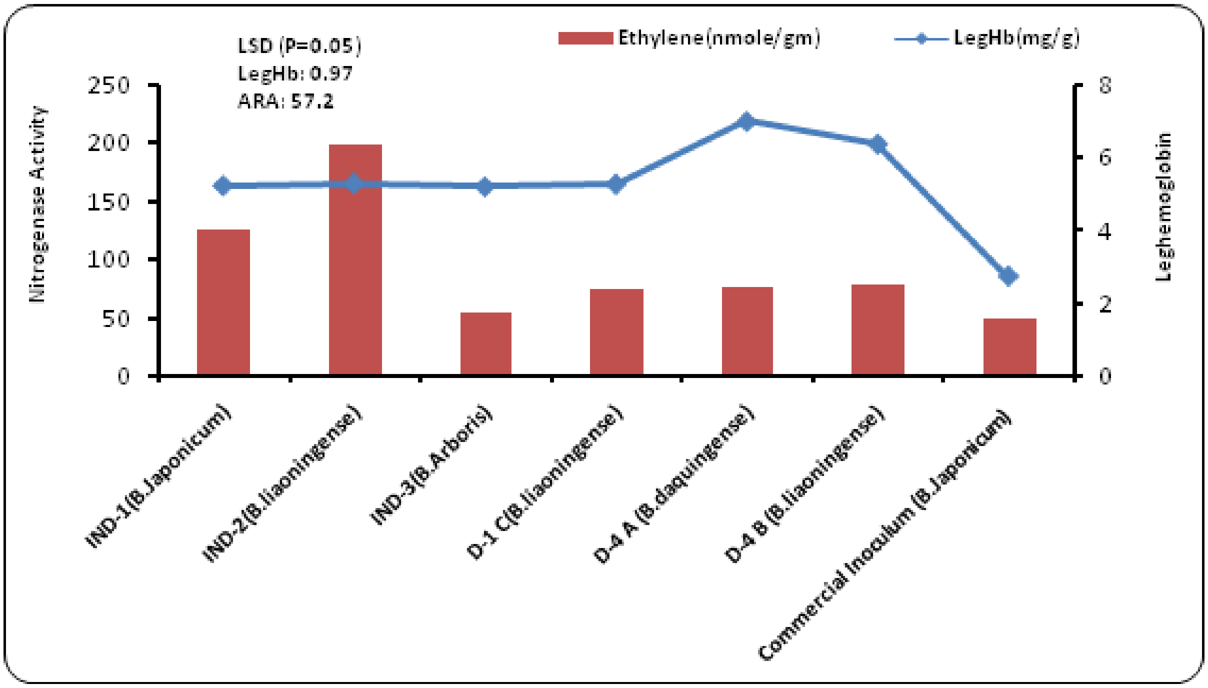
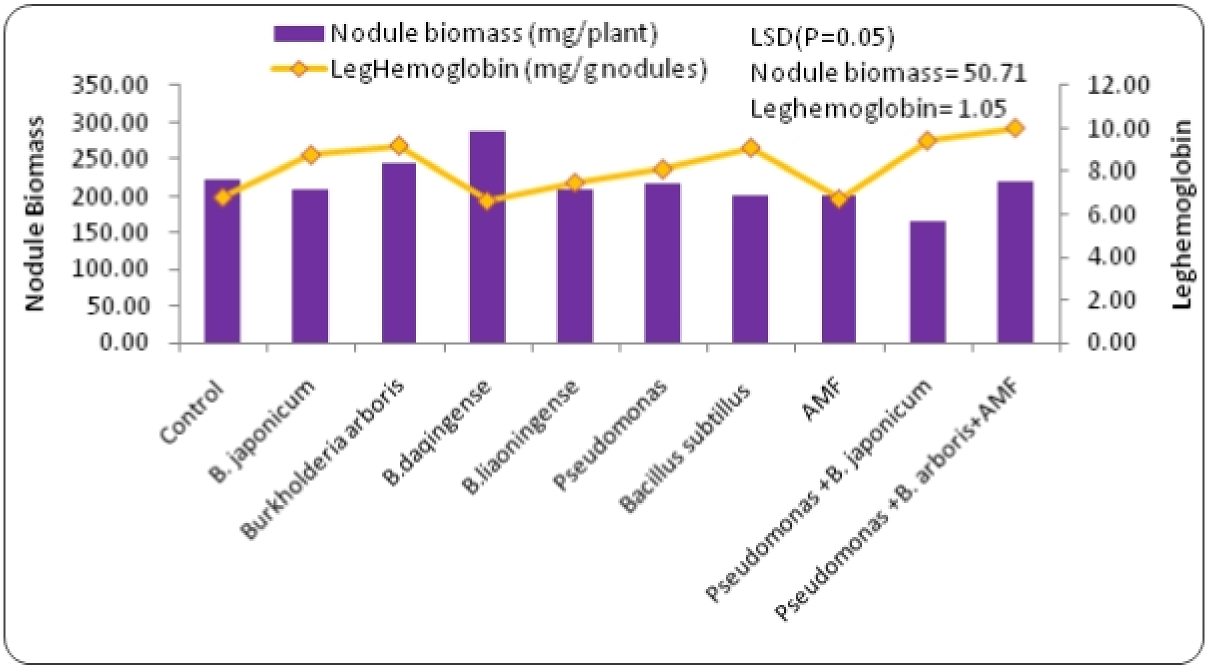


Fig. 16: Nodulation parameters i.e., biomass (bottom) and leghaemoglobin content and nitrogenase activity (top) evaluated with different bacterial cultures under microcosm conditions. Data are average of 3 replications; LSD, least significance difference at 5% level of significance by Duncan's multiple range test of ANOVA



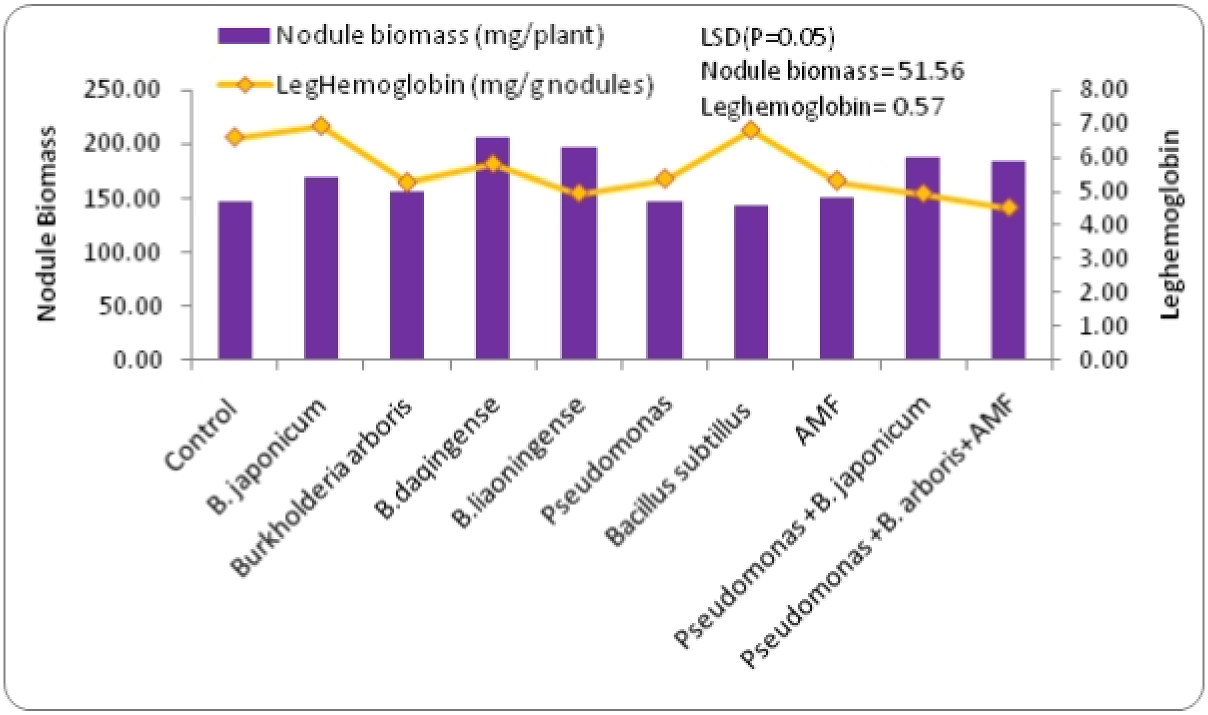


Fig. 17: Effect of microbial inoculations on nodulation parameters in unstressed (at R_5 stage) conditions under microcosms. Data are average of 3 replications; LSD, least significance difference at 5% level of significance by Duncan's multiple range test of ANOVA

Table 16: Effect of microbial inoculation on RWC (%), chlorophyll and root nitrogen assessed under unstressed and stressed conditions in soybean grown in pots. Data are average of 3 replications; LSD, least significance difference at 5% level of significance by Duncan's multiple range test of ANOVA

Treatment	RWC (%)		Chlorophyll (µg/g)		Root nitrogen (%)	
	Normal	Stressed	Normal	Stressed	Normal	Stressed
Control	61.62	48.19	3.63	3.35	0.86	0.77
B. japonicum	74.51	54.20	3.83	3.32	0.72	0.43
Burkholderia arboris	75.31	42.01	3.94	3.88	0.85	0.68
B. daqingense	71.08	38.78	3.78	3.50	0.96	0.70
B. liaoningense	71.23	37.66	4.10	2.84	0.97	0.71
Pseudomonas	75.42	37.04	3.69	3.10	0.76	0.62
B. subtilis	73.28	47.37	3.69	3.42	1.05	0.81
AMF	71.63	38.73	3.32	3.35	0.97	0.70
Pseudomonas + B. japonicum	75.47	44.80	3.75	2.78	1.01	0.67
Pseudomonas + B. arboris + AMF	70.20	46.59	3.75	2.66	0.88	0.69
LSD (P=0.05)	5.23	8.83	0.06	0.47	0.08	0.06

6.0 BIOTIC STRESS

- **Genome wide identification of InDels in soybean accession EC 241780 and their comparative analysis**
- **Multilocation evaluation of pre-breeding lines for YMV resistance**
- **Decision Support System for identification of soybean insects and their management**
- **Development of forewarning model for insect incidence in soybean based on weather parameters**
- **Effects of genotypic diversity on soybean insect-pests and their natural enemies populations**

6.0 BIOTIC STRESS

6.1 Genome wide identification of Insertion-Deletions (InDels) polymorphisms from soybean accession EC 241780 and identification of markers ass ociated with soybean rust

Soybean rust is considered one of the most destructive foliar diseases in soybean. Development of resistant or tolerant soybean cultivars is considered as a suitable alternative for disease control. Comparative analysis of whole genome sequence of rust resistant soybean genotypes EC 241780 with Williams 82 reference genome was performed. Genome wide identification and characterization of Insertion-deletions (Indels) polymorphisms was conducted. A total of 311, 361 InDels were identified and further characterized for their presence in intergenic and genic regions. Sequence comparisons revealed presence of Indels in NBS-LRR disease resistance genes. We identified indels in nine NBS-LRR genes viz *Glyma18G46875*, *Glyma18G51533*, *Glyma18G51546*, *Glyma18G51715*, *Glyma18G51741*, *Glyma18G51765*, *Glyma18G51930*, *Glyma18g51950* and *Glyma18G51960* on chromosome 18 between genomic region 56545509 to 6069629. The InDels identified in this study will be valuable for genotyping the mapping populations originating from a combination of EC 241780 and JS 335. Thus, we predict that our analyses will be valuable for enhancing rust resistance in soybean.

6.2 Multilocation evaluation of Pre-breeding lines for YMV resistance

A total of 531 pre breeding lines were screened for YMV disease resistance under field conditions at Ludhiana and Delhi locations. Susceptible check JS 335 and NRC 37 varieties were sown as infector rows to compare the disease infection between the pre breeding lines and susceptible checks. A total of 74 and 126 lines were identified as resistance to YMV disease at Ludhiana and Delhi respectively. Further, 41 lines were shown resistant to YMV at both Ludhiana and Delhi locations.

6.3 Identification of Insect resistant /non-preferred soybean genotypes using food consumption and utilization indices

For identification of insect resistant or non-preferred sources, soybean genotypes were screened under controlled conditions using food consumption and digestibility indices against test insect, *Spodoptera litura*. Antixenosis reaction was assessed based on Preference Index (C), whereas antibiosis reaction was assessed by calculating Approximate Digestibility (AD), Efficiency of Conversion of Ingested food (ECI) and Efficiency of Conversion of Digested food (ECD).

6.3.1 Antixenosis (non-preference) studies

Antixenosis study was conducted with 41 soybean genotypes against Spodoptera litura. Preference Index was calculated to classify the genotypes based on reference values. Germplasm line PR15-126-3-8, PR 35 and DSb 1 (0.5, 0.46, and 0.49, respectively) found to exhibit strong antixenosis, while 15 genotypes i.e., SPC 174, TGX 849-D-13-4, TGX 854-42 D, TGX 833-32 E, V 1, PPI 72-2-5-6, VP 1162, VP 1164, EC 241807, EC 250591, GPC 32, JS 20-37, NRC 78, NRC 84 and PS 1347 (0.65, 0.68, 0.60, 0.66, 0.72, 0.73, 0.70, 0.65, 0.58, 0.87, 0.67, 0.70, 0.56, 0.74, and 0.63, respectively) showed moderate antixenosis and 24 genotypes i.e., P501, PK5, EC 358002, VP 11478A, EC 390981A, DB 1588, DN 290, EC 18594, EC 241650, EC 241756, EC 241768, EC 241771, EC 241777, EC 241778A, EC 241778 B, EC 242104, EC 245986B, EC 250591, EC 251886, JS 20-42, KB 17, MAUS 176, NRC 67 and NRC 71 (0.89, 0.92, 0.85, 0.78, 0.80, 0.94, 0.99, 0.91, 0.89, 0.85, 0.83, 0.97, 0.90, 0.99, 0.82, 0.86, 0.83, 0.87, 0.75, 0.87, 0.77, 0.88, 0.89, and 0.87, respectively) exhibited slight antixenosis. Rest 8 genotypes were found to be the preferred hosts.

6.3.2 Antibiosis studies in selected soybean genotypes

Antibiosis study was conducted with 7 genotypes and Approximate Digestibility (AD), Efficiency of Conversion of Ingested food (ECI) and Efficiency of Conversion of Digested food (ECD) were calculated using food consumption and utilization indices. It was observed that amount of food ingested by *Spodoptera litura* larvae ranged between 8.99 (G5P22) and 3.75 (CAT 47). Higher food ingested was observed in genotypes G5P22 (8.99) followed by EC333902, VP1165 and JS 335 (8.78, 8.74 and 7.84 respectively). Lowest food ingested was observed in CAT 47 (3.75) followed by CAT 146 (5.79), CAT 139 (6.61) and EC 333879 (7.58). Minimum weight gain of larvae was observed in genotypes CAT 47 (0.19) and maximum in genotypes EC 333902 (1.70) which is closely followed by genotypes JS 335 and G5P22 (0.83 and 0.80 respectively). Maximum weight of frass was observed in EC 333902 (0.64) followed by genotypes JS 335 (0.54) and G5P22 (0.45). The minimum weight of frass were observed in genotypes CAT 47 (0.26) and CAT 146 (0.26) followed by CAT 139, EC 333879 and VP 1165 (0.28, 0.32 and 0.42 respectively). Genotypes showing strong and moderate antixenosis and antibiosis reaction against *Spodoptera litura* are given in Table 17

Table 17: Genotypes showing strong and moderate antixenosis and antibiosis reaction against *Spodoptera litura*

Genotypes	Insect resistance attribute
PR 15-126-3-8, PR 35 and DSb 1	Strong antixenosis (C=0.26 to 0.50)
SPC 174, TGX 849-D-13-4, TGX 854-42 D, TGX 855-32E, V 1, PPI 72-2-5-6, VP 1162, VP 1164, EC 241807, EC 250591, GPC 32, JS 20-37, NRC 78, NRC 84 and PS 1347	Moderate antixenosis (C= 0.51 to 0.75)
CAT 47, CAT 146 and VP 1165	Antibiosis (AD, ECI and ECD lower as compared to other genotypes)

6.4 Effects of genotypic diversity on soybean insect-pests and their natural enemies

To test the effects of genotypic diversity on soybean insect-pest and their natural enemies population eight treatments have been chosen. The details about treatment have been given below-

T1: JS 95-60, JS 20-34, MAUS 47 and MAUS 1460 (T1) - 90 days
T2: JS 93-05, JS 20-29, RVS 2001-4 and DSb 28-3 (T2) – 90-95 days
T3: NRC 86, JS 97-52, JS 20-98 and RKS 45 (T3) – 95-100 days
T4: NRC 37, JS 335, RSC 1046 and RKS 113 (T4) – 100-105 days
T5: JS 95-60 (Check variety for T1)
T6: JS 93-05 (Check variety for T2)
T7: NRC 86 (Check variety for T3)
T8: JS 335 (Check variety for T4)

Among eight treatments (T1-T8), four treatments (T1-T4) were varietal mixture treatment and rest four treatments were of single variety (check variety) treatments chosen from their respective mixture treatments.

6.4.1 Effects of genotypic diversity on sucking pests

The lowest population of whitefly, mite, leafhopper, thrips, mealy bugs, treehoppers and spittle bugs population (nymphs and adults) was found in T2 (0.7), T3 (0.9), T3 (0.1), T3 (0.1), T4 (1.9), T3 (0.1) and T2 (0.2), respectively and the highest population was found in T8 (1.9), T7 (2.1), T5 (1.1), T5 (1.5), T6 (5.3), T5 (0.9) and T5 (1.1), respectively.

6.4.2. Effects of genotypic diversity on stem borers, defoliators and pod borer

The minimum and maximum per cent

stem tunneling by stem fly was observed in T4 (48.57%) and T2 (69.23%), respectively, while minimum per cent infestation and damage by girdle beetle was observed in T6 (3.78%) and T3 (0.0%), respectively. The maximum per cent infestation and damage by girdle beetle was observed in T4 (1.9%) and T1 (1.62%), respectively. The lowest population of defoliators viz., *S. exigua, S. litura,* semiloopers, tussock moth, grey weevil, blue beetle and leaf miner was observed in T2 (1.1), T2 (0.9), T2 (2.8), T2 (0.1), T2 (1.1), T2 (0.0) and T2 (0.6). The highest population was found in T8 (3.1), T7 (3.1), T7 (6.0), T7 (1.3), T6 (3.1), T8 (0.7) and T8 (1.3), respectively. The lowest population density of pod borer was observed in T1 (0.7%) and the highest population was found in T8 (2.0%).

6.4.3. Effects of genotypic diversity on natural enemies

The highest population density of predators viz., coccinellids, spiders, rove beetle, cantheconidia, predatory thrips and hoverfly was observed in T3 (1.6), T4 (15.7), T3 and T4 (1.3), T3 (5.2), T2 (3.2), T3 (1.0), T2 (1.5), T3 (5.5), T2 (6.1) and T4 (3.5), respectively, and the lowest population was found in T6 (0.0), T8 (7.0), T7 (0.0), T6 (1.0), T6 (1.0), T5 (0.6) and T7 (0.0), respectively. In case of microbial pest control by *B. bassiana* and *N. rileyi*, the highest total number of lepidopteran larvae infected was observed in T2 (1.5) and T3 (5.5) and the lowest was found in T5 (0.2) and T5 and T6 (1.0), respectively. The highest and lowest parasitoid activity of *Encarsia transvenna* on whitefly was found in T2 (6.1) and T6 (1.7% parasitization/leaf), respectively and braconids on lepidopteran larvae/m^2 was observed in T2 (4.1) and T6 (0.7 parasitized larvae/ m^2), respectively.

6.4.4. Diversity indices of insect-pests of soybean

Higher values of Shannon- Winner index and Simpson index was found in mixed varietal treatments as compare to single varietal treatments. It indicates that mixed varietal treatments more diverse than single varietal treatments. Lower values of prey to predator were found in mixed varietal treatments as compared to single varietal treatments. Lower value indicates lower densities of insect-pests.

6.4.5 Development of forewarning model for insect incidence

Village level daily data was collected under the CROPSAP for twenty districts of Maharashtra. Data from 2010 to 2016 on insect incidence of tobacco caterpillar (egg-mass, gregarious larva, solitary larva), semi-looper, pod borer and girdle beetle along with district-wise daily data of weather variables (Max. Temperature, Min. Temperature, Relative Humidity and Rainfall) was collected and compiled for the analysis.

Correlation analysis between insect incidence and current week ($TMax_0$, $TMin_0$, RH_0, RF_0), first previous week ($TMax_1$, $TMin_1$, RH_1, RF_1) and second previous week ($TMax_2$, $TMin_2$, RH_2, RF_2) of weather variables was carried out using Aggregate/Pooled, Mean and Peak Week data (Table 18). In Pooled Correlation all observations of different years are pooled, week-wise mean of five years data is taken in Mean Correlation and peak incidence week value of five year mean of different districts is taken in the Peak Correlation. Mean Correlation Analysis is giving the best results. The observations considered for analysis are from first emergence week to their Peak Emergence Week

The favorable conditions in which the peak incidence of insects occurs in the soybean crop are shown in Table 19.

Table 18:Correlation analysis between insect incidence and weather variables

Insect	Peak week (smw)	Positive correlation variables	Negative correlation variables
Spodoptera litura (Egg mass)	33rd	$TMax_0$, $TMin_0$, RH_0, RF_0, $TMax_1$, $TMin_1$, RF_1, $TMax_2$, $TMin_2$, RF_2	RH_1 RH_2
Spodoptera litura (Gregarious larva)	35th	$TMin_0$, $TMin_1$, RF_1, $TMin_2$, RH_2, RF_2	$TMax_0$, RH_0, RF_0, $TMax_1$, RH_1, $TMax_2$
Spodoptera litura (Solitary larva)	36th	$TMax_0$, RH_2	$TMin_0$*, RH_0*, RF_0*, $TMin_0$*, RH_0*, RF_0*, $TMax_2$, $TMin_2$*, RF_2*
Gessonia gemma (Semi-looper)	36th	RF_0, $TMax_1$, $TMin_1$, RF_1, $TMax_2$*, $TMin_2$, RF_2	$TMax_0$, $TMin_0$, RH_0, RH_1*, RH_2*

Insect	Peak week (smw)	Positive correlation variables	Negative correlation variables
Helicoverpa armigera (Pod borer)	35th	$TMin_0$*, RF_0* $TMax_1$, $TMin_1$*, RF_1, $TMax_2$, $TMin_2$*, RF_2	$TMax_0$, RH_0, RH_1*, RH_2
Oberiopsis brevis (Girdle beetle)	36th	$TMax_0$, $TMin_0$, RH_0*, RF_0, $TMin_1$, RH_1*, RF_1, $TMin_2$, RH_2*, RF_2	$TMax_1$, $TMax_2$

(* - Variable Significant at 5%)

Table 19: Favorable conditions for peak incidence of insect *Spodoptera litura* in soybean

Insects / Weather Variable	*Spodoptera litura* (Egg mass)	*Spodoptera litura* (Gregarious larva)	*Spodoptera litura* (Solitary larva)
$TMax_2$	28.0 - 32.8	27.4 -31.7	27.3 - 32.5
$TMin_2$	20.4 - 23.7	20.5 -24.8	20.2 - 24.8
RH_2	84.2 - 91.2	86.0 -93.8	82.5 - 92.8
RF_2	26.5 - 92.9	26.0 -12.7	15.8 - 112.7
$TMax_1$	27.1 - 30.5	27.5 -31.7	26.6 - 31.9
$TMin_1$	20.4 - 23.7	20.5 -24.8	20.2 - 24.9
RH_1	84.9 - 92.4	86.0 -93.3	84.4 - 93.
RF_1	28.7 - 92.9	27.1 -109	15.0 - 112.7
$TMax_0$	27.1 - 30.5	27.3 -31.5	27.1 - 31.7
$TMin_0$	19.3 - 23.4	20.3 -25	21.0 - 25
RH_0	87.0 - 91.3	86.7 -93.6	86.0 - 93.8
RF_0	28.7 - 93	31.7 -102.2	25.6 - 125.3

Note : $TMax_2$, $TMax_1$, $TMax_0$ represents 2nd previous week, 1st previous week and current week respectively, and similarly for others.

7.0 CROP PRODUCTION TECHNOLOGIES

- **System efficiency enhancement through resource conservation technologies**
- **Effect of organic and inorganic management on productivity of soybean-based cropping systems**
- **Effect of reduced seed rate on seed yield in early and medium maturing varieties**
- **Nitrogen and sulphur use efficiency**
- **Development of AM fungi mass production technology**
- **Long-term impact of crop sequences and tillage practices on mycorrhizal biomass and soil quality parameters**

7.0 CROP PRODUCTION TECHNOLOGIES

7.1 System efficiency enhancement through conservation technologies

A long term field trial (initiated during 2009) was undertaken during 2017-18 involving 7 rotational tillage systems such as CR-CR-CR-CR (C-conventional tillage in *kharif* & R-reduced in *rabi*), CR-RR-CR-RR (RR-reduced tillage in both the *kharif* and *rabi* season), CR-RR-RR-CR, CR-RR-RR-RR, RR-RR-RR-RR, SRR (single reduced tillage) and SS (sub soiling) under different soybean-based cropping systems comprising of soybean-wheat, soybean-chickpea and soybean-mustard. The maximum soybean yield was recorded under conventional tillage once after two years (CR-RR-RR-CR) followed by sub soiling once in a four year and conventional tillage alternate year (CR-RR-CR-RR). The highest yield of *rabi* season crops (wheat, chickpea & mustard) were registered with CR-CR-CR-CR treatment. The maximum system efficiency in terms of soybean equivalent ratio (SEY) and economic viability was recorded under CR-RR-RR-CR treatment. The highest B: C ratio was found with SS and CR-RR-RR-CR compared to other treatments. Among the different cropping systems, soybean-wheat was found to be the most productive, remunerative and energy efficient.

7.2 Effect of organic and inorganic management on productivity of soybean based cropping systems

Three nutrient management systems, namely, 100% organic, 100% inorganic and integrated (50% organic & 50% inorganic) under soybean-wheat and soybean chickpea were evaluated under strip plot designs with 5 replications. The results of ten years study revealed that the soybean yield was ranged from 524 to 2251 kg/ha under soybean-wheat system and 479 to 2468 kg/ha under soybean-chickpea system. Soybean yield variability was more when soybean grown after chickpea compared to wheat. The soybean sustainability was higher when grown after wheat. Yield of wheat and chickpea varied from 2207 to 3550 and 362 to 2422 kg/ha over the years, respectively. Wheat yield showed less variation over the years with higher sustainability index. The total system productivity in terms of soybean equivalent yield (SEY) indicated that the soybean–wheat cropping system showed higher SEY, less yield variability over the years, more sustainable, stable, higher gross and net energy output as compared to soybean–chickpea. System productivity revealed that the soybean-wheat cropping system was found to be more productive and sustainable with less variability in productivity and stable performance under all the three management practices. Soybean–wheat system produced maximum energy output. The maximum energy efficiency and energy productivity with low energy intensiveness was recorded with integrated nutrient management system under both the cropping systems. The maximum net returns were noted with integrated and inorganic management systems under soybean –wheat and soybean –chickpea cropping systems. However, the maximum B:C ratio was with inorganic management system. The lower net returns and B:C ratio under organic and integrated management practices may be due to the higher cost of cultivation.

7.3 Effect of reduced seed rate on seed yield in early and medium maturing varieties

Effect of reduced seed rate was studied in two varieties JS 20-34 early maturing (<90 days) and NRC 86 medium maturity group (95-105 days) which were selected based on their difference in maturity days. The seed rate for 13.5 m^2 experimental plot (6 rows of 5 m length with 45 cm row spacing) was calculated as 40, 54, 68, 82 and 95 g for respective seed rate of 30, 40, 50, 60 and 70 kg/ha (Table 20). The initial shock to seedlings was due to lack of initial rainless days at early vegetative stage which caused reduction in plant height from optimum in all the treatment plots. The crop duration i.e. flowering and maturity period were not varied among the treatments in both the varieties. The plant population was significantly high with higher seed rate and yield was also significantly increased with increasing seed rate in both the varieties. The crop growth was affected and the yield was compensated due to increase in plant population. The germination of seeds was also highly affected and remained below 70%. The incidence of high rate of abnormality in seedlings indicates that either the seed were failed to develop fully or incidence of diseases caused seed death. The rainless days during 1st and 2nd week of August followed by heavy rain and succeeding dry spell caused incidence of diseases which damaged the seed crop. The air temperature during pod filling stage during 2nd week of September had negative impact on seed development thus caused reduced seed size.

Table 20: Yield and yield attributing characters in JS 20-34 and NRC 86 as influenced by reduced seed rate during *kharif* 2017

Variety	Treatment	50% flowering (Days)	Plant height (cm)	Plant population	Days to maturity	Yield (q/ha)	100-seed weight (g)
JS 20-34	T1 (30 kg/ha)	32	41.01	230	88	4.09	9.212
	T2 (40 kg/ha)	32	42.54	303	90	4.91	9.263
	T3 (50 kg/ha)	32	43.22	361	90	5.64	9.453
	T4 (60 kg/ha)	33	44.21	438	92	7.78	9.519
	T5 (70 kg/ha)	33	48.25	497	92	8.15	9.810
	Average	32.40	43.84	365.93	90.40	6.11	9.45
	CD at 5%	-	1.659	56.16	-	0.806	0.857
NRC 86	T1 (30 kg/ha)	43	52.89	238.7	104	3.323	7.830
	T2 (40 kg/ha)	43	54.88	280.0	105	3.783	7.781
	T3 (50 kg/ha)	44	55.75	345.3	104	3.802	7.752
	T4 (60 kg/ha)	44	57.03	451.3	106	4.677	8.281
	T5 (70 kg/ha)	45	63.24	529.7	107	5.630	8.436
	Average	43.80	56.76	369.00	105.20	4.24	8.02
	CD at 5%	-	1.177	51.51	-	0.549	0.707

7.4 Nitrogen and sulphur use efficiency

A field experiment was conducted during *kharif* 2017 to evaluate different levels and methods of nitrogen and sulphur application on mobilization, uptake use efficiency and productivity of soybean. In this context, the experiment comprised of 14 treatments such as basal application of N (25 and 50 kg/ha), sulphur (20 and 50 kg/ha) and split application of N (12.5, basal + 12.5 at R_2 stage, 25 + 25 kg/ha) and S (12.5, basal + 12.5 at R_2 stage, 25 + 25 kg/ha) in combination with N and S. The results revealed that highest plant height was observed with split application of N25 + 25 and S25 + 25 and did not significantly vary with basal application of N50 and split application of N and S (N25 + S50) and N25 + 25. The data on pods/plant revealed that highest pod yield was obtained with application of split application of N and S (N25 + S50) and did not significantly vary with treatments comprising of basal application of N (N50), split application of N and S (N25 + 25, S12.5 + 12.5, and N25+25, S25 + 25). Highest seed yield was obtained with the split application of N and S (N25 + 25, S25 + 25) and did not significantly vary with treatment N25 + S50, basal application of N50 and split application at the rate of N25 + 25, S12.5 + 12.5 (Table 21).

Highest N content in seed was recorded with the split application of N and S (N25 + 25, S25 + 25) and did not significantly vary with basal application of N50. Highest sulphur content in seed was observed with application of N25 + 25, S25 + 25 (Table 22). Available N was significantly influenced with split application of N and S N25 + 25, S25 + 25, and did not significantly vary with basal application of N and split application of N and S. In the case of available S content, split application of N25 + 25, S25 + 25 recorded higher soil available S and did not significantly vary with basal application of N and S (N25 + S50), basal application of S (S50) and split application of N and S (N 12.5 + 12.5, S 25 + 25) (Table 23).

Table 21: Effect of different levels and methods of application of nitrogen & sulphur on soybean yield and its attributes

Treatment	Plant height (cm)	Pods/plant	Seed yield (kg/ha)
Control	55	70	1892
N25	66	86	2098
N50	70	89	2461
N25 + 25	68	83	2303
N12.5 + 12.5	61	76	2031
S25	58	75	1951
S50	61	78	2091
S12.5 + 12.5	56	70	1949
S25 + 25	62	78	2035
N25 + 25, S12.5 + 12.5	69	89	2335
N12.5 + 12.5, S12.5 + 12.5	64	80	2134
N12.5 + 12.5, S25 + 25	65	82	2303
N25 + 25, S25 + 25	72	97	2506
N25 + S50	69	91	2437
LSD *(p=0.05)*	5	9	175

Table 22: Effect of different levels and methods of application on nitrogen and sulphur content in seed (%)

Treatment	N content	S content
Control	5.86	0.13
N25	6.02	0.15
N50	6.11	0.16
N25 + 25	6.09	0.15
N12.5 + 12.5	6.03	0.14
S25	5.95	0.17
S50	5.98	0.18
S12.5 + 12.5	5.92	0.16
S25 + 25	5.97	0.17
N25 + 25, S12.5 + 12.5	6.12	0.17
N12.5 + 12.5, S12.5 + 12.5	6.07	0.16
N12.5 + 12.5, S25 + 25	6.02	0.17
N25 + 25, S25 + 25	6.17	0.19
N25 + S50	6.09	0.18
LSD *(P=0.05)*	0.07	0.02

Table 23: Effect of different levels and methods of application of nitrogen & sulphur on soil available nitrogen and sulphur status

Treatment	Available N content (ppm)	Available S content(ppm)
Control	219	2.71
N25	261	2.87
N50	275	3.03
N25 + 25	275	2.93
N12.5 + 12.5	243	2.71
S25	247	3.10
S50	252	3.20
S12.5 + 12.5	243	3.02

Treatment	Available N content (ppm)	Available S content(ppm)
S25 + 25	252	3.12
N25 + 25, S12.5 + 12.5	271	3.09
N12.5 + 12.5, S12.5 + 12.5	257	2.95
N12.5 + 12.5, S25 + 25	271	3.14
N25 + 25, S25 + 25	303	3.26
N25 + S50	289	3.19
LSD (p=0.05)	42	0.13

Table 24: Effect of cropping systems, crop establishment's method/land configuration and residue management practices on yields of soybean

Treatment	Pods/plant (Nos.)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)
Cropping systems				
Soybean–wheat	39	2191	2543	4733
Soybean–maize	39	2162	2611	4774
Soybean–chickpea	39	2015	2696	4711
SEm±	1.79	80.09	99.53	72.30
CD *(P=0.05)*	7.01	314.41	390.74	283.83
Crop establishments method/ Land configuration				
PBBF + R	43	2317	2547	4864
PBBF + WR	42	2259	2514	4774
CTFP + R	36	1963	2695	4658
CTFP + WR	34	1950	2712	4662
SEm±	1.04	55.52	62.39	78.87
CD *(P=0.05)*	3.58	192.11	215.87	272.87

PBBF= Permanent broad bed furrow; CTFP= Conventional tillage as per farmers practices; R= Residues; WR= without residues

Residues retentions:-

(a) 50% soybean residues retaining;
(b) 30% wheat residues retaining;
(c) 30% maize residues retaining;
(d) 50% chickpea residues retaining

A perusal of data (Table 24) revealed that number of pods/plant, grain, straw and biological yield were did not vary significantly among the different cropping systems. However, crop establishment methods/land configurations were significantly influenced the pods/plant and grain yield. Significantly the highest pods/plant and grain yield of soybean were observed under permanent broad bed furrow as compared to crop sown under conventional tillage as per farmers practices.

7.5.1 Mass production of AMF in substrates amended with soybean hulls and vermicompost

- Besides conventional microscopic methods being used for examining the production of AMF, the use of signature fatty acids i.e., 16; 1ω5c ester linked fatty acids (ELFA), phospholipid fatty acid (PLFA) and neutral lipid fatty acid (NLFA) as analytical biochemical method is now gaining importance for quantifying the live biomass of AMF and provides an edge over conventional methods.16:1ω5c PLFA represent the hyphal biomass and 16;1ω5c NLFA represents the spores of AMF. The heat stable AMF glycoprotein glomalin has also been linked to AMF biomass in soil.
- In the study, both the trap plants, i.e., sorghum and amaranthus maintained higher AMF biomass in terms of spore density, colonization and 16;1ω5c signature fatty acids i.e., PLFA, NLFA and ELFA and glomalin content when grown on a combination of hulls, vermicompost and sand-soil mix (Fig. 18). However, sorghum maintained significantly higher AMF biomass in soil i.e., 16.37 nmoles NLFA/g soil, 3.84 nmoles PLFA /g soil and 16.28 nmoles ELFA /g soil, ELFA of roots 24.04 nmoles/ g roots. Particularly in sorghum a significant positive correlation was obtained between PLFA and AMF root colonization (r=0.82); NLFA and spore density (r=0.83), ELFA and spore density (r=0.72), ELFA root and AMF root colonization (r=0.86), NLFA and glomalin (0.70). Overall sorghum was found to be a better host than amaranthus. Among the different substrate combinations, the combination of soil-sand mix amended with soybean hulls and vermi-compost was found to be the most optimum substrate sustaining higher production of AMF. Therefore, based on quantification of 16;1ω5c AM signature fatty acids, glomalin and conventional microscopic methods used for assessing the AMF biomass in the current study, the soybean processing mill waste and vermi-compost amended with sand-soil mix can be used as potential substrates for mass production of AMF using sorghum as trap plant.

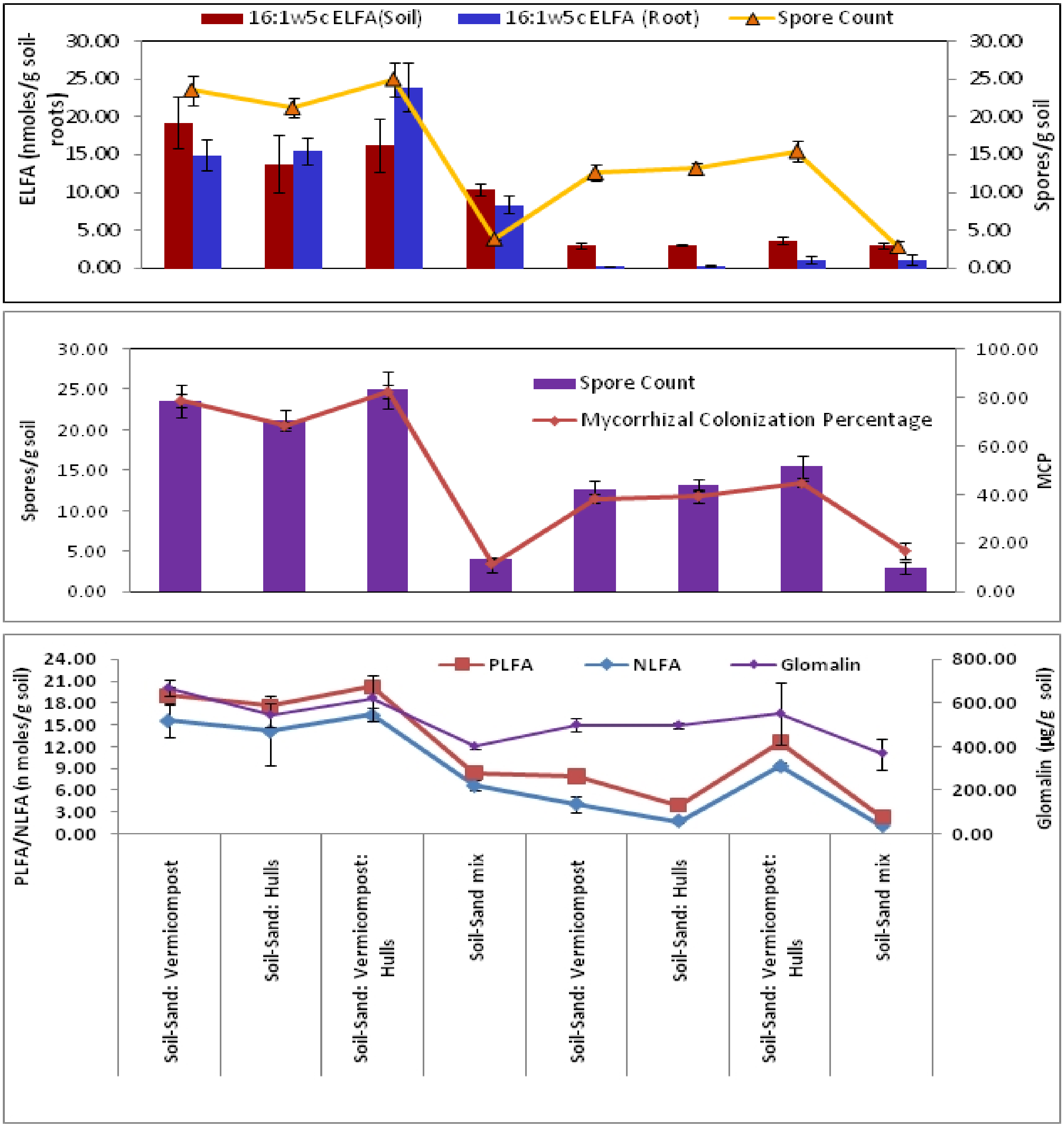


Fig. 18: 16:1ω5c Ester linked fatty acid content (ELFA), PLFA and NLFA in soil/root, AMF spore count in soil and root colonization (MCP) of sorghum and *Amaranthus* grown in different combinations of soybean mill processing mill waste (hulls) and vermicompost

7.6 Assessing the long-term impact of crop sequences and tillage practices on mycorrhizal biomass and soil quality parameters

Study involved the impact of agricultural management practices on AMF signature fatty acids, soil health and microbial communities from a long-term agronomic trial conducted at IISR Indore. The samples consisted from 3 cropping sequences (chickpea, mustard and wheat in rotation with soybean during *kharif*), managed with 7 tillage systems i.e., sub-soiling (SS), single cultivation (SR), reduced-reduced (RR), conventional reduced (CR) in the following sequence for four years SS, SR, RR-RR-RR-RR, CR-RR-RR-CR, CR-RR-RR-CR, CR-RR-CR-RR, CR-CR-CR-CR allocated in a completely randomized block design. The sampling was carried out from rhizosphere of wheat-at stem elongation stage; panicle initiation stage, chickpea-at reproductive growth stage and mustard at flowering stage during *rabi,* 2017.

Table 25: Relationship (r values) of glomalin, root colonization and spore density with AMF signature fatty acid biomarkers (16:1ω5c Ester linked fatty acid content (ELFA), phospholipid fatty acid (PLFA) and neutral lipid fatty acid (NLFA) assessed in host plants (*Amaranthus* and sorghum) grown in different combinations of soybean mill processing waste (hulls) and vermicompost

Parameter	Sorghum			*Amaranthus*		
	Spore density	AMF root colonization	Glomalin	Spore density	AMF root colonization	Glomalin
ELFA soil	0.72	-	0.70	0.41	-	0.53
ELFA root	-	0.86	-	-	-0.23	-
PLFA soil	0.81	0.82	0.63	0.13	0.15	0.30
NLFA soil	0.83	0.82	0.70	0.66	0.69	0.54

- The results revealed that among cropping sequences soybean-chickpea maintained significantly higher microbial biomass carbon (257.26 mg C kg/soil) and AMF biomass in terms of PLFA (2.08 nanomoles g/soil) and NLFA (33.617 nanomoles g/soil) over soybean-wheat and soybean-mustard (Table 25).
- The activity of the β-glucosidase enzyme

differed non-significantly among the treatments but higher values were observed in the plots of soybean-wheat and soybean-chickpea.

- Among different tillage systems, plots managed with reduced tillage for four years showed significantly higher microbial biomass carbon (262.54 mg C kg/soil) and β-glucosidase activity (Fig. 19).

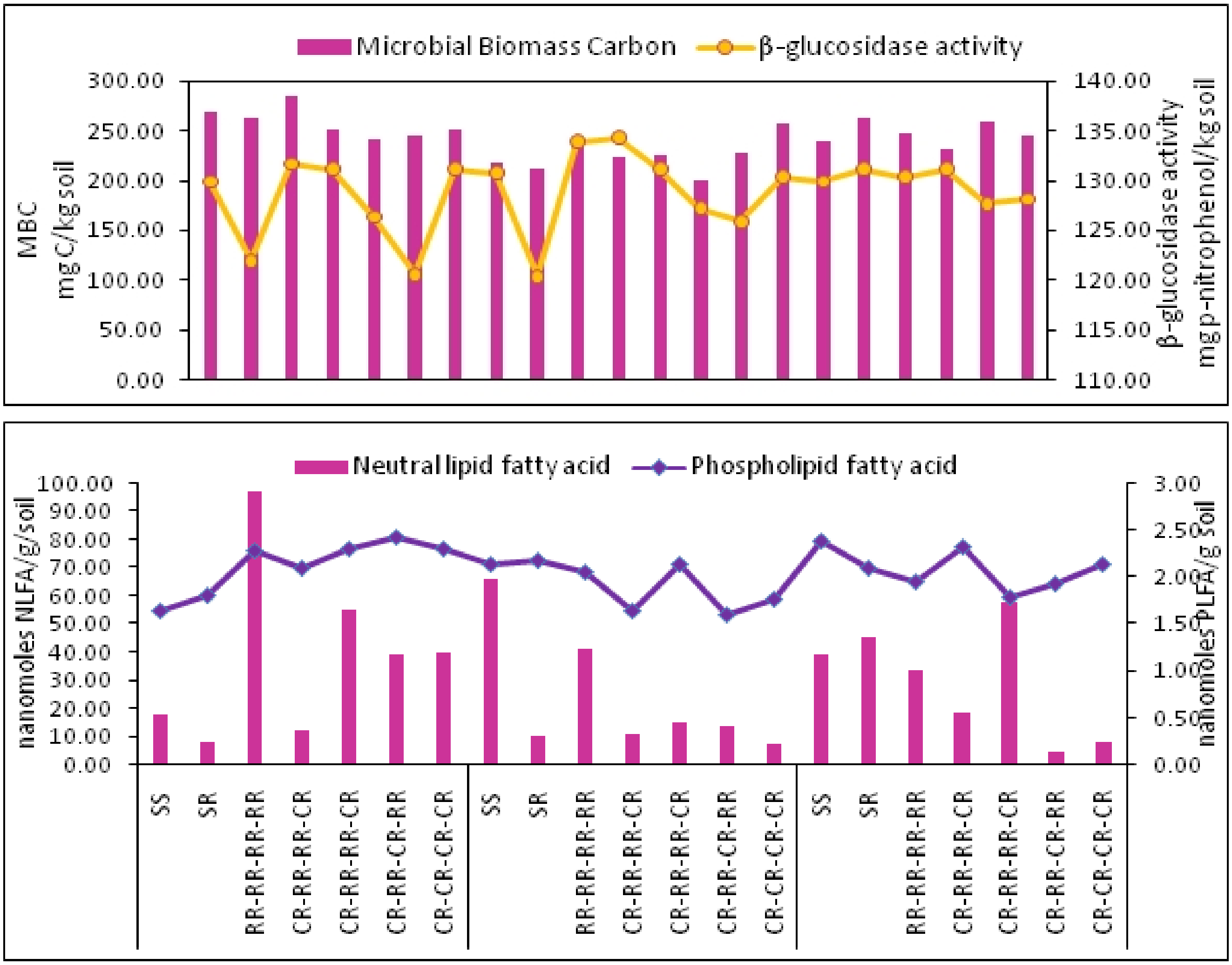


Fig. 19: Influence of different cropping sequences and tillage systems on microbial biomass carbon and β-glucosidase activity and AM signature fatty acids 16:1ω5c, PLFA and NLFA in rhizospheresoil of different systems. Data are average of 3 replications; LSD, least significance difference at 5% level of significance by Duncan's multiple range test of ANOVA

In the plots managed with reduced tillage the content of PLFA and NLFA 16:1ω5 were found to be the highest i.e., 2.09 nanomoles g/soil and 53.69 nanomoles g/soil respectively. A shift in PLFA microbial communities was also observed.

8.0 SOCIAL SCIENCES & TECHNOLOGY TRANSFER

- **Determinants of farm yield variability and technical efficiency**
- **Development of mobile app for farmer's**
- **Soybean market monitor**
- **Technology transfer**
- **Mera gaon mera gaurav**
- **Frontline demonstrations**
- **Advisory for soybean farmer's**
- **Organisation of training programme**

8.0 SOCIAL SCIENCES & TECHNOLOGY TRANSFER

8.1 Determinants of farm yield variability and technical efficiency of soybean

The factors determining farm yield variability of soybean such as crop management, soil quality, socio-economic and other factors were studied using primary data collected from farmers of selected districts of Madhya Pradesh. The data analysis revealed that the average yields of farmers was 15.32 q/ha and varied from 5 to 28 q/ha (Fig.20).

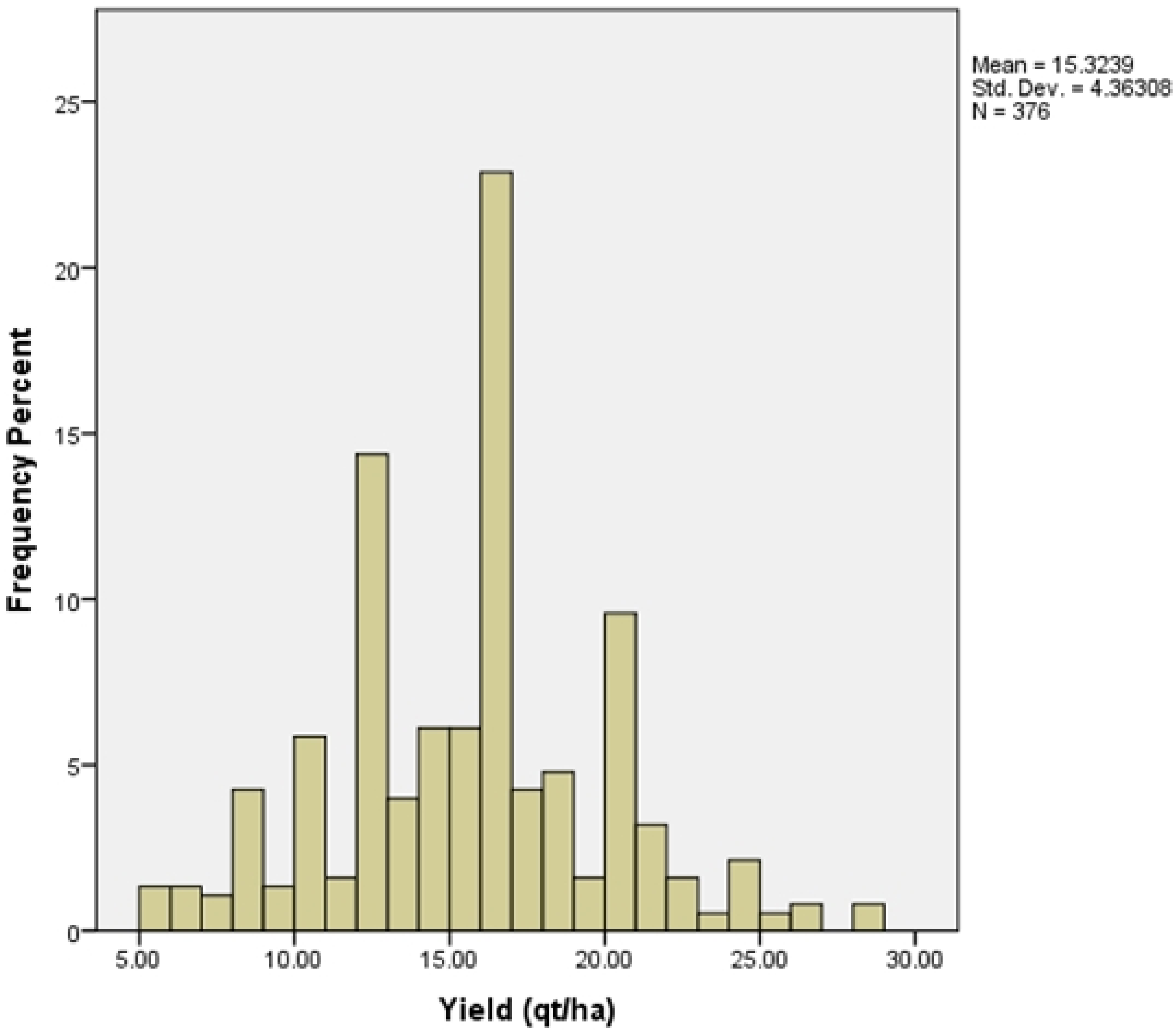


Fig. 20: Histogram of soybean yield realized by selected farmers

Classification and regression tree (CART) was used to identify the main factors controlling yield variability and categorised into relatively homogenous groups. Results indicated that farmers with higher yield follow recommended production practices, procures seed from government/ cooperative sources and were in regular contact with extension agencies. Farmers followed optimum plant population and purchased seed from government or cooperative realized that higher average yield of soybean (20.08 qt/ha). Further application of required dose of potash yielded 21.7 qt/ha of soybean yield. Similarly, farmers followed with seed treatment, deep summer ploughing and haven't resorted to re-sowing reaped higher yield of 18.03 qt/ha. Farmers who have applied sulphur along with seed treatment, deep summer ploughing and no resowingof the crop achieved the higher average soybean yield (19.56 qt/ha).

The technical efficiency index was worked out using stochastic frontier model which indicated that technical efficiency of soybean farmers ranged from 31 to 96%, with an average of 72%, implying that the soybean output of the 'average farmer' could be increased by 28% by adopting the recommended technology followed by the 'best practice' farmers. A positive correlation was found between technical efficiency index and soybean yield meaning as the technical efficiency index increases, the yield realisation of soybean also increased (Fig. 21).

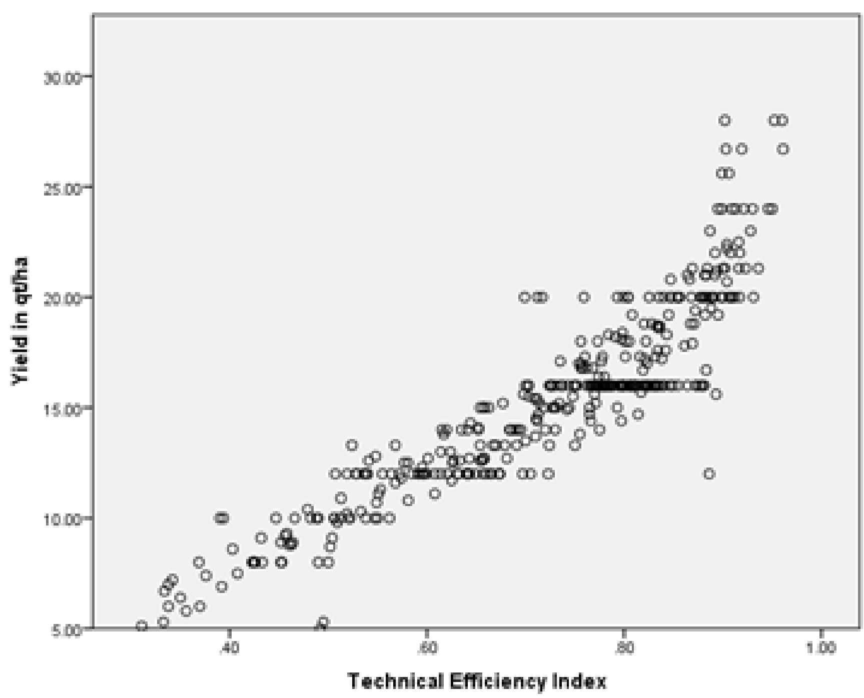


Fig. 21: Technical efficiency index and soybean yield

8.2 Soybean Market Monitor

ICAR-IISR started a quarterly publication covering soybean production scenario in India and world, domestic and international price movements of soybean and products, import and export of soybean and products from India. Soybean market monitor can be accessed through below website.

- **September 2017** (https://iisrindore.icar.gov.in/pdfdoc/soybeanmonitorsep2017.pdf)
- **Oct-Dec. 2017** (https://iisrindore.icar.gov.in/pdfdoc/SoybeanMonitorDec2017.pdf)
- **Jan-Mar. 2018** (https://iisrindore.icar.gov.in/pdfdoc/SoybeanMonitorMarch2018.pdf)

8.3 Development of Mobile App for Farmer's

Soybean Gyan- A Mobile App for Soybean Farmers is developed by ICAR-Indian Institute of Soybean Research, Indore (Fig. 22). The information available in different literatures in the institute is compiled at one place in the form of a Mobile App. It includes information about different aspects viz agronomic practices, production technology, crop management, insect management, disease management, weeds management, food uses and health benefits and farm machinery. It also provides expert's recommendations about farm preparation, suitable selection of promising soybean varieties, seed treatment, fertilizer doses, sowing, seed-rate, harvesting, seed storage etc (Fig. 23). The App is regularly updated with new scientific recommendations generated by the Institute under different research programs. The App is linked to the Web-based Farmer Advisory System developed at the Institute. Therefore, it also provides the facility to the soybean farmers to submit their queries alogwith photos about the problems faced by them in real field conditions. The solutions are then sent through SMS generated by the system by domain experts of the institute.It has been published at Google play store. It is freely available for user to download. The link of the application is:

https://play.google.com/store/apps/details?id=com.icar.soyainfo&hl=en.

Fig. 22: Main screen of Soybean Gyan Mobile App

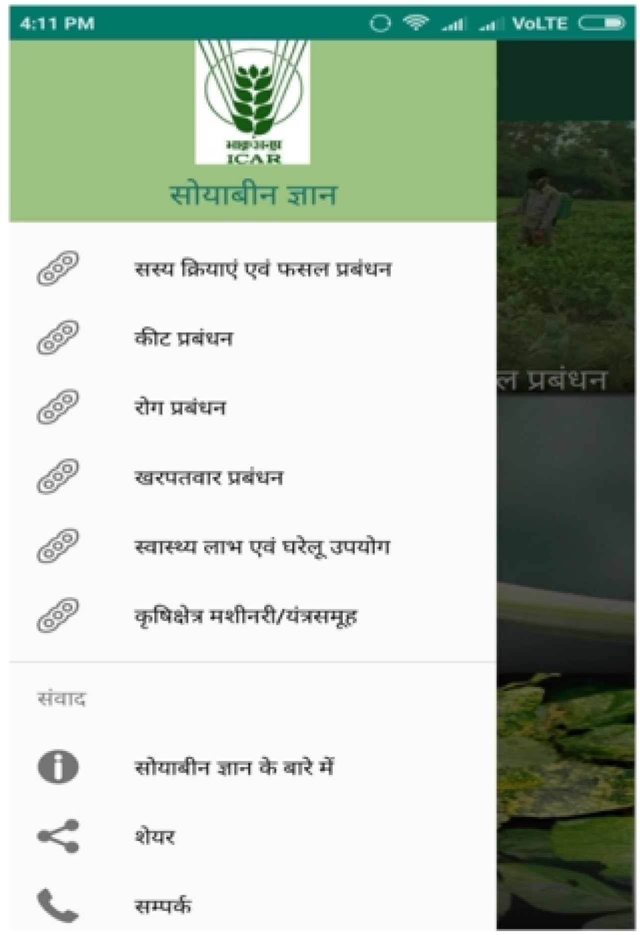


Fig. 23: Screen showing direct menu options of Soybean Gyan

8.4 TECHNOLOGY TRANSFER

8.4.1 Organization of National Soybean Mela

The institute organized National Soybean Mela on 11th December, 2017 with participation of more than 850 progressive farmers from major soybean growing states like Madhya Pradesh, Maharashtra, Rajasthan and

Gujarat. The event was sponsored by the Department of Agriculture & Cooperation, Ministry of Agriculture and Farmers Welfare, Government of India. About 40 exhibition stalls comprising ICAR/SAU/KVK/Private companies associated with soybean R&D exhibited their technologies and products during this Mela. Further five progressive farmers viz. Shri Ramavtar Meena (Rajasthan), Mrs. Manjulabehan Chauhan (Gujarat) Shri Laxmansingh Mandloi, Shri Devraj Patidar and Shri Farukh Sheikh (Madhya Pradesh) who accomplished record soybean yield during the year were felicitated during the event.

Organization of "National Soybean Mela" and 31st Foundation day of ICAR-IISR on 11th December 2017

Release of IISR publication on success stories of soybean growers during the foundation day and National Soybean Mela organized at ICAR-IISR

Participation of farmers in Soybean Mela

Launch of institute mobile app "Soybean-Gyan Samadhan)

8.4.2 Participation in Agricultural Exhibitions

The Institute has actively participated in following agricultural exhibitions during the year.

Dates	Event	Organized by	Venue
7-9th May, 2017	Krishi Mela	Deptt of Agriculture, Indore	College of Agriculture, Indore
29th August 2017	Krishi Mela	KVK, Indore	KVK, Indore
23rd September 2017	Krishi Mela	College of Agriculture, Indore	College of Agriculture, Indore
16-18th March 2018	Krishi Unnati Mela	Indian Agricultural Research Institute, New Delhi	Indian Agricultural Research Institute, New Delhi

Exhibition stall of ICAR-IISR at College of Agriculture, Indore

ICAR-IISR Exhibition stall during Krishi Unnati Mela organized at ICAR-IARI, New Delhi

Exhibition stall of ICAR-IISR at Wheat Research Station, Indore

8.4.3 Mera Gaon Mera Gaurav

The programme is being implemented in 25 villages of Indore districts in which five multi-disciplinary team of scientists are maintaining close contact with farmers. During *kharif* 2017, a total of 50 frontline demonstrations on improved soybean production technology have been laid out in the selected villages. Beside soybean production tecnniques, the scientists are facilitating information flow of other agricultural commodities and the agricultural/developmental schemes launched by Government of India for the overall development of rural masses.

Glimpse of ICAR-IISR scientists visits to Farmer's fields under the MGMG programme

8.4.4 Frontline demonstrations

During 2017-18, a total 50 frontline demonstrations were conducted in 14 villages (Arjun Baroda, Silotia, Borkhedi, Navda, Harsola, Sater, Gujarkheda, Memdi, Ambachandan, Bhagora, Chordia, Fulkaradia, Jambudihapsi and Budania). The new released varieties JS 20-29 and JS 20-34 were demonstrated with improved soybean production technologies. The adaptation of improved soybean production technologies enhanced the soybean yield by 21.7% with the extra expenditure of ₹ 1400/ha and increased the net returns to the tune of 35.4% as compared to farmer's practice.

8.4.5 Advisory for Soybean Farmers

During *kharif* 2017, the institute has issued weekly advisories containing specific information regarding agronomic practices to be followed by soybean growers as well as measures for control of insect-pest and diseases were sent through email, websites, mobile phones, television, radio and also via officers of Department of Agriculture and SAUs of major soybean growing states of Madhya Pradesh, Rajasthan, Maharashtra, Karnataka and Telangana. Further, the advisories on specific topic were sent through mKisan Portal to more than 3 lakh soybean farmer's.

8.5 TRAININGS

8.5.1 Organization of short term 10 days training program

ICAR sponsered CAFT training for duration of ten days on "Conventional and Molecular Breeding Approaches for Increasing Soybean Productivity under Changing Climatic Situations in India" was organized during 16th – 25th January, 2018. Total of eighteen soybean breeders from different states participated in the programme. The training has been designed for soybean workers for providing them the knowledge on recent genetic advances in soybean including molecular and conventional breeding. Dr. S. P. Tiwari Ex-Director, ICAR-IISR and Ex-DDG (Education and Crop Science, ICAR) was the chief guest of the function and inaugurated the training programme.

Director, IISR, Dr. V.S. Bhatia welcoming the chief guest

Interaction of Dr. S.P Tiwari, with training participants

8.5.1 Model Training Course (MTC)

The institute has successfully organized a model training course on "Technologies and Approaches for Management of Biotic & Abiotic Stresses in Soybean Production" during September 5-12, 2017 with the participation of 25 officers belonging to state agriculture department of seven states. The course was sponsored by the Directorate of Extension, Ministry of Agriculture and Farmer's Welfare, Govt . of India.

8.5.2 Trainers' Training Programmes

The institute organized trainers' training programme on "Good Agricultural Practices for Soybean" on 1st June 2017 for 31 field level officers of Madhya Pradesh, Rajasthan and Chhatisgarh.

8.5.3 Farmer's Training Programmes

During this year, 73 Farmers' Training Programmes of one day duration were organized with the cumulative participation of 2667 farmers belonging to the states of Madhya Pradesh, Rajasthan, and Maharashtra. All the recommended package of practices including agronomic, moisture conservation techniques, integrated approach for managing weeds, insect pests, diseases and processing aspects of value added soy products were covered in these training programmes.

Women's Training Programme on Processing and Utilization of Soybean: Twenty four training programmes on "Processing and Utilization of Soybean for Food Uses at household level" were organized with the participation of 881 women belonging from Madhya Pradesh and Rajasthan.

Trainers Training to Field officers of Solidaridad

One day Farmers Training Programme on Improved Soybean Production Technology

Model Training Course on "Strategies for increasing soybean productivity through integrated approaches" organized at ICAR-IISR during September, 7-14, 2017

One day training programme on "Processing and Utilization of Soybean for Food Uses" for rural women

9.0 XLVIII ANNUAL GROUP MEETING OF AICRP ON SOYBEAN

Highlights of 48th Annual Group Meet of All India Coordinated Research Project on Soybean

The 48th Annual Group Meet of All India Coordinated Research Project on Soybean was organized jointly by Indira Gandhi Agricultural University, Raipur and ICAR-Indian Institute of Soybean Research, Indore during March 15-17, 2018. Chief Guest of the inaugural session Dr. S. K. Patil, H'ble Vice Chancellor, IGKU, Raipur expressed concerned over reduction in area, production and productivity of soybean in the country in last few years. He stressed upon developing new high yielding varieties and making them available to the farmers. He emphasized on identification of new niches for soybean cultivation in Chhattisgarh. For increasing the varietal diversity, he asked the scientists to explore the possibilities in mutation breeding. He also expressed the necessity of increasing farm mechanization.

As the special guest, Dr. D. K. Yadava, Assistant Director General (Seed), ICAR, New Delhi mentioned that soybean production is being done in the country in a big way, mainly because of extensive research work under the All India Coordinated Research Project on Soybean. He emphasized that the centers with specific specialization and expertise should be mandated to concentrate in those areas only. He asked all the centers to publish success stories based on technologies developed by them.

Presiding over the function, Dr. V. S. Bhatia, Director, ICAR-Indian Institute of Soybean Research, Indore gave a detailed overview of AICRP on Soybean and appealed to the scientists to develop varieties suitable under delayed sowing, moisture stress, excess rains and high temperature besides high yield potential.

The Annual Group Meet was attended by over one hundred Scientists working under AICRP on Soybean, representatives of Agri-input manufacturers, seed organizations, processing organizations etc.

During the AGM, the Varietal Identification Committee screened the identification proposals and identified total 9 varieties for different agro-climatic zones: JS 20-94, JS 20-116, RVS 2007-6, RSC 10-46, NRC 127 for Central Zone, JS 20-116 for Eastern Zone, RSC 10-46 , JS 20-116 for North Eastern Hill Zone, VL Soya 89 for North Hill Zone and PS 1572, SL 1028 and SL 1074 for Northern Plain Zone.

Inaguration of Annual Group Meeting on Soybean at IGKV, Raipur

10.0 BREEDER SEED PRODUCTION

10.1 Soybean Breeder Seed Production

The indent of soybean breeder seed for *kharif* 2018, to be produced in 2017 was 21950.50 q. The indent comprised of 34 varieties. 65% of the indent were given for five major varieties namely JS 95-60 (14.8%), JS 93-05 (13.8%), JS 335 (12.8%), JS 20-29 (11.9%) and JS 20-34 (11.2%). The largest indent was 3258q for JS 95-60 comprising of 14.8% of total indent. The details of indent, target and seed produced is presented in Table 26.

Table: 26 The variety wise breeder seed indent, target and production during *kharif* 2017

Sl. No.	Variety	DAC Indent (q)	Target (q)	Production (q)
1.	JS 335	2808	3450	2195
2.	JS 93-05	3024	2900	1315
3.	JS 95-60	3258	3070	1095
4.	JS 97-52	590	610	66.8
5.	JS 20-29	2612	3290	509
6.	JS 20-34	2459	915	523.7
7.	JS 20-69	600	1000	354
8.	NRC 86	223.5	225	38
9.	NRC 7	20	20	2
10.	NRC 37	40	40	1.6
11.	RVS 2001-4	951	1000	740
12.	MAUS 71	651	660	790
13.	MAUS 158	663	665	617
14.	MAUS 162	650	650	276
15.	Pratap Soya 2	0.50	1	0
16.	Pratap Soya-45	510	510	97
17.	RKS 24	320	320	290
18.	CG Soya 1	20	20	9.80
19.	MACS 1188	224	225	225
20.	Phule Kalyani	349	350	350
21.	Phule Agrani	377	380	380
22.	DSb 21	624.5	625	300
23.	DSb 1	10	10	0
24.	Pant Soya 1042	0.6	1	0.5
25.	Pant Soya 1225	23	23	42
26.	Pant Soya 1347	12	12	16
27.	SL 958	0.35	1	4
28.	VLS 65	6	6	5.5
29.	VLS 63	4	4	4
30.	Hara Soya	2	2	2
31.	MAUS 612	8	200	272
	Total	21950.5	20985	10609.9

Breeder seed production field *kharif* 2017

११. राजभाषा–कार्यन्वयन

संस्थान में अप्रैल 2017 से मार्च 2018 के दौरान राजभाषा–कार्यान्वयन संबंधी विभिन्न गतिविधियाँ

राजभाषा विभाग, गृह मंत्रालय, भारत सरकार के दिशा–निर्देश के अनुसार भा. कृ. अनु. प. – भारतीय सोयाबीन अनुसंधान संस्थान, इंदौर में भी इस दिशा में राजभाषा के प्रसार–प्रचार हेतु अनेकानेक कार्यक्रम किए जा रहे हैं। जिनके फलस्वरूप भारतीय सोयाबीन अनुसंधान संस्थान में राजभाषा कार्यान्वयन के क्षेत्र में उत्तरोत्तर प्रगति के साथ अनेक आधारभूत कार्य हुए हैं, जो राजभाषा के प्रगामी प्रयोग में अत्यंत सार्थक सिद्ध हो रहे हैं। इस क्षेत्र में किए जा रहे क्रियाकलापों का संक्षिप्त विवरण निम्नवत् हैं।

क) हिन्दी कार्यशालाएं : इस दिशा में संस्थान में हिन्दीमय वातावरण विनिर्मित करने हेतु प्रत्येक तिमाही में कम से कम एक हिन्दी कार्यशाला का आयोजन किया जा रहा है। जिसमें संस्थान के सभी सवंर्गों को आमंत्रित किया जाता है तथा संबंधित विषयानुसार कार्यशालाएं सम्पन्न की जाती है । अप्रैल–मार्च 2018 में अब तक 04 कार्यशालाओं का आयोजन किया गया, जिसकी सूची निम्नानुसार है :

क्र.	दिनांक	विषय	अतिथि वक्ता
1.	07 जून, 2017	हिन्दी भाषाः स्तरीय स्वरूप एवं आवश्यकता	डॉ. शोभा चतुर्वेदी सहायक प्राध्यापक हिन्दी, शासकीय निर्भय सिंह पटेल विज्ञान महाविद्यालय, इन्दौर ।
2.	04 सितम्बर, 2017	राजभाषा के प्रति समर्पण और विकास के आयाम	डॉ. जयश्री बंसल, प्राध्यापक हिन्दी, देवी अहिल्या विश्वविद्यालय, इन्दौर
3.	07 दिसम्बर, 2017	कार्यालय में हिन्दी का प्रयोग – समस्या और समाधान	डॉ. पद्मा सिंह पूर्व प्राचार्य एवं विभागाध्यक्ष – तुलनात्मक भाषा अध्ययन शाला, देवी अहिल्या विश्वविद्यालय, इन्दौर ।
4.	03 मार्च, 2018	व्यक्तित्व के विकास में भाषा की भूमिका	श्री हरेराम बाजपेयी प्रबंध संपादक–वीणा, इन्दौर ।

ख) प्रशिक्षणः संस्थान में राजभाषा के प्रचार–प्रसार हेतु कृषको एवं प्रशिक्षणार्थियों को प्रशिक्षण संबंधित सारी सामग्रियाँ हिन्दी में भी प्रदान की जा रही है । इस दृष्टिकोण से 2017–18 के दौरान प्रचार–प्रसार हेतु निम्न सामग्री तैयार की गई ।

- विस्तार बुलेटिन – 13,000
- फोल्डर्स – 10,000
- कैलेण्डर – 5,000
- पम्प्लेट्स – 500
- सफलता की गाथाऐं – 500
- वीडियो फिल्म – 1

ग) राजभाषा नीति पर जागरूकता कार्यक्रमः उक्त प्रशिक्षणों के अतिरिक्त संस्थान में कर्मचारियों, अधिकारियों एवं वैज्ञानिको हेतु राजभाषा नीति के संवैधानिक प्रावधानों से अवगत कराने तथा इसके प्रति जागरूक करने हेतु समय–समय पर राजभाषा नीति विषय पर विचारों का आदान–प्रदान किया जा रहा है ।

घ) अनुवाद द्विभाषी प्रपत्रः संस्थान में कार्यालयीन कार्य में प्रयुक्त होने वाले विभिन्न पत्रों, प्रपत्रों आदि का अनुवाद कार्य भी प्रगति पर है, जिससे दैनिंदिन के साथ ही प्रायः प्रयुक्त होने वाले सभी पत्रों, प्रपत्रों के द्विभाषी मुद्रित रूप को प्रभावी किया जा सके। यह कार्य राजभाषा क्रियान्वयन की दिशा में स्थाई एवं आधारभूत उपलब्धि है।

ङ) मौलिक लेखन कार्य का प्रादुर्भावः संस्थान में राजभाषा संबंधी विभिन्न क्रियाकलापों के साथ मौलिक लेखन कार्य को द्रुतगामी आयाम प्रदान करने में अधिकारियों एवं कर्मचारियों की रूचि अद्वितीय है ।

च) शब्दकोश में वृद्धिः संस्थान में प्रतिदिन एक शब्द हिन्दी एवं अंग्रेजी को द्विभाषी रूप में "आज का शब्द" के रूप में प्रदर्शित किया जा रहा है, ताकि कर्मचारियों, अधिकारियों एवं वैज्ञानिकों के हिन्दी शब्द ज्ञान में वृद्धि करने के साथ ही साथ कार्यालयीन उपयोग में भी सहायता प्राप्त हो सके ।

छ) राजभाषा कार्यान्वयन समिति की तिमाही बैठक

- प्रथम बैठक : दिनांक 06 अप्रैल, 2017
- द्वितीय बैठक : दिनांक 07 जुलाई, 2017
- तृतीय बैठक : दिनांक 06 अक्टूबर, 2017
- चतुर्थ बैठक : दिनांक 08जनवरी, 2018

ज) क्षेत्रीय कार्यान्वयन कार्यालय (मध्य) द्वारा निरीक्षण : दिनांक 30 जुलाई 2017 को क्षेत्रीय कार्यान्वयन कार्यालय (मध्य) भोपाल द्वारा संस्थान में राजभाषा कार्यान्वयन संबंधी कार्यों का निरीक्षण किया गया ।

झ) प्रोत्साहन योजनाएं : संस्थान में सर्वप्रथम राजभाषा संबंधित गतिविधियों के प्रसार–प्रचार हेतु प्रोत्साहन योजनाओ पर ध्यानाकर्षित किया गया । चूँकि यह "क" स्थित क्षेत्र है फिर भी कर्मचारियों, अधिकारियों एवं वैज्ञानिको में हिन्दी के प्रति रूचि में वृद्धि करने हेतु समयानुसार प्रोत्साहन योजनाओं का आयोजन किया जाता है, ताकि सभी संवर्गो को हिन्दी में कार्य करने हेतु प्रेरणा मिलता रहे । प्रोत्साहन योजना 2016–17 के दौरान प्रथम पुरस्कार श्री रविशंकर कुमार, श्रीमती प्रियंका सावनय द्वितीय पुरस्कार श्री श्यामकिशोर वर्मा, श्री

अविनाश कलंके, डॉ. मृणाल कुचलानय तथा तृतीय पुरस्कार श्री अनिल क्रास्को, श्री अजय कुमार, डॉ. पूनम कुचलान, डॉ. निखिलेश पाण्डया एवं श्री राकेश चंद्र शाक्या जी को प्रदान किया गया । अतेव प्रोत्साहन योजना के माध्यम से इस कार्य में अत्याधिक सार्थकता प्रदान करने की कोशिश की जा रही है ।

ञ) मध्य क्षेत्रीय राजभाषा प्रथम पुरस्कार:

भारत सरकार, गृह मंत्रालय,राजभाषा विभाग द्वारा वर्ष 2016–17 के दौरान मध्य–क्षेत्र अर्थात् मध्यप्रदेश एवं छत्तीसगढ़ राज्यों के समस्त सरकारी कार्यालय में से संस्थान को संघ की राजभाषा नीति के श्रेष्ठ निष्पादन करने हेतु दिनांक 12 जनवरी 2018 को माननीय राज्यपाल, महाराष्ट्र श्री चेन्नमनेनी विद्यासागर राव जीय विशिष्ट अतिथि श्री रजनीश कुमार, अध्यक्ष, भारतीय स्टेट बैंकय श्रीमती आशा अग्रवाल, मुख्य आयकर आयुक्त, गुजरात–अहमदाबाद एवं श्री प्रभास कुमार झा, सचिव, राजभाषा विभाग के कर कमलों द्वारा प्रथम राजभाषा पुरस्कार प्रदान किया गया ।

ट) हिन्दी पखवाड़ा का आयोजन : सरकारी एवं सरकार के अधीनस्थ या संबद्ध कार्यालयों, सार्वजनिक उपक्रमों एवं प्रतिष्ठानों में हिन्दी पखवाड़ा का आयोजन अनिवार्य रूप से सम्पन्न करना अति आवश्यक है। इस संदर्भ में वर्ष 2017–18 के दौरान संस्थान में "हिन्दी पखवाड़ा–2017" का आयोजन किया गया, जिसमें विभिन्न प्रकार की प्रतियोगिताओं का आयोजन किया गया एवं सभी प्रतियोगिताओं में संस्थान के वैज्ञानिक, अधिकारी एवं कर्मचारी के साथ–साथ सहायक वर्ग के कर्मियों ने भी अपनी सहभागीता को स्वछंद रूप से व्यक्त किया । "हिन्दी–पखवाड़ा" में हिन्दी भाषियों के साथ ही साथ हिन्दीत्तर भाषियों ने भी प्रतियोगिताओं में सम्मिलित होकर अपनी उत्साह को व्यक्त किया ।

राजभाषा कार्यान्वयन के क्षेत्र में भा.कृ.अनु.प. –भारतीय सोयाबीन अनुसंधान संस्थान की प्रगति आख्या का एक स्वर्णिम झलक आपके समक्ष प्रस्तुत है। उपरोक्त गतिविधियों पर यदि दृष्टिपात करें तो ज्ञात होता है कि संस्थान में राजभाषा कार्यान्वयन की दिशा में एक सकारात्मक एवं सार्थक कार्य चल रहा है, जो संस्थान में हिन्दी के सुनहरे भविष्य का आभास कराते है।

कैमरे की नजर से :

हिन्दी पखवाड़ा 2017 के दौरान दीप प्रज्जवलित करते हुए निदेशक, डॉ. वी. सिं. भाटिया सहित डॉ. अमर नाथ शर्मा, प्र. वै. तथा प्रभारी अधिकारी राजभाषा एवं डॉ. एस. डी. बिल्लौरे, प्र. वै. ।

हिन्दी पखवाड़ा 2017 के दौरान आयोजित होने वाली "त्वरित आशु भाषण" प्रतियोगिता में सम्मिलित अधिकारी एवं कर्मचारीगण ।

	
'हिन्दी पखवाड़ा 2017 के दौरान आयोजित होने वाली "प्रश्न–मंच" प्रतियोगिता में सम्मिलित अधिकारी एवं कर्मचारीगण ।	दिनांक 12 जनवरी 2018 को मध्य क्षेत्रीय राजभाषा प्रथम पुरस्कार वर्ष 2016–17 की प्राप्ति के उपरांत संस्थान के निदेशक, डॉ. वी. सिं. भाटियाय डॉ. अमरनाथ शर्मा, प्रभारी हिन्दी अधिकारीय श्री श्यामकिशोर वर्मा, स. स. रा. भा .का. स. (बाएँ) एवं श्री विकास कुमार केशरी, हिन्दी अनुवाद (दाएँ)

12.0 MISCELLANEOUS

- **On-going research projects**
- **Publications**
- **Awards & recognition**
- **Linkages and collaborations**
- **Important committees**
- **Participation in conference/ workshops/ training**
- **Infrastructure and facility development**
- **Distinguished visitors**
- **News and events**
- **Personnel**
- **Appointments, promotions, transfer, etc**

12.0 MISCELLANEOUS

12.1 ON GOING RESEARCH PROJECTS

12.1.1 INTERNALLY-FUNDED PROJECTS

Project No.	Project Title	PI	Duration
	CROP IMPROVEMENT		
Mega theme- 1	**Soybean genetic resource management- Acquisition, conservation, characterization, documentation and utilization**		
NRCS 1.1/87	Augmentation, management and documentation of soybean germplasm	Dr. Sanjay Gupta	1987- LT
Mega Theme- 2	**Genetic improvement of soybean for yield, wide adaptability, nutrient use efficiency, resistance to biotic and abiotic stresses and improvement in quality of soybean seed**		
NRCS 1.6/92	Hybridization, selection and development of multi-parent population for genetic improvement of yield potential in soybean	Dr. M. Shivakumar	1992- LT
IISR1.31/16	Development and validation of multi-trait allele specific SNP panel for high throughput genotyping of breeding populations in soybean	Dr. Giriraj Kumawat	2019
IISR 1.33/16	Development of YMV resistant soybean varieties using marker assisted selection	Dr. Anita Rani	1999-LT
IISR 1.34/17	Enhancing disease resistance in soybean using genomic approaches	Dr. Milind Ratnaparkhe	2023
IISR1.35/17	Improvement in soybean seed viability and strength of seed coat by genetic amelioration of seed coat traits	Dr. P. Kuchlan	2022
Mega Theme- 3	**Managing the impact of current and future climate variability in soybean**		
DSR 5.6/08	Breeding for drought resistance / tolerance varieties in soybean	Dr. G.K. Satpute	2019
IISR 5.7/17	Drought amelioration in terms of morpho-physiological, biochemical characters and seed yield in soybean through foliar application of nutrients	Dr. Maharaj Singh	2020

Project No.	Project Title	PI	Duration
CROP IMPROVEMENT			
Mega Theme- 4	**Development of specialty soybean varieties for secondary agriculture and industrial uses**		
NRCS 1.12/02	Breeding for food grade characters and high oil content	Dr. Anita Rani	LT
DSR 1.28/14	Mapping QTLs for oleic acid and development of high oleic acid soybean	Dr. Vineet Kumar	2021
IISR 1.32/16	Screening soybean germplasm for vegetable type characteristics and optimization of processing parameters	Ms. Neha Pandey	2018
CROP PROTECTION			
Mega Theme - 5	**Surveillance, forecasting and control strategies for insect-pest complex in soybean**		
IISR 2.11/16	Identification of defoliator resistant/non-preferred soybean genotypes through food consumption and utilization indices	Dr. A.N. Sharma	2019
IISR 2.12/17	Effect of genotypic diversity on soybean insect pest and their natural enemies population	Dr. L.K. Meena	2020
CROP PRODUCTION			
Mega Them- 6	**Development of technologies for soybean-based cropping systems efficiency enhancement through resource conservation technologies, nutrient management, plant growth promoting microbes and farm machineries.**		
DSR 4.10/09	System efficiency enhancement through resource conservation technologies	Dr. S. D. Billore	2020
DSR 6.8/13	Inoculum development of niche AM fungi for application in soybean-based cropping systems	Dr. M. P. Sharma	2018
IISR 6.9/17	Bacterial mediated sulphur bioavailability in soybean	Sh. Hemant Maheshwari	2020
IISR 9.9/17	Design, development and validation of (A) Tractor PTO operated root stock cutting/shaving machine (B) Tractor PTO operated root stock breaking machine to prevent burning of root stock for Vertisols and associated soils	Dr. D. V. Singh	2020
IISR 4.12/16	Nitrogen and sulphur management for sustainable soybean productivity	Dr. A. Ramesh	2018

Project No.	Project Title	PI	Duration
	CROP PRODUCTION		
IISR 4.13/17	Evaluation of residue management practices under changes in land configuration/crop establishment methods for sustaining/improving resources use efficiency, soil health and crop productivity in soybean-based cropping systems	Dr. Rakesh Verma	2022
	EXTENSION		
Mega Theme-7	**Information digitization, technology dissemination, impact analysis and socio-economic research for soybean.**		
DSR 7.5/15	Decision support system for identification of soybean insects and their management	Dr. Savita Kolhe	2018
IISR 7.6/16	Development of forewarning model for insect incidence in soybean-based on weather parameters	Sh. R. M. Patel	2018
IISR 8.14/16	Evaluation of package of practices of improved soybean production technologies and economic feasibility of soybean growers	Dr. B.U. Dupare	2018
IISR 8.15/17	Assessment of soybean economy and impact of technology in India	Dr. P. Sharma	2020

12.1.2 EXTERNALLY-FUNDED PROJECTS

Sponsoring Agency	Project Title	PI	Duration
DAC, Government of India	DUS Project	Dr. M. Kuchlan	Since 2002
DBT, Govt. of India	Marker assisted elimination of off flavor generating lox II gene from KTI free genotypes	Dr. Vineet Kumar	2020
DBT, New Delhi	Assessing the bio-availability of nutrients and reduction of heavy metals in soil amended with inorganic and organic waste in presence of AM fungi and biochar	Dr. M. P. Sharma	2020
ICAR-Network Project	Identification of high-trehalose producing soybean rhizobia and their integration with AM for enhanced drought tolerance in soybean	Dr. M. P. Sharma	2020
FSSAI	Kunitz trypsin inhibitor free and phytic acid in soybean: Assessment of methods of estimation and profitability of commercial varieties, germplasm and soy-based products in India	Dr. Vineet Kumar	2018

Sponsoring Agency	Project Title	P.I.	Duration
DBT, Government of India	Development of genetic stocks for maturity and growth habit genes in soyabean (*Glycine max* (L.) Merr.)	Dr. Sanjay Gupta	2019
CSIR	Development of an efficient scalable clustering algorithm for big data and investigation of integrated system for protein sequence classification	Dr. Milind B. Ratnaparkhe	2020

12.2 PUBLICATION

12.2.1 Research Article

Bhat NA, Riar A, Ramesh A, Iqbal S, Sharma, MP, Sharma,SK and Bhullar GS (2017) Soil biological activity contributing to phosphorus availability in vertisols under long-term organic and conventional agricultural management. **Frontiers of Plant Science** 8:1523. doi: 10.3389/fpls.2017.01523

Billore SD (2017) Enhancing the water stress tolerance in soybean through anti-transpirants and mulches. **Soybean Research** 15(1):25-34

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Choudhary M, Rana KS, Bana RS, Ghasal PC, Choudhary GL, Jakhar P and Verma RK (2017) Energy budgeting and carbon footprint of pearl millet-mustard cropping system under conventional and conservation agriculture in rain-fed semi-arid agro-ecosystem. **Energy** 141:1052-1058

Dhakar R, Sarath Chandran MA, Nagar S and VishaKumari V (2017) Probabilistic assessment of phenophase-wise agricultural drought risk under different sowing windows: a case study with rainfed soybean. **Environmental Monitoring Assessment** 189: 645

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Ghasal PC, Shivay YS, Pooniya V, Choudhary M and Verma RK (2017) Zinc fertilization on macro and micro-nutrients concentrations and uptake in wheat varieties. **Indian Journal of Agronomy** 62 (4): 470–475

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Jumrani K and Bhatia VS (2018) Impact of combined stress of high temperature and water deficit on growth and seed yield of soybean. **Physiology and Molecular Biology of Plants** 24: 37-50

Jumrani K, Bhatia VS and Pandey GP (2018) Screening soybean genotypes for high temperature tolerance by in vitro pollen germination, pollen tube length, reproductive efficiency and seed yield. **Indian Journal of Plant Physiology** 23:227-244

Khande R, Sharma SK, Ramesh A and Sharma MP ((2017) Zinc solubilizing *Bacillus* strains that modulate growth, yield and zinc biofortification of soybean and wheat. **Rhizosphere** 4: 126–138

Kuchlan MK, Kuchlan P, Onkar M, Ramesh A and Husain SM (2017) Influence of seed coat compactness around cotyledons, protein and mineral composition on mechanical strength of soybean [*Glycine max* (L.) Merrill] seed coat. **Legume Research** DOI:10.18805/ijar.vOiOF.7649

Kuchlan P, Kuchlan MK and Ansari MM (2018) Efficient application of *Trichoderma viride* on soybean [*Glycine max* (L.) Merrill] seed using thin layer polymer coating. **Legume Research** DOI: 10.18805/LR-3834

Kumar M, Singh JK, Kumar S and Kumar A (2017) A comprehensive overview on black scurf of potato. **International Journal of Current Microbiology and Applied Sciences** 6(10): 4981-4994

Kumar S, Mehta N, Singh JK, Kumar M and Kumar A (2017) A protocol for callus induction in chilli genotypes from hypocotyls as explant. **International Journal of Current Microbiology and Applied Sciences** 6(10): 4937-4942

Kumar Surendra, Dhoble S and Kumar S (2017) Collaboration pattern in groundnut and mustard research in the world: a scientometric study. **Indian Journal of Agricultural Library and Information Services** 32(1): 65-71

Kumar V, Rani A, Hussain L, Yadav M, Jha P, Petwal VC and Dwivedi J (2017) Changes in physico-chemical properties of native and toasted defatted soy flour on submission to electron beam radiation**. Food and Bioproduct Processing** 105: 141-146

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Mathura S, Sharma MP and Jajoo A (2018) Improved photosynthetic efficacy of maize (*Zea mays*) plants with arbuscular mycorrhizal fungi (AMF) under high temperature stress. **Journal of Photochemistry and Photobiology** 180: 149–154

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Meena LK and Dey D (2018) A review of Indian subgenus, agandrena and oreomellissa of andrena. **Journal of Entomology and Zoology Studies** 6(1): 1182-1185

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Raghavendra M, Singh YV, Das TK and Meena MC (2017) Effect of crop residue and potassium management practices on productivity and economics of conservation agriculture based maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system. **Indian Journal of Agricultural Sciences** 87 (7): 855–61

Rajput LS, Sharma T, Madhusudhan P and Sinha P (2017) Effect of temperature on rice blast infection process with emphasis on appressoria formation by *Magnaporthe oryzae* - **International Journal of Current Microbiology and Applied Sciences** 6(4): 1931-1939

Rajput LS, Sharma T, Madhusudhan P and Sinha P (2017) Effect of temperature on growth and sporulation of rice leaf blast pathogen *Magnaporthe oryzae*. **International Journal of Current Microbiology and Applied Sciences** 6(3): 394-401

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Rathod DR, Yashpal, Chandra S, Yadav RR, Poonia S, Kumar A, Lal SK and Talukdar A (2017) Creation of genetic variability through wide hybridization and its assessment using SSR markers in soybean [*Glycine max* (L.) Merril.] **Journal of Soils and Crops** 27(1):7-17

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Sharma S and Sharma P (2017) Agricultural production, marketing and food security in India: A peep into progress. **Productivity** 58(2): 155-165

Shivakumar M, Giriraj Kumawat, Gireesh C, Ramesh SV and Husain SM (2018) Soybean MAGIC population: a novel resource for genetics and plant breeding. **Current Science** 114 (2): 521-523

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Venkattakumar R, Mysore S, Khandekar N, Narayanaswamy B and Balakrishna B (2017) Farmers producers company and broad-based extension services: A case of Ayakudi guava producers in Dindigul district of Tamil Nadu. **Indian Research Journal of Extension Education** 17(3):33-38

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Verma RK, Shivay YS and Ghasal PC (2017) Effect of different cropping systems and nutrient sources on growth, productivity and economics of direct seeded basmati rice. **Indian Journal of Agricultural Sciences** 87(10): 114-120

12.2.2 Bulletin

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कुचलान एम. के एवं कुचलान पी (2017) सोयाबीन बुवाई के पहले बीज सम्बंधित महत्वपूर्ण जानकारी. विस्तार फोल्डर क्र. 19, भा. कृ. अनु. प. – भारतीय सोयाबीन अनुसंधान संस्थान, इंदौर।

12.2.3 Popular article

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Meena LK (2018) Conservation and enhancement of natural enemies by habitats manipulation. **Agrobios Newsletter**, 09(XVI):100-101

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Shivakumar M, Nataraj V and Giriraj Kumawat (2017) Metabolomics a functional genomic tool for crop improvement. **Popular Kheti** 5(3): 99-104

12.2.4 Book chapter

Billore SD (2017) Soybean-based cropping systems. In: Enhancing Nutrient Use Efficiency, (Eds: Ramesh K, A. K. Biswas, B. Lakaria, S. Srivastava and A. K. Patra) New India Publishing Agency, New Delhi, India. pp. 299-349

Chourasiya D, Sharma MP, Maheshwari HS, Ramesh A, Sharma SK and Adhya TK (2017) Microbial

diversity and soil health in tropical agroecosystems. In: Adhya T, Mishra B, Annapurna K, Verma D & Kumar U. (eds) Advances in soil microbiology: Recent trends and future prospects. **Microorganisms for Sustainability** 4: 19-35

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12.2.5 Seminar/Symposium/Conference etc.

Arya M, Satpute GK, Gupta S, Devadas R, Ratnaparkhe M and Bhatia VS (2017) Metabolic activity in breeding lines favoring drought tolerance in soybean (*Glycine max* (L.) Merrill) In: Inter Drought –V held at Hyderabad, India from 21-25 February, pp 192

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Khande R, Sharma SK, Ramesh A, Sharma MP (2017) Inoculation of zinc solubilizing *bacillus* spp. Modulate soil enzyme activity, nutrition yield and Zn biofortification in soybean. 58th Annual conference of association of microbiologists of India and international symposium on microbes for sustainable development: Scope and Applications, Nov-16-19, BBAU, Lucknow, pp 175-176

Khandekar Nita and Rakesh Kumar Verma (2018) Soybean residue utilization through mushroom *(Pleurotus)* cultivation: Avenue of additional income, value addition and waste disposal "In: proceedings/abstract book of national conference on organic waste management for food and environment security" held at ICAR-Indian Institute of Soil Science, Bhopal (Madhya Pradesh) from February 08-10, pp 29-30

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Ratnaparkhe MB, Kavishwar R, Rathod S, Jumrani K, Kumawat G, Satpute G, Arya M, Gupta S, Singh AK and Bhatia VS (2017) Molecular and evolutionary studies of genes associated with drought tolerance in soybean. In: Inter Drought –V held at Hyderabad, India from 21-25 February, pp 225

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12.2.6 Institute publication

Kumawat G and Shivakumar M (2018) Techniques in molecular breeding of soybean – A laboratory manual. ICAR – Indian Institute of Soybean Research, Indore

सोयाबीनः फसल उत्पादन तकनीकी (2017) विस्तार बुलेटिन क्रमाकं 14 (संकलन एवं संपादनः बी. यू. दुपारे एवं एस. डी. बिल्लौरे), भा. कृ. अनु. प. – भा. सो. अनु. सं., प्रकाशन, इंदौर।

सोयाबीन की माहवार कार्यमाला (2017–18) भारतीय सोयाबीन अनुसंधान संस्थान का कृषि उपयोगी वार्षिक केलेण्डर– भा. कृ. अनु. प. – भा. सो. अनु. सं., प्रकाशन, इंदौर।

12.3 AWARDS AND RECOGNITIONS

12.3.1 Award to Institute

The Institute received first prize in Raj Bhasha Hindi for central region for the year 2016-17

12.3.2 Award to Individuals

1. Punam Kuchlan received the Young Scientist Award for outstanding contribution in the field of Seed Science and Technology from Society for Scientific Development in Agriculture and Technology in International Conference on "Global Research Initiatives For Sustainable Agriculture & Allied Science" during 02-04 December, 2017 held at Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan), India

2. Kuchlan M. K. received the Young Scientist Award for outstanding contribution in the field of Seed Science and Technology from Astha Foundation, Meerut, UP on 04th December'17 in International Conference on Global Research Initiatives For Sustainable Agriculture & Allied Science (Grisaas-2017) during 02-04 December, 2017 held at Maharana Pratap University of Agriculture & Technology, Udaipur (Rajasthan), India

3. Richa Agnihotri et al. received best paper presentation award for the work " Prospects of mycorrhizal fungi in enhancing soil carbon sequestration assessed from long-term soybean based field trials" during the national conference on organic waste management for food and environment security during Feb 8-10, 2018 held at ICAR-IISS, Bhopal

4. Raghavendra et al. received best poster presentation award for the work "Potassium management in conservation agriculture under maize-wheat cropping system". In International conference on advances in potassium research for efficient soil and crop management held on 28-29 August 2017 at NASC complex, New Delhi, India.

12.4. Linkages & collaborations

Effective linkages and collaborations were made with the following International, National and Regional institutions/organizations for soybean research and development and extension activities.

International
Asian Vegetable Research and Development Centre, Taiwan
International Institute of Tropical Agriculture, Ibadan, Nigeria
Brazilian Agricultural Research Enterprise, National Soybean Research Center, EMBRAPA.
University of Illinois, Urbana, Illinois, 61821, USA.
University of Arkansas, USA
Soybean Production Research, USDA, ARS, Stoneville, Mississippi 38776, USA.
IOWA State University, USA.
International Potash Institute, Switzerland.
International Plant Genetic Resources Institute, Rome, Italy
National
SAUs in the States of Madhya Pradesh, Chhatisgarh, Maharashtra, Himachal Pradesh, Uttar Pradesh, Uttarakhand, Rajasthan, Punjab, Haryana, Jharkhand, Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal and North-Eastern States.
ICAR-National Bureau of Plant Genetic Resources, New Delhi
ICAR-Central Research Institute for Dryland Agriculture, Hyderabad
ICAR-Indian Institute of Pulses Research, Kanpur
ICAR-Central Institute of Agricultural Engineering, Bhopal
ICAR-National Research Centre for Plant Biotechnology, New Delhi
ICAR-Indian Institute of Oilseed Research, Hyderabad
ICAR-Indian Agricultural Research Institute, New Delhi
ICAR-National Academy of Agricultural Research Management, Hyderabad
National Bank for Agriculture and Rural Development
National Fertilizer Limited
Agharkar Research Institute, Pune
Indian Institute of Technology, Indore
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra
ICAR-Directorate of Groundnut Research, Junagadh, Gujarat
University of Delhi, New Delhi

Regional
Department of Agriculture of major soybean growing states of the country, NGOs like SOPA, OILFED, State Cooperative Development Banks of respective States, State Seed Corporation and Department of Seed Certification

12.5. Important committees

There are number of committees which support the R & D programme as well as management and administrative work of the Institute.

12.5.1. Research Advisory Committee (w. e. f. 14.12.2016 to 18.12.2019)

Chairman	Dr. S. P. Tiwari, Ex-Vice Chancellor, SKRAU, Bikaner and DDG-ICAR, New Delhi
Member	Dr. S. K. Rao, Vice Chancellor, RVSKVV, Gwalior
Member	Dr. D. M. Hegde, Ex-Project Director, DOR, Hyderabad
Member	Dr. D. C. Upreti, Ex-Principal Scientist, Plant Physiology, IARI, New Delhi
Member	Dr. V. Dinesh Kumar, Principal Scientist, ICAR-IIOR, Hyderabad
Member	Dr. A. K. Sharma, Ex-Director, NBAIM, Mau
Member	Dr. V. S. Bhatia, Director ICAR-IISR, Indore
Member	ADG, Oil Seeds & Pulses, ICAR, New Delhi
Member	Dr. Raghuraj Kishore Tiwari, Farmers representative, Reewa
Member	Dr. Bharat Singh, Farmers representative, Indore
Member Secretary	Dr. S. D. Billore, Principal Scientist, ICAR-IISR, Indore

12.5.2 Institute Management Committee (2017-18)

Chairman	Dr. V. S. Bhatia, Director, ICAR- IISR, Indore
Member	Joint Director (Agriculture), Indore, Govt. of Madhya Pradesh
Member	Director, Soil Conservation & Water Management, Govt. of Rajasthan, Jaipur
Member	Director of Research, JNKVV, Jabalpur
Member	Dr. Akshay Talukdar, Principal Scientist, ICAR- IARI, New Delhi
Member	Dr. P. S. Shukla, Professor (Plant Breeding), GBPUAT, Pantnagar (Uttarakhand)
Member	Dr. Raghuraj Kishore Tiwari, Farmers representative, Reewa
Member	Dr. Bharat Singh, Farmers representative, Indore
Member	Dr. A. N. Sharma, Principal Scientist, ICAR-IISR, Indore
Member	Dr. Sanjay Gupta, Principal Scientist, ICAR-IISR, Indore
Member	Dr. Anita Rani, Principal Scientist, ICAR-IISR, Indore
Member	Dr. M. P. Sharma, Principal Scientist, ICAR-IISR, Indore
Member	Finance and Account Officer, ICAR-IISS, Bhopal
Member Secretary	Administrative Officer, ICAR-IISR, Indore

12.5.3 Institute Joint Staff Council

Chairman	Dr. V. S. Bhatia, Director Official side
Member	Dr. A. N. Sharma, Principal Scientist
Member	Dr. M. P. Sharma, Principal Scientist
Member	Dr. S. D. Billore, Principal Scientist
Member	Dr. Savita Kolhe, Senior Scientist
Member	Finance & Accounts Officer
Member Secretary	Administrative Officer Staff Side
Secretary	Shri Balveer Singh, SSG-II
Member	Shri O. P. Vishwakarma, Technical Officer, (L/V)
Member	Shri Ravi Shankar Kumar, Assistant Shri Francis Damasus, Sr. Technical Assistant Shri Anil Kumar Carrasco, Sr. Clerk and CISC Member Shri Sanjeev Mishra, Duplicating Operator

12.5.4 Other Committees of the Institute (2017-18)

1.	**Official Language Implementation Committee** Director, ICAR-IISR (Chairman) Dr. A. N. Sharma, Dr. (Smt.) Savita Kolhe Dr. D. N. Bharaskar Shri S. K. Pandey Shri S. K. Verma Shri Vikas Kumar Keshari Administrative Officer Finance & Accounts Officer	**2.**	**Institute Technical Management Unit (ITMU) Committee** Dr. M. P. Sharma (Chairman) Dr. Vineet Kumar Dr. M. K. Kuchlan Shri Yogesh Sohani Finance & Accounts Officer Administrative Officer

3.	**Priority Setting Monitoring and Evaluation (PME) Cell** Dr. S. D. Billore (In charge) Dr. B. U. Dupare Dr. Purushottam Sharma Dr. M. Shivakumar	4.	**Purchase Advisory Committee** Dr. Maharaj Singh (Chairman) Dr. A. Ramesh Dr. Giriraj Kumawat Dr. Mrinal Kuchlan Indenter Finance & Accounts Officer Administrative Officer
5.	**Human Resource Development Committee** Dr. Sanjay Gupta, (Chairman) Dr. Nita Khandekar Dr. Savita Kolhe Dr. Rajkumar Ramteke Shri R. N. Singh Administrative Officer	6.	**Consultancy Processing Cell (CPC)** Dr. A. N. Sharma (Chairman) Dr. S. D. Billore Dr. Vineet Kumar Dr. Purushottam Sharma Finance & Accounts Officer Administrative Officer
7.	**Student Affairs Committee & Higher Study Committee** Dr. Vineet Kumar (Chairman) Dr. A. Ramesh Dr. M. Shivakuamr	8.	**Higher Education Committee** Dr. B. U. Dupare (Chairman) Dr. Savita Kolhe Dr. A. Ramesh Dr. Milind Ratnaparkhe Administrative Officer
9.	**Library Advisory Committee** Dr. Anita Rani (Chairman) Dr. D. V. Singh Dr. Purushottam Sharma Dr. Punam Kuchlan Shri R. M. Patel Finance & Accounts Officer Administrative Officer Dr. Surendra Kumar	10.	**Printing and Publication Committee (General)** Dr. A. N. Sharma (Chairman) Dr. S. D. Billore Dr. M. P. Sharma **Publication Committee (Annual Report/Newsletter)** Dr. Vineet Kumar Dr. M. B. Ratnaparkhe Dr. M. Shivakumar Dr. Surendra Kumar

11.	**Works Committee** Dr. M. P. Sharma (Chairman) Dr. Dev Vrat Singh Dr. M. Shivakumar Estate Officer Administrative Officer Finance & Account Officer Dr. G. K. Satpute	**12.**	**Hindi Cell** Dr. A. N. Sharma (In charge) Shri S. K. Verma Shri Vikash Keshari Shri Avinash Kalenke
13.	**House Allotment Committee** Dr. A. N. Sharma (Chairman) Dr. M. P. Sharma Shri Hemant Singh Maheshwari Dr. Yogendra Mohan Secretary, IJSC Administrative Officer	**14.**	**Estate Committee** Dr. Purushottam Sharma (Chairman) Dr. Rakesh Kumar Verma Dr. V. P. S. Bundela Shri R. N. Shrivastava Shri R. C. Shakya Administrative officer Estate Officer
15.	**Public Information Officer** Shri Rakesh Dubey, A. O. Shri Ajay Kumar, A.A.O.	**16.**	**Public Relation Officer** Shri Rakesh Dubey, A.O. Shri Ajay Kumar A.A.O.
17.	**ARIS Committee (IT Cell)** Dr. Savita Kolhe (Chairman) Shri Ram Manohar Patel Smt. Priyanka Sawan	**18.**	**Centralized Public Grievance Cell and Monitoring Systems (CPGCMS)** Dr. Vineet Kumar
19.	**Guest House /Management Committee** Dr. B. U. Dupare Dr. Giriraj Kumawat Shri R. M. Patel Shri R. N. Shrivastava Shri Om Prakash Vishwakarma Shri Prahlad Singh Administrative officer	**20.**	**Women Harassment Complaint Committee** Dr. Nita Khandekar (Chairperson) Dr. M. B. Ratnaparkhe Dr. Poonam Kuchlan Mrs. Priyanka Sawant Third party representative (As when Required) Administrative Officer

21.	**Nodal Scientist IASRI-NAIP Statistics Project** Shri Ram Manohar Patel	22.	**Nodal Officer, RFD Unit** Dr. Anita Rani
23.	**Security Cell** Shri Rakesh Dubey, A O Shri O. P. Vishwakarma	24.	**Library In Charge** Dr. Surendra Kumar
25.	**Technical Specification Committee (above Rs. 50,000.00)** Dr. Sanjay Gupta (Chairman) Dr. M. P. Sharma Dr. M. B. Ratnaparkhe Dr. Giriraj Kumawat Dr. Punam Kuchlan, Indenter	26.	**Publicity Committee** Dr. B. U. Dupare (Chairman) Dr. Purushottam Sharma Dr. R. N. Singh Shri S. K. Verma Shri D. N. Baraskar
27.	**Farm Produce Disposal and Price Fixation Committee** Dr. Purushottam Sharma (Chairman) Dr. M. K. Kuchlan Dr. Lokesh Kumar Meena Dr. V. P. S. Bundela Store Officer Finance & Accounts Officer Administrative Officer	28.	**Physical Verification Committee** Dr. Vineet Kumar (Chairman) Mr. Hemant Singh Maheswari Dr. Sanjeev Kumar Store Officer
29.	**Condemnation and Auction Committee** Dr. Vineet Kumar (Chairman) Dr. Giriraj Kumawat Store officer Shri R. N. Srivastava Shri I. R. Khan Finance & Accounts Officer Administrative Officer	30.	**Staff Welfare Fund Committee** Dr. M. P. Sharma (Chairman) Dr. Vineet Kumar Smt. Neha Pandey Administrative Officer Finance & Account Officer Secretary, IJSC Shri Balveer Singh

31.	**Laboratory Incharge** Shri Sanjeev Kumar - Pathology Dr. Maharaj Singh- Physiology Dr. Sanjay Gupta - Plant Breeding, Seed Technology, Germplasm Dr. M. K. Kuchalan - DUS Testing, Dr. Milind B. Ratnaparkhe- Biotechnology Dr. A. N. Sharma - Entomology Dr. Anita Rani - Transgenics Dr. M. P. Sharma - Microbiology Dr. Vineet Kumar – Biochemistry Dr. S. D. Billore - Agronomy Dr. Savita Kolhe - Computer Dr. B. U. Dupare - Extension	**32.** **33.**	**Estate Officer** Shri Shyam Kishor Verma **Record Officer** Shri Ajay Kumar, AAO **Vehicle Incharge** Dr. Nikhlesh Pandya **Store Incharge** Shri S. S. Vasuniaya **Tofu Plant Incharge** Ms. Neha Pandey Shri S. N. Verma **Guest House Incharge** Shri R. N. Shrivastava
34.	**Sport Committee** Dr. A. N. Sharma (Chairman) Shri R. N. Shrivastava Smt Priyanka Sawan Shri Gorelal Chauhan Shri Balveer Singh	**35.**	**Soybean Market Intelligence Cell** Dr. Purushottam Sharma Shri Ram Manohar Patel

12.6. Participation in Seminar, Symposium, Conference, Workshops etc

Participant	Event	Venue and date
Dr. Vennampally Nataraj	Attended training on Phenomics: Perspectives for application in the improvement of abiotic stress tolerance in crop plants	ICAR-NIASM, Baramati 20-29 July 2017
Dr. R. K. Verma,	Attended national workshop on "weed risk assessment"	NIPHM, Hyderabad, Dated 30-31 August, 2017
Dr. Shivani Nagar	National Conference on Technological Challenges in Social, Environmental and Agricultural Reforms (TECHSEAR-2017)	Green Reap Welfare Society, Hyderabad. 9 -10, September 2017
Shri Sanjeev Kumar	Morphological and molecular characterization of *Macrophomina phaseolina* causing charcoal rot in soybean	ICAR-NBPGR, New Delhi 13th Nov 2017 - 13th February 2018
Shri Ram Manohar Patel	21 days training program on "Advances in Simulation Modeling and Climate Change Research towards Knowledge Based Agriculture"	ICAR – Indian Agricultural Research Institute at New Delhi from 16/11/17 to 06/12/17
Dr. Laxman Singh Rajput	Professional Attachment Training on and molecular characterization of Phomopsis species associated with seeds"	ICAR-NBPGR, New Delhi December 20, 2017 – April 03, 2018
Dr. Subhash Chandra	Professional Attachment Training on "Phenotyping of traits associated with drought adaptation in plants" drought adaptation in plants"	UAS, GKVK, Bangalore December 26, 2017 – March 25, 2018
Shri Viraj Gangadhar Kamble Kamble	Professional Attachment Training on i) Genetic transformation of potato for amelioration of cold induced sweetening ii) A practical approach toward genome editing in fruit crop	i) ICAR-NRCPB New Delhi, December 27, 2017 – February 10, 2018 ii) National Agri-Food Biotechnology Institute, Mohali, Punjab February 12, 2018- March 28, 2018
Dr. Vangala Rajesh	Professional Attachment Training on "Plant Genetic Resources (PGR) Management"	ICAR- Indian Institute of Millets Research (IIMR), Hyderabad. December 27, 2017 to March 27, 2018

Participant	Event	Venue and date
Dr. Raghavendra M	Professional Attachment Training: "Integrated nutrient management studies in soybean-wheat cropping system to enhance productivity and soil health in central India"	ICRISAT, Hyderabad, From January 4 to 5 April 2018
Dr. Shivani Nagar	Training on Conventional and molecular breeding approaches for increasing soybean productivity under changing climatic situations in India	ICAR-IISR, Indore 16-26 January 2018
Dr. Vangala Rajesh	One day learning workshop on Digital Field book	ICAR- Indian Institute of Millets Research (IIMR), Hyderabad, 2, February 2018
Dr. Surendra Kumar	Training on Koha for Library staff of ICAR	ICAR-NAARM, Hyderabad 05-09 February 2018
Dr. R. K. Verma,	Attended National Conference on Organic Waste Management for Food and Environment Security	ICAR-Indian Institute of Soil Science, Bhopal (Madhya Pradesh), Dated 08-10 February, 208
Dr.Vangala Rajesh	Sorghum germplasm field day and learning workshop on APPS for agriculture	ICAR- Indian Institute of Millets Research (IIMR), Hyderabad, March 21-22, 2018

12.7 Instruments and Facilities developed

12.7.1Works

Name of the facility developed	Total cost (₹)
Construction of water logging structures	₹ 327000
Ramp for physically challenged persons	₹ 98300

12.7.2 Equipments

The following major equipment costing above ₹ 50, 000 were purchased

Name of the equipment	Total Cost (₹)
Rotavator	105000
Cultivator & Duck Foot Cultivator	128620
Seed Counter	81302
Refrigerated Centrifuge	197295
Air conditioner	79800
PUSA STFR Soil Kit	65000
Furniture	109060
Computer (IT)	139192

12.8 DISTINGUISHED VISITORS

The following are the eminent persons visited this institute during the year 2017-18

Name and Affiliation	Date of Visit
Dr. S. K. Chaturvedi, ADG (Oilseed and Pulses) ICAR, Krishi Bhawan, New Delhi	19.04. 2017
Dr. D. M. Hegde, Ex-Project Director, ICAR-IIOR, Hyderabad	19.04. 2017
Dr. S. K. Rao, Director of Research, JNKVV, Jabalpur	19.04. 2017
Dr. D. Khare, Director Research, JNKVV, Jabalpur	18.8.2017
Dr. S. P. Tiwari, Chairman of RAC and Ex-DDG, ICAR	02.09.2017
Dr. Trilochan Mohapatra, Secretary DARE and Director General, ICAR, Krishi Bhawan, New Delhi	23.09.2017
Dr. A. K Singh, Vice chancellor, RVSKVV, Gwalior	23.09.2017
Dr. S. K. Srivastava, Director Extension, RVSKVV Gwalior and Ex-Director, ICAR-IISR, Indore	23.09.2017
Dr. Aupam Mishra , Director, ATARI, Jabalpur	23.09.2017
Dr. A. K. Singh, DDG (Agril. Extension), ICAR, Krishi Bhawan, New Delhi	03.10.2017
Dr. P. S. Bhatnagar, Founder Director, ICAR-IISR, Indore	11. 12. 2017
Dr. S. K. Dalal, National Consultant (Oil Seeds), DAC & FW New Delhi	11. 12. 2017
Dr. T. P. Singh, Additional Commissioner (Oil Seeds) DAC & FW, New Delhi	11. 12. 2017

Distinguished visitors of ICAR-IISR during 2017-18

12.9 News and Events

Research Advisory Committee Meeting

47th AICRP workshop at G.B.P.U.A.T.

Institute Management Committee Meeting

Lecture on Sexual Harassment Act 2013 at Workplace

Cleanliness drive by ICAR-IISR staff under Swatchata Abhiyan programe

12.10. PERSONNEL

(As on 31 March 2018)

A.	**Research Management**		
1.	Dr. V. S. Bhatia	Director	
B.	**Scientific**		
2.	Dr. M. M. Ansari	Principal Scientist	Plant Pathology (Up to 31st July 2017
3.	Dr. A. N. Sharma	Principal Scientist	Entomology
4.	Dr. Nita Khandekar	Principal Scientist	Agricultural Extension
5.	Dr. S. D. Billore	Principal Scientist	Agronomy
6.	Dr. Sanjay Gupta	Principal Scientist	Plant Breeding
7.	Dr. (Smt.) Anita Rani	Principal Scientist,	Plant Breeding
8.	Dr. Mahaveer P. Sharma	Principal Scientist	Microbiology
9.	Dr. Vineet Kumar	Principal Scientist	Biochemistry
10.	Dr. A. Ramesh	Principal Scientist	Soil Science
11.	Dr. B. U. Dupare	Principal Scientist	Agricultural Extension
12.	Dr. Savita Kolhe	Principal Scientist	Computer Application
13.	Dr. Maharaj Singh	Principal Scientist	Plant Physiology
14.	Er. (Dr.) DevVrat Singh	Principal Scientist	Farm Machinery and Power
15.	Dr. Purushottam Sharma	Senior Scientist	Agricultural Economics
16.	Dr. Milind B. Ratnaparkhe	Senior Scientist	Biotechnology
17.	Dr. Gyanesh Kumar Satpute	Senior Scientist	Genetics
18.	Dr. Rajkumar Ramteke	Scientist (Senior Scale)	Genetics
19.	Dr. Poonam Kuchlan	Scientist (Senior Scale)	Seed Technology
20.	Dr. Giriraj Kumawat	Scientist (Senior Scale)	Biotechnology
21.	Dr. Mrinal Kumar Kuchlan	Scientist	Seed Technology
22.	Shri Ram Manohar Patel	Scientist	Agril. Statistics
23.	Dr. Mamta Arya	Scientist	Genetics (Up to 22nd June 2017)
24.	Dr. M. Shivakumar	Scientist	Genetics & Plant Breeding
25.	Ms. Neha Pandey	Scientist	Food Technology
26.	Dr. Lokesh Kumar Meena	Scientist	Entomology

27.	Shri Hemant Singh Maheshewari	Scientist	Microbiology
28.	Dr. Rakesh Kumar Verma	Scientist	Agronomy
29.	Dr. Shivani Nagar	Scientist	Plant Physiology
30.	Dr. V. Nataraj	Scientist	Genetics & Plant Breeding
31.	Shri Sanjeev Kumar	Scientist	Plant Pathology
32.	Dr. Subhash Chandra	Scientist	Genetics & Plant Breeding
33.	Dr. Laxman Singh Rajput	Scientist	Plant Pathology
34.	Dr. Vangala Rajesh	Scientist	Genetics & Plant Breeding
35.	Dr. Raghvendra Madar	Scientist	Agronomy
36.	Shri Viraj Gangadhar Kamle	Scientist	Plant Biotechnology
C.	**Technical**		
37.	Dr. Surendra Kumar	Chief Documentation Officer	Library & Documentation
38.	Shri R. N. Singh	Chief Technical Officer	Field & Farm
39.	Dr. Nikhlesh Pandya	Chief Technical Officer	Field & Farm
40.	Dr. V. P. S. Bundela	Chief Technical Officer (Farm Manager)	Field & Farm
41.	Dr. Yogendra Mohan	Chief Technical Officer	Field & Farm
42.	Shri S. K. Pandey	Assitt. Chief Technical Officer	Field & Farm
43.	Dr. Sushil Kumar Sharma	Assitt. Chief Technical Officer	Field & Farm
44.	Shri S. S. Vasunia	Assitt. Chief Technical Officer	Field & Farm
45.	Shri R. N. Srivastava	Assitt. Chief Technical Officer	Field & Farm
46.	Dr. D. N. Baraskar	Senior Technical Officer	Artist & Photography
47.	Shri S. K. Verma	Senior Technical Officer	Field & Farm
48.	Shri O. P. Vishwakarma	Technical Officer (L/V)	Tractor Driver
49.	Shri I. R. Khan	Senior Technical Assistant	Field & Farm
50.	Shri Gorelal Chouhan	Senior Technical Assistant	Field & Farm
51.	Shri R. C. Shakya	Senior Technical Assistant	Field & Farm

52.	Shri Francis Yunis	Senior Technical Assistant (L/V)	Staff Car Driver
53.	Shri Devendra Singh Yadav	Technical Assistant	Field & Farm
54.	Shri Vikas Kumar Keshari	Hindi Translator	Official Language Cell
55.	Shri Bilbar Singh	Senior Technician (L/V)	Staff Car Driver
56.	Shri Shambhu Nath Verma	Senior Technician	Field & Farm
D.	**Administration and Accounts**		
57.	Shri A. K. Maheshwari	Finance and Account Officer	Audit & Account (Up to 25th April 2017)
58.	Shri Rakesh Dubey	Administrative Officer	Administration
59.	Shri Ravindra Kumar	Finance and Account Officer	Audit & Account (w. e. f. 22nd June 2017)
60.	Shri Ajay Kumar	Assistan Administrative Officer	Administration
61.	Shri S. P. Singh	PS to Director	Administration
62.	Ku. Priyanka Sawan	Assistant	Administration
63.	Shri Ravi Shankar Kumar	Assistant	Administration
64.	Shri Avinash Kalanke	Senior Clerk	Administration
65.	Shri Anil Kumar Carrasco	Senior Clerk	Administration
66.	Shri Sanjeev Kumar	Duplicating Operator	Administration
E	**Skilled Supporting Staff**		
67.	Shri Gulab Singh	SSG III	Up to 31st December 2017
68.	Shri Dhan Singh	SSG III	
69.	Shri Roop Singh	SSG II	
70.	Shri Nirbhay Singh	SSG II	
71.	Shri Bhav Singh	SSG II	Up to 22nd June 2017
72.	Shri Janglia	SSG II	
73.	Shri Surla	SSG I	Up to 31st July 2017
74.	Shri Sur Singh	SSG I	
75.	Smt. Prakaswati Sura	SSG I	
76.	Shri Balveer Singh	SSG I	
77.	Shri Prahlad Singh	SSG I	

12.11 APPOINTMENTS, PROMOTIONS, TRANSFER, ETC.

12.11.1 Appointments

Name	Post	Date of joining
Dr.V. Nataraj	Scientist (Genetics & Plant Breeding)	26.04.2017
Shri Sanjeev Kumar	Scientist (Plant Pathology)	12.04.2017
Dr. Nita Khandekar	Principal Scientist (Agricultural Extension)	08.06.2017
Shri Ravindra Kumar	Finance & Account Officer	22.06.2017
Dr. Subhash Chandra	Scientist (Genetics & Plant Breeding)	07.10.2017
Dr. Laxman Singh Rajput	Scientist (Plant Pathology)	10.10.2017
Dr. V. Rajesh	Scientist (Genetics & Plant Breeding)	12.10.2017
Dr. Raghvendra Madar	Scientist (Agronomy)	12.10.2017
Shri Viraj Gangadhar Kamle	Scientist (Plant Biotechnolgy)	13.10.2017

12.11.2 Promotions

Name	Promoted to the Post of	w. e. f.
Dr. D. V. Singh	Principal Scientist (Farm Machinery & Power)	29.06.2015

12.11.3 Transfers

Name	From	To	w. e. f.
Shri Ajay Kumar Maheshwari	ICAR-IISR, Indore	ICAR-IIRR, Hyderabad	25.04.2017
Dr. Mamta Arya	ICAR-IISR, Indore	ICAR-NBPGR, New Delhi	22.06.2017

12.11.4 Retirement

Dr. M. M. Ansari, Principal Scientist, w.e.f. 31st July, 2017

Smt. Prakashwati Sura, SSG-I, w.e.f. 31st July, 2017

Shri Roop Singh, SSG-II, w.e.f. 31st December, 2017

12.11.5 Higher education

Name	Name of Degree	University/ Institution
Shri Vennampally Nataraj	Ph.D (Genetics & Plant Breeding) "Cytogenetic Characterization and Molecular mapping of *Triticum militinae* derived Leaf rust resistance in wheat"	ICAR- Indian Institute of Agricultural Research, New Delhi
Shri Subhash Chandra	Ph.D (Genetics & Plant Breeding) "Genetics studies and identification of molecular markers for seed coat permeability in soybean"	ICAR- Indian Institute of Agricultural Research, New Delhi
Shri Laxman Singh Rajput	Ph.D (Plant Pathology) "Simulation of cycling adenosine monophoshate dependent protein kinase A activity in relation to aspersoria formation in *Magnaporthae oryzae*"	ICAR- Indian Institute of Agricultural Research, New Delhi

12.11.12 Obituary

Shri Bhav Singh, SSG-2, 22.06.2017