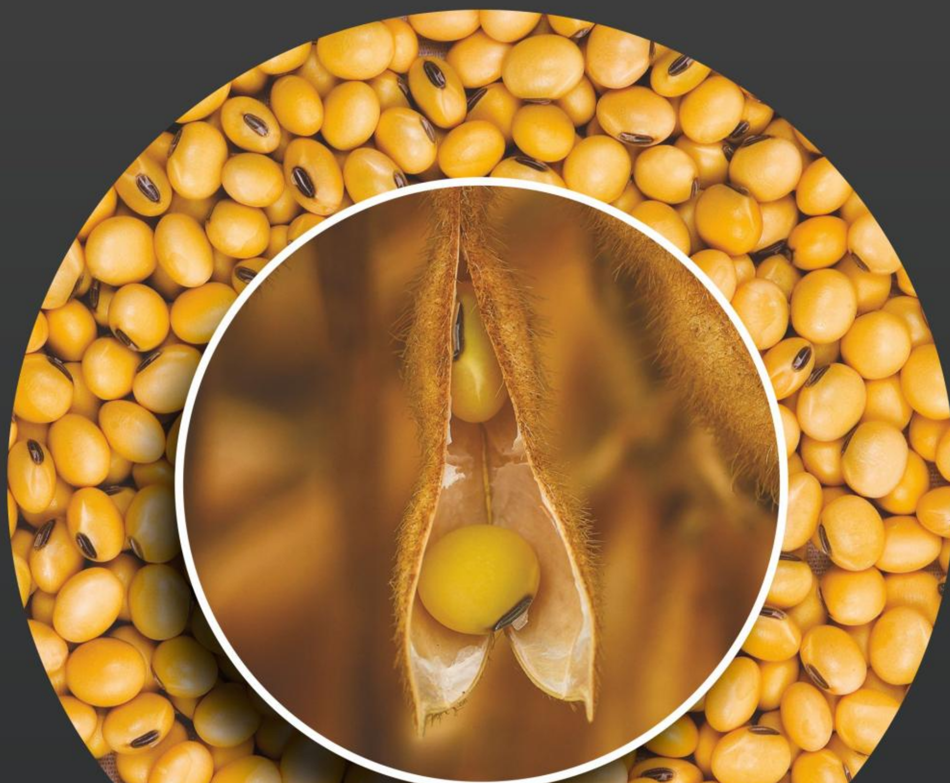
ANNUAL REPORT
वार्षिक प्रतिवेदन
2019



भा. कृ. अनु. प. -भारतीय सोयाबीन अनुसंधान संस्थान

ICAR-INDIAN INSTITUTE OF SOYBEAN RESEARCH

वार्षिक प्रतिवेदन
Annual Report

2019

भाकृ अनुप
ICAR

भा. कृ. अनु. प. – भारतीय सोयाबीन अनुसंधान संस्थान
ICAR-Indian Institute of Soybean Research
खण्डवा रोड, इन्दौर – 452 001 (म.प्र.)
Khandwa Road, Indore - 452 001 (M.P.)

प्रकाशन / **Published by**
डॉ. वी.एस. भाटिया / **Dr. V.S. Bhatia**
निदेशक / **Director**
भा.कृ.अनु.प.– भारतीय सोयाबीन अनुसंधान संस्थान / **ICAR-Indian Institute of Soybean Research**
खण्डवा रोड, इन्दौर / **Khandwa Road, Indore**

संपादक / Editors
डॉ. शिवकुमार एम./ Dr. Shivakumar M.
डॉ. राकेश कुमार वर्मा / Dr. Rakesh Kumar Verma
डॉ. वी. नटराज / Dr. Vennampally Nataraj
डॉ. लक्ष्मण सिंह राजपुत / Dr. Laxman Singh Rajput
डॉ. मनोज श्रीवास्तव / Dr. Manoj Srivastava
डॉ. सुरेन्द्र कुमार / Dr. Surendra Kumar

छायाचित्र तथा मुख्य पृष्ठ डिजाइन / Photography and Cover Design
डॉ. डी. एन. बारस्कर / Dr. D. N. Baraskar

हिन्दी ट्रान्सलेशन / Hindi Translation
विकास केशरी / Vikas Keshari

Citation
Annual Report 2019. ICAR- Indian Institute of Soybean Research, Indore

PREFACE

It is a matter of great honor and pride for me to present the annual report 2019 of ICAR-Indian Institute of Soybean Research, Indore. The research accomplishments and technological competence of the institute can be judged by the fact that soybean was introduced for commercial cultivation in late 60's, and in a span of 5 decades it has become the most important oilseed crop of India. At present, the crop is grown in ~ 11.0 million hectare with a production of 13.7 million tones. In a scenario of meeting edible oil demand by importing almost 60% of country's requirement, the contribution of soybean to total oilseeds and edible oil produced in the country is 42 and 22 per cent, respectively. Soybean seed contains 40% protein and 20 % oil and it is one of the most economical sources of good quality protein. It also contains many minerals and useful nutraceuticals like iso-flavones having immense health benefits. Therefore, the crop has a potential to provide nutritional security and eradicate rampant protein malnutrition in the country.

Productivity enhancement of the crop is one of the major challenges faced by the soybean researchers. The climatic variability leading to delay in monsoon, drought spells of different durations at various growth stages, waterlogging conditions and raise in temperatures particularly at seed fill stage are the main reasons of low productivity of soybean in India. In addition, increased infestation by insects and diseases due to repeated dry spells and increased temperatures further aggravate the situation. Scientists at ICAR-IISR are making all possible efforts to overcome these problems and continuing to strive for increasing productivity in the face of considerable climatic changes. Major strategies include development of climate resilient 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 achievements of 2019 includes identification of new soybean genotypes with various agronomically important traits such as high yield; early maturity; tolerance to high temperature, drought and salinity; insect and YMV resistance; vegetable soybean genotypes with fragrance; high oleic acid and lipoxygenase-free genotypes. Institute also developed two CRISPR vectors for targeted silencing of the RPG1B and PDH1 genes involved in bacterial blight resistance and pod shattering mechanism, respectively. ICAR-IISR trained a number of farmers regarding the recent technologies to enhance the soybean production in the country. Similarly, a number of women farmers were trained regarding preparation of soya based foods and made them aware of their health benefits. I am glad to present the Annual report for the year 2019, which would give a panoramic scenario of research, development and extension activities undertaken by this institute. I would also thank the Chairman and members of RAC who guided and directed us for the strategic research planning. 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. 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 one of them.

VSBhatia

(V. S. Bhatia)
Director

CONTENTS

1. कार्यकारी सारांश

- खाद्य पदार्थ के रूप में उपयोग हेतु विकसित जिनोटाइपों एन.आर.सी. 132, एन.आर.सी. 133, एन.आर.सी. 142, एन.आर.सी. 150, एन.आर.सी. 151, एन.आर.सी. 152 एवं एन.आर.सी. 153 का मूल्यांकन अखिल भारतीय समन्वित सोयाबीन अनुसंधान परियोजना (अ.भा.स.सो.अनु.परि.) के अंतर्गत किया जा रहा है।
- अधिक तेल मात्रा के लिए विकसित जिनोटाइपों एन.आर.सी. 148 एवं एन.आर.सी. 149 का मूल्यांकन अ.भा.स.सो.अनु.परि. के अंतर्गत किया जा रहा है ।
- शीघ्र परिपक्वता के लिए विकसित सोयाबीन जिनोटाइपों एन.आर.सी. 138, एन.आर.सी. 150, एन.आर.सी. 151, एन.आर.सी. 152, एन.आर.सी. 153, एन.आर.सी. 155, एन.आर.सी. 156, एन. आर.सी. 158 एवं एन.आर.सी. 159 का मूल्यांकन अ.भा.स.सो.अनु.परि. के अंतर्गत किया जा रहा है ।
- मूंगबीन पीला मोजेक भारतीय विषाणु (MYMIV) के प्रतिरोधी के रूप में विकसित जिनोटाइपों एन. आर.सी.एस.एल. 1 एवं एन.आर.सी.एस.एल. 2 का मूल्यांकन अ.भा.स.सो.अनु.परि. के अंतर्गत किया जा रहा है ।
- प्रकाश संवेदनशीलता के लिए विकसित सोयाबीन के दो जीनोटाइपों का मूल्यांकन अखिल भारतीय समन्वित सोयाबीन अनुसंधान परियोजना के अंतर्गत किया जा रहा है। सूखा सहिष्णुता के लक्षणों से युक्त जिनोटाइपों एन.आर.सी. 136 एवं एन.आर.सी. 137 का मूल्यांकन भी अखिल भारतीय समन्वित सोयाबीन अनुसंधान परियोजना के अंतर्गत किया जा रहा है ।
- अधिक उत्पादन क्षमता, जलभराव, सहिष्णुता, मूंगबीन पीला मोजेक, भारतीय विषाणु प्रतिरोधी एवं चारकोल सड़न रोग के लिए मध्यम प्रतिरोधी गुणों से युक्त एन.आर.सी. 128 का मूल्यांकन अखिल भारतीय समन्वित सोयाबीन अनुसंधान परियोजना के अंतर्गत किया जा रहा है ।
- सब्जी सोयाबीन की 12 जीनोटाइपों में सुगंध के लिए कारक एलील की पहचान की गई । इसमें से 11 जीनोटाइपों, ए.जी.एस. 28, ए.जी.एस. प्रक्षेत्र परिग्रहण, ए.जी.एस. 457, ए.जी.एस. 459, डेमामे, ईसी 916032, ई.सी. 916033, ई.सी. 916034, ई. सी. 916035, ई.सी. 916036 एवं ई.सी 916037 में FG-Indel 2139 एलील विद्यमान था, जबकि जीनोटाप वी.आर.पी.एच. 1961 में दुर्लभ एलील SNPFG-SNF2213 उपस्थित था ।
- सिंचाई जल की EC–8 लवणता स्तर पर सहिष्णुता के लिए 5 जिनोटाइप आई.सी. 195, टी.जी .एक्स. 849–309 डी., टाइप 49, ई.सी. 341115 एवं यू.पी.एस.एम. 862 का मूल्यांकन भा. कृ.अनु.प. – केंद्रीय मृदा लवणता अनुसंधान संस्थान, करनाल के सहयोग से किया गया ।
- कार्यकीय एवं फिजियोलॉजिकल आधार पर परीक्षण करने के बाद सोयाबीन जीनोटाइप एन. आर.सी. 146, जे.एस. 20–30 तथा जे.एस. 20–98 उच्च तापमान के प्रति सहिष्णु सिद्ध हुए ।
- हाइड्रोपोनिक्स प्रणाली से परीक्षण के उपरांत सोयाबीन जीनोटाइप ई.सी. 538828 में सूखा सहिष्णुता के लक्षणों की उपस्थिति सिद्ध हुई ।
- सोयाबीन में जलभराव सहिष्णुता के स्तर की जांच के लिए तकनीकी विकसित की गई । इसमें सोयाबीन को वनस्पति अवस्था V2 में 10 सेंटीमीटर के जलभराव में 10 दिनों तक रखने पर सहिष्णु एवं संवेदनशील जिनोटाइपों को विभेदित किया जा सकता है। विकसित जलभराव संरचनाओं में जे.

एस. 97–52× जे.एस. 90–41 के क्रॉस से प्राप्त RIC प्रजनको का जलभराव सहिष्णुता के लिए मूल्यांकन किया गया। सोयाबीन जिनोटाइप हार्डी, टी.जी.एक्स 317–37 डी,ई.सी. 291400, ई.सी. 313974, सेल 1–34, ई.सी. 93601, टी.जी.एक्स 825–1 ई, जे.एस. 20–38, एन.आर.सी. 128 एवं एन.आर.सी. 131 में जलभराव सहिष्णुता के गुण पाए गए ।

- सूखा, उच्च तापमान तथा जलभराव प्रतिरोधी जिनोटाइपों के परीक्षण के लिए 300 जिनोटाइपों के फिनोटाइप मूल्यांकन से GWAS तालिका का निर्माण किया गया । सूखा प्रतिरोधी सूचांक के आधार पर जिनोटाइप टी.जी.एक्स. 849– 143व, जे.एस.एम. 288, ई.सी. 291400 एवं वी.एल.एस. –75, सूखा प्रतिरोधी सिद्ध हुए । उत्पादन में प्रतिशत कमी के आधार पर जिनोटाइप ई.सी. 456556, ई. सी. 95815, जे.एस.एम 288 एवं जे.एस. 75– 46 जलभराव सहिष्णु तथा जिनोटाइप ई.सी. 456556, ई.सी. 39177, ई.सी. 251388, ई.सी. 396065 एवं टी.जी. एक्स 317 –37ई उच्च तापमान सहिष्णु सिद्ध हुए ।
- पौधे की ऊंचाई एवं नोड संख्या से संबंधित एक नये एस.एन.पी. मार्कर जी.एम.194292–1997 की पहचान शीघ्र परिपक्वता वाले जीनोटाइप आई.सी. 15089 में की गई । अधिक ऊंचाई वाली शीघ्र परिपक्वता सोयाबीन किस्मों के विकास में यह मार्कर सहायक होगा ।
- एंथ्राकोनोज रोग की प्रतिरोधकता के अनुवांशिक कारणों का अध्ययन तीन f2 क्रॉस, ई.सी. 34372×जे.एस. 95–60, ई.सी. 457254×जे.एस. 95–60, ई.सी. 457254× जे.एस. 95–60 तथा ए. के.एस.एस. 67× जे.एस. 95–60 में किया गया । इससे एंथ्राकोनोज रोग प्रतिरोधक क्षमता के लिए दो जीनो के परस्पर सहभागिता प्रदर्शित हुई ।
- सोयाबीन के जीवाणु झुलसा रोग प्रतिरोधकता के लिए कारक जीन RPGIB और फली विखरन के प्रतिरोधी जीन PDHI को निष्क्रिय करने के लिए दो क्रिस्पर वेक्टर रूपांकित किए गए ।
- PCR द्वारा एग्रोबैक्टेरियम राइजोजींस के दो उपभेदों एम.टी.सी.सी. 53 एवं एम.टी.सी.सी. 2364 में Ri प्लास्मिड के RoI A और RoI B की उपस्थिति सिद्ध की गई ।
- स्पोडोप्टेरा लिटूरा के विरूद्ध एंटीजीनोटिक अध्ययन से सोयाबीन जीनोटाइपों, पी.आर. 15–126–3–8, पी.आर –35 एवं डी.एस.बी.1 में प्रबल एंटीजिनोसिस की उपस्थिति पाई गई । इसी तरह जीनोटाइप ई.सी. 333902, स्पोडोप्टेरा लिटूरा के विरूद्ध प्रबल एंटीबायोसिस प्रदर्शित करता है ।
- एस्पर्जिलस फ्लेवस, फ्यूजेरियमफाल्सीफोर्म, मैक्रोफोमिना फेजियोलिना जैसे एंडोफाइटो के जैव रासायनिक विश्लेषण से इनके द्वारा काइटिनेज, सेल्यूलेज, एमाइलेज एवं प्रोटियेज एंजाइमों के संश्लेषण की पुष्टि हुई ।
- मैक्रोफोमिना फेजियोलिना के 43 आइसोलेट्स का आणविक निरूपण आई.टी.एस. 1 एवं आई.टी.एस. –4 का उपयोग करके किया गया ।
- कम आद्रता तनाव की स्थिति में सोयाबीन के नाड्यूलेशन एवं शारीरिक विकास पर एक नवीन राइजोवियल वियोजक, ब्रैडीराइजोवियम डाक्वीजींस का मूल्यांकन किया गया । सभी प्रयुक्त वियोजकों की तुलना में ब्रैडीराइजोवियम डाक्वीजींस के उपयोग ने तनाव के विरूद्ध बेहतर प्रदर्शन किया । इससे सोयाबीन के पौधों में तनाब सहिष्णुता के लिए इस वियोजक की एक महत्वपूर्ण भूमिका सिद्ध होती है ।
- राइजोबिया एवं ए.एम.एफ. के मिश्रण का 75% संस्तुत उर्वरक के साथ उपयोग करने पर उत्पादन 100% संस्तुत उर्वरक से बेहतर पाया गया । ब्रैडीराइजोवियम डाक्वीजींस के एकल प्रयोग से भी उत्पादन में समानता पाई गई । इस प्रकार ब्रैडीराइजोवियम डाक्वीजींसके प्रयोग से

उत्पादकता को प्रभावित किए बिना 25% नाइट्रोजन उर्वरको के उपयोग को कम किया जा सकता है ।

- संस्थान द्वारा किसानों को जलवायु परिवर्तन के अनुकूल कृषि तकनीकियों से संबंधित अनेक प्रशिक्षण कार्यक्रम आयोजित किए जाते हैं । कीटों के प्रकोप पूर्वानुमान एवं इसकी जानकारी किसानों को समय–समय पर उपलब्ध कराई जाती है । इस सूचना को सोया ज्ञान एप पर भी प्रसारित किया जाता है।

1. EXECUTIVE SUMMARY

- Soybean genotypes *viz*., NRC 132, NRC 142, NRC150, NRC 151, NRC152 and NRC 153 were developed aiming at food grade characteristics and are being evaluated under AICRP trials.
- Soybean genotypes, NRC 148 and NRC 149 bred for high oil content are being evaluated under AICRP trials.
- Early maturing genotypes *viz*., NRC 138, NRC 150, NRC 151, NRC 152, NRC 153, NRC 155, NRC 156, NRC 158 and NRC 159 are under AICRP trials.
- Mungbean Yellow Mosaic India Virus (MYMIV) resistant genotypes, NRCSL 1 and NRCSL 2 are being evaluated under AICRP trials.
- Two photo-insensitive genotypes, NRC 130 and NRC 131 and two drought tolerant genotypes, NRC 136 and NRC 137 are being evaluated under AICPP trials.
- NRC 128 having high yield potential, water logging tolerance, MYMIV resistance and moderately resistance to charcoal rot disease being evaluated under AICRP trials.
- Twelve vegetable soybean genotypes were identified for carrying fragrance allele; of these, eleven genotypes namely AGS 328, AGS farm accession, AGS 457, AGS 459, Demame, EC 916032, EC 916033, EC 916034, EC 916035, EC 916036 and EC 916039 possess FG_Indel2139 allele and one genotype VRPH 1961, possesses rare SNP allele FG_SNP2213.
- Screening for salinity tolerance in collaboration with CSSRI, Karnal, led to the identification of five genotypes namely IC 195, TGX 849-309D, Type 49, EC 341115 and UPSM 862 as salt tolerant at EC=8 dS^{m-1} of irrigated water.
- Based on agro-morphological and physiological traits, NRC 146, JS 20-38 and JS 20-98 were found to be high temperature tolerant.
- Germplasm line EC 538828 found tolerant to drought conditions based on seedling survival after root exposure to air under hydroponics system.
- Screening technique for water logging tolerance at vegetative stage was standardized by keeping 10 cm of water level for 10 days at V_2 stage and it was found efficient in differentiating water logging tolerant and susceptible genotypes.
- Genotypes viz., Hardee, TGX 317-37 E, EC 291400, EC 313974, Sel 1-34, EC 93601, TGX 825-1E, JS 20-38, NRC 128 and NRC 131 were identified as water logging tolerant at vegetative stage when screened under controlled condition in a water logging structure.
- Phenotyping of GWAS panel (N=300) for drought, heat and water logging tolerance

revealed TGX 849-143 D, JSM 288, EC 291400 and VLS 75 as drought tolerant based on drought resistance index (DRI) on grain yield and genotypes, EC 456556, EC 95815, JSM 288 and JS 75-46 as water logging tolerant based on percentage yield reduction. Accessions viz., EC 456556, EC 39177, EC 251388, EC 396065 and TGX 317-37 E found heat tolerant based on percentage reduction in yield.

- A new SNP marker, Gm1942921997 was identified to be linked with plant height and number of nodes in an early maturing genotype IC15089. This marker will help in the development of early maturing genotypes with agronomically desirable plant height.
- Genetics of anthracnose disease resistance in three F_2 crosses viz., EC 34372 × JS 95-60, EC 457254 × JS 95-60 and AKSS 67 × JS 95-60 revealed that the resistance in each of the three resistant sources viz., EC 34372, EC 457254 and AKSS 67 was governed by two major genes interacting in complementary mode.
- Two CRISPR (clustered regularly interspaced short palindromic repeats) vectors were designed for targeted silencing of *RPG1B* and *PDH1* genes involved in bacterial blight resistance and seed shattering mechanism, respectively.
- *Agrobacterium rhizogenes* strains, MTCC 532 and MTCC 2364 were characterized for the presence of Ri Plasmid genes, RolA and RolC by Polymerase Chain Reaction.
- Antixenotic studies in soybean genotypes against *Spodoptera litura* revealed that genotypes PR 15-126-3-8, PR 35 and DSb1 exhibited strong antixenosis. Similarly, antibiosis studies revealed EC 333902 exhibiting highest antibiosis against *Spodoptera litura*.
- Based on biochemical analysis of endophytes viz., *Aspergillus flavus, Fusarium falciforme, Macrophomina phaseolina* and strains of *Fusarium* spp were found to produce certain enzymes such as chitinase, cellulose, amylase and protease that are suitable candidates for management of these major soybean pathogens.
- Molecular characterization of 43 isolates of *Macrophomina phaseolina* has been done using ITS 1 and ITS 4. Aligned sequence of ITS 1 and ITS 4 were submitted and published through NCBI gene bank.
- Direct sowing of soybean in *kharif* and wheat and maize crops in *rabi* sown with broad bed furrow machine in permanent broad bed furrow system without tillage resulted in increased crop productivity in the changing weather scenario along with stability in production. In the permanent broad bed furrow system, 50% of the soybean crop residue was left in the field during the subsequent *rabi* season followed by 50% of the gram, 30% of the wheat and maize crop residue was left in the field during the subsequent *kharif* season resuted in not only increasing the productivity of soybean-based cropping systems but also improves the soil health.
- A novel rhizobial strain, *Bradyrhizobium daqingense* (isolated from drought-tolerant line PK 472) was evaluated on soybean under low moisture stress conditions to enhance nodulation, growth and physiological status of plants. Application of B. daqingense improved plant fitness against stress, performed better under both the conditions than all other strains that signify the role of this inoculant in stress tolerance of soybean plants.

- Under field evaluation, co-inoculation of rhizobia with AM fungi at 75% RDF although produced significantly higher yield than control (100% RDF) and commercial strains of rhizobia and AMF but the response was statistically at par with single inoculation of *B. daqingense*. Hence, inoculation of *B. daqingense* performed significantly when compared to local commercial strains available in the market and saved 25% use of N fertilizers without compromising the productivity.
- ICAR-IISR organised several training program for farmers regarding adoption of climate smart teschnolgies like, use of BBF, longer duration varieties and cafeteria approach to mitigate the climate change.
- Scientist of this institute developed forewarning model for insect pest incidence for Maharatra state and advisories were circulated and predisposed conditions were uploaded on soya gyan app.

2. INTRODUCTION

Indian Council of Agricultural Research (ICAR) was established the ICAR-Indian Institute of Soybean Research (IISR) 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 ICAR-IISR.

Physiography

ICAR-IISR campus is located 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.

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.

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, usually begins from mid June and extends up to early October. Generally duration of monsoon is approximately 98 days with about 800 mm mean annual rainfall and soybean is grown during this season as rainfed crop. (b) post-rainy season which runs from mid October to March, also known as rabi, is dry and cool and (c) warm and dry season, which begins in February and lasts until April May/June is called zaid or summer/spring and any crop grown during this season requires irrigation.

Past achievements

Major achievements of this Institute includes a vast collection of soybean germplasm comprising exotic, indigenous, breeding lines and wild species. Currently, 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 were identified for various traits like photoperiod insensitivity, drought tolerance, and resistance to diseases such as rust and YMV and insect pests. Genotypes with high oleic acid (NRC 106, IC 210), low linolenic acid (VLS 59), vegetable soybean genotypes (NRC 105), null kunitz trypsin inhibitor genotypes (NRC 101, NRC 102) have been developed at this institute.

High yielding varieties having 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. First Null KTI genotype in the country, NRC 127, has been identified for release in the Central Zone. Two germplasm accessions EC 390977 and MACS 330 having photoperiodic genes and early maturity traits were registered at ICAR-NBPGR, New Delhi.

In the field of crop production, *In situ* moisture conservation technology 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 cropping system were developed. Soil health enhancing microbes including Zn, Fe solubilizing bacteria and rhizobia have been identified. In the field of plant protection, integrated management schedule for major soybean insect pests were worked out. Studies on epidemiology of rust occurrence in soybean revealed that the source of rust inoculum for south India lies in the Krishna valley. The economic benefit of adoption of rust resistant varieties in rust prone districts of Maharatra and Karnataka states were estimated and widespread adoption of rust resistant soybean varieties significantly contributed to farm income and crop stabilization in the region. Web-based expert systems for varietal and disease identification and data management systems for AICRPS have been developed. Soybean Gyan- a mobile app for soybean farmers has been developed by the institute provides information on different aspect of cultivation viz., agronomic package of practices, insect and disease management etc. It also gives information about selection of suitable varieties; seed treatment seed rate and seed storage. Consequently, the Institute has emerged as a catalyzing force to facilitate rapid increase in acreage and production of soybean since 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.

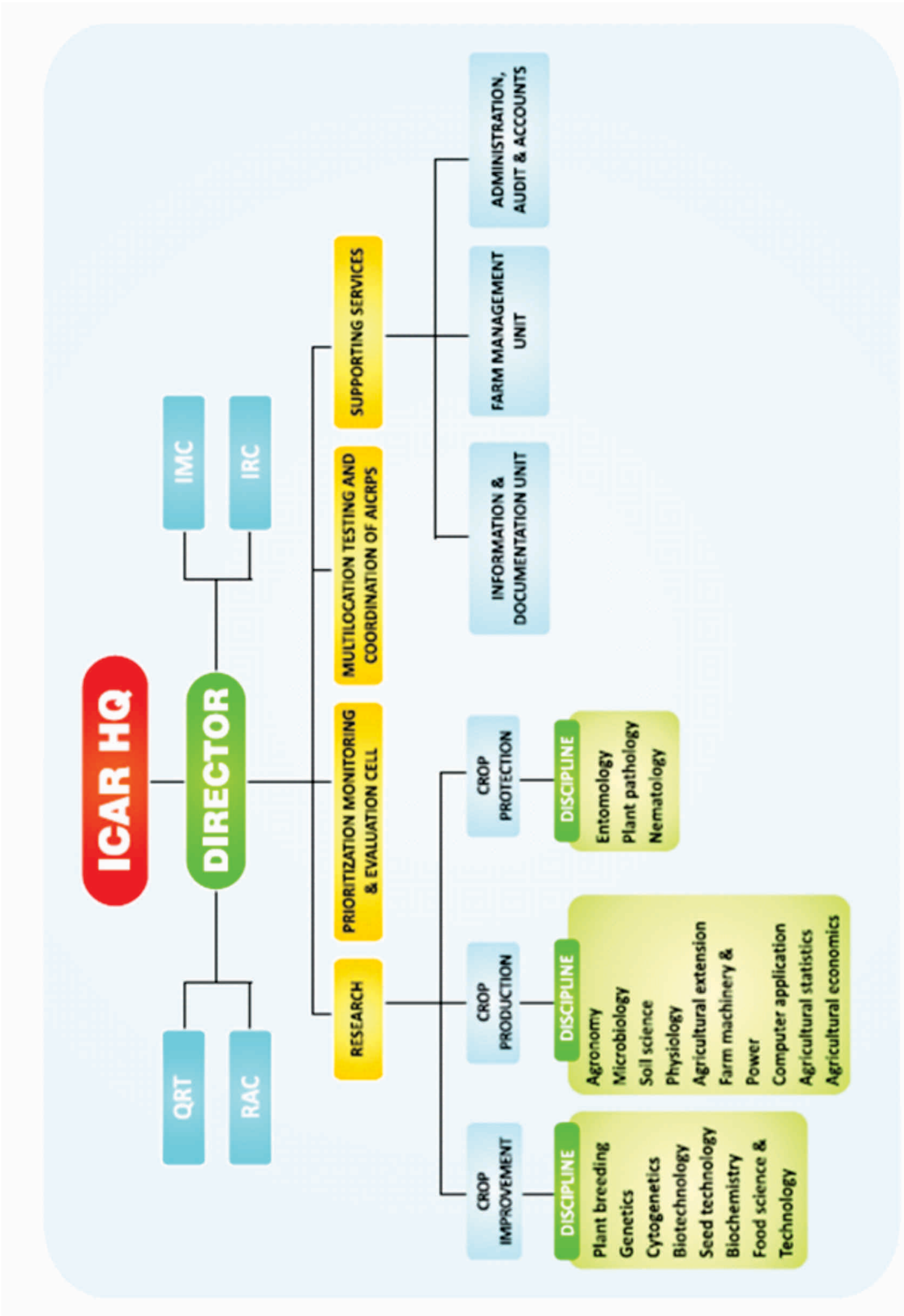
Mandate

Following are the mandate to support production systems research along with basic information and breeding material:

- 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

Organizational set-up

For efficient functioning of institute and to achieve the mandate and objectives, the organizational pattern of the Institute has been evolved and depicted below.



Organogram of ICAR-IISR

Library

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

Staff and budget

The total sanctioned staff position of ICAR-IISR as on 31 December 2019 is 82 comprising 37 scientific, 22 technical, 23 administrative and supporting positions. Out of which 69 are in positions as on 31 December 2019.

Budget and expenditure of ICAR-IISR for 01.04.2019 to 31.12.2019 (₹ in lakhs)

Head	ICAR-IISR grant	
	R. E.	Actual Exp.
Pay & Allowances	1180.71	977.47
T.A.	20.00	10.75
Other Charges Recurring	344.34	201.28
(a) Information Technology	6.30	3.40
(b) Equipments	20.00	1.85
(c) Works	7.97	3.97
(d) Library	3.90	0.40
(e) Furniture & Fixures	1.83	0.65
(f) HRD	4.00	1.58
(g) Pension & Retirement Benefits	40.00	37.83
(h) Loans & Advances	26.00	25.50
(i)NEH	40.49	30.36
(j)TSP	5.00	2.50
(k)SCSP	5.00	3.39
Total	**1705.54**	**1300.93**

3. GENETIC RESOURCES: CONSERVATION, CHARACTERIZATION AND UTILIZATION

Augmentation and characterization

In effort to augment soybean germplasm collection, core collection of USDA has been imported and post entry quarantine (PEQ) of 763 accessions has been completed by ICAR-NBPGR in association with the institute. These accessions have been received from ICAR-NBPGR, New Delhi for multiplication and subsequent deposition in long-term storage (LTS) at NBPGR. In off-season, under first round of multiplication, five hundred forty eight of these accessions are being multiplied in glass house in at ICAR-IISR Indore and rest at University of Agricultural Sciences, Bangalore. Eight hundred twenty seven new germplasm comprising those from USDA, AVRDC, Canada, NBPGR-Bhowali centre are under evaluation and characterization.

Quarantined USDA germplasm under first round of multiplication in glass house at ICAR-IISR Indore

Deposition of germplasm in long-term storage and getting national identity

ICAR-IISR received 112 bold seeded vegetable soybean accessions from AVRDC, Taiwan after quarantine at ICAR-NBPGR, New Delhi. Eighty-five of these accessions have been deposited in LTS. Institute sent 1490 accessions for deposition in LTS during 2018 and received IC numbers for 704 accessions which were without national identity. In 2019, 489 accessions were deposited at NBPGR for allotment of IC numbers for 365 accessions.

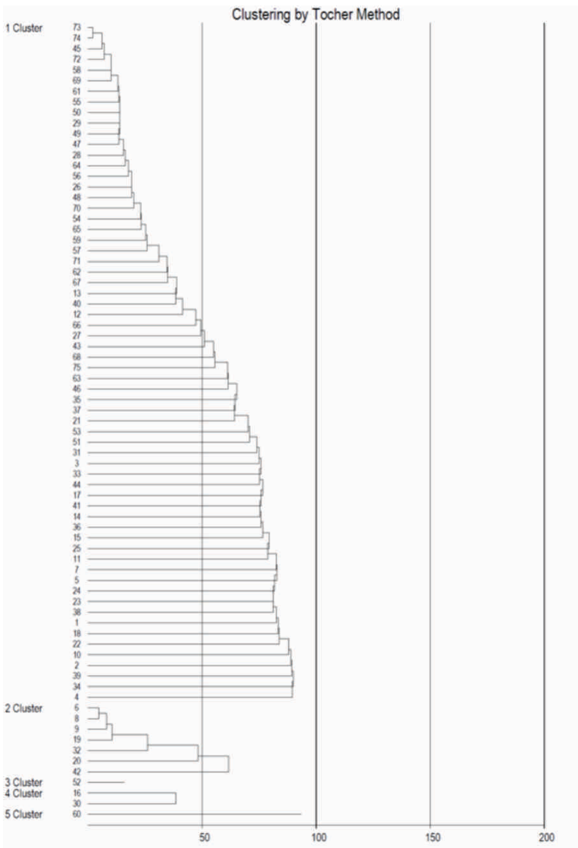
Conservation and maintenance of germplasm and trait specific panel

Four thousand fifty germplasm accessions are being conserved in medium term storage (MTS) of ICAR-IISR. Part of the core collection set (180 accessions) and 1443 old accessions were rejuvenated. Trait specific germplasm set having 322 accessions for characters like photoinsensitivity, long juvenility, drought tolerance, YMV resistance, disease resistance, rust differentials, antibiosis to *spodoptera*, insect tolerance, vegetable type, early maturity, bold seeded, small seeded, salt tolerance, high seed longevity, high yielding, high oil, low linolenic acid, null KTI, Lox 2 free, high protein, high oleic, low lipoxygenase and less mechanical damage were maintained and multiplied for distribution to soybean workers in India. In addition to trait specific panel, allelic panel comprising 13 accessions with known E genes, 3 accessions with salt tolerant alleles, two accessions with known hard seededness alleles and two accessions with known long juvenile alleles were maintained and multiplied.

4. BREEDING FOR EARLY MATURITY, HIGHER YIELD, WIDER ADAPTIBILIY AND FOOD-GRADE CHARACTERS

Evaluation of advanced breeding lines yield and attributing traits

Sixty-nine advanced breeding lines derived from diverse crosses were evaluated for yield and attributing traits. Group Balanced block design was followed to evaluate early, medium and late maturing genotypes seperately. Genotypes were grouped into three blocks each with 23 genotypes and two checks in each block (early maturity-JS 20-34 and JS 95-60: medium maturity- NRC 86 and JS 20-29 and late maturity- JS 20-69 and JS 97-52) were used to compare the genotypes. Some of the promising genotypes were identified for further evaluation in station trial. Further, diversity analysis was performed and the results were presented below.



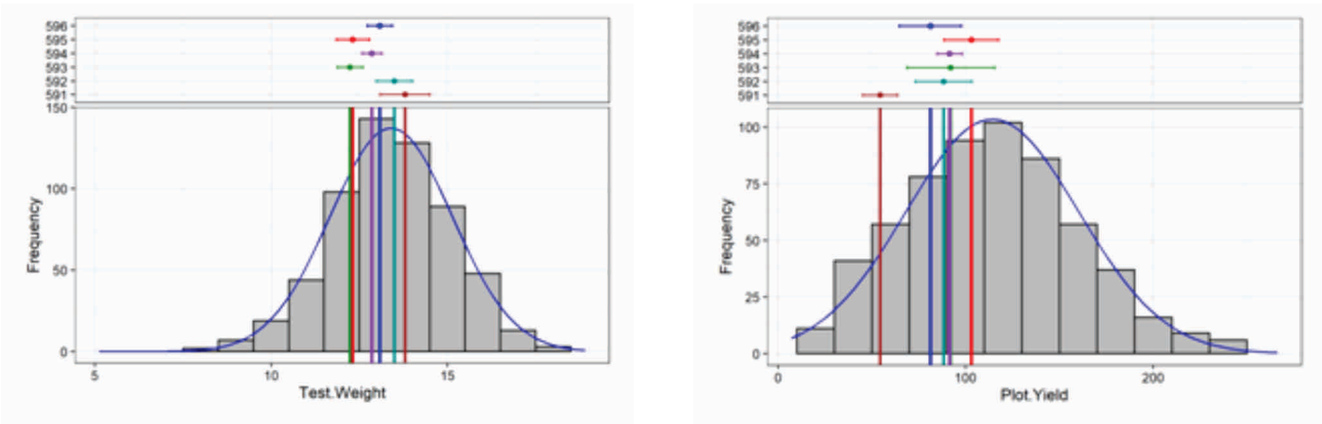
Evaluation of NRC 128 in AICRPS trial

NRC 128 genotype having high yield, water logging tolerance and MYMIV resistance was evaluated in AVT II in Eastern and North Plain Zone (NPZ). In Eastern Zone, it produced a mean yield of 1871 kg/ha which is 22.9% greater yield than best check JS 97-52 (1522 kg/ha) over the three years. Similarly, in NPZ the entry produced mean yield of 2268 kg /ha which is 20.2 % greater yield than best check PS 1347 (1887 kg/ ha). NRC 159 an entry having high oleic acid content

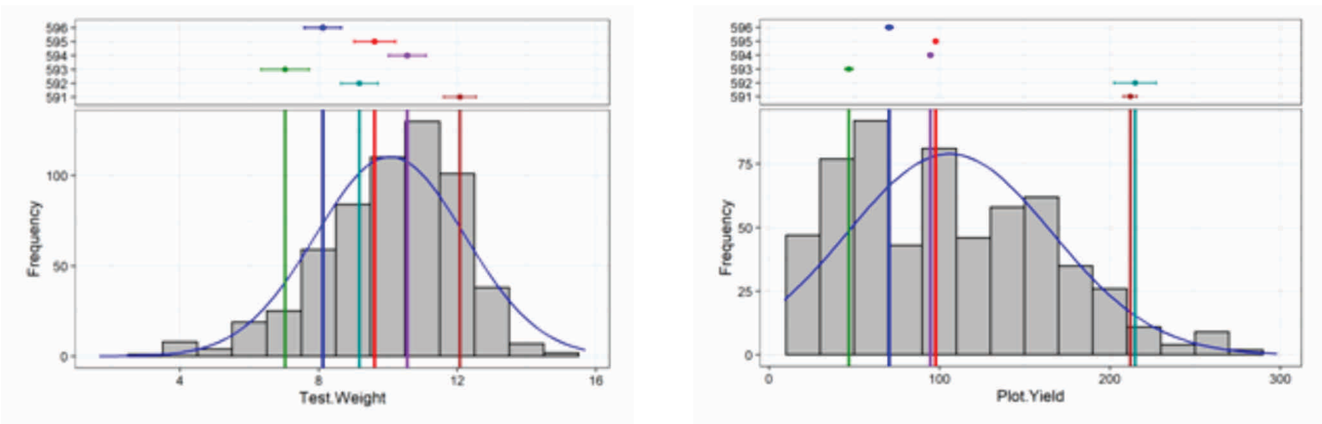
(>40%) along with early maturity was evaluated under IVT early trial during 2019.

Multi-location evaluation of soybean MAGIC population

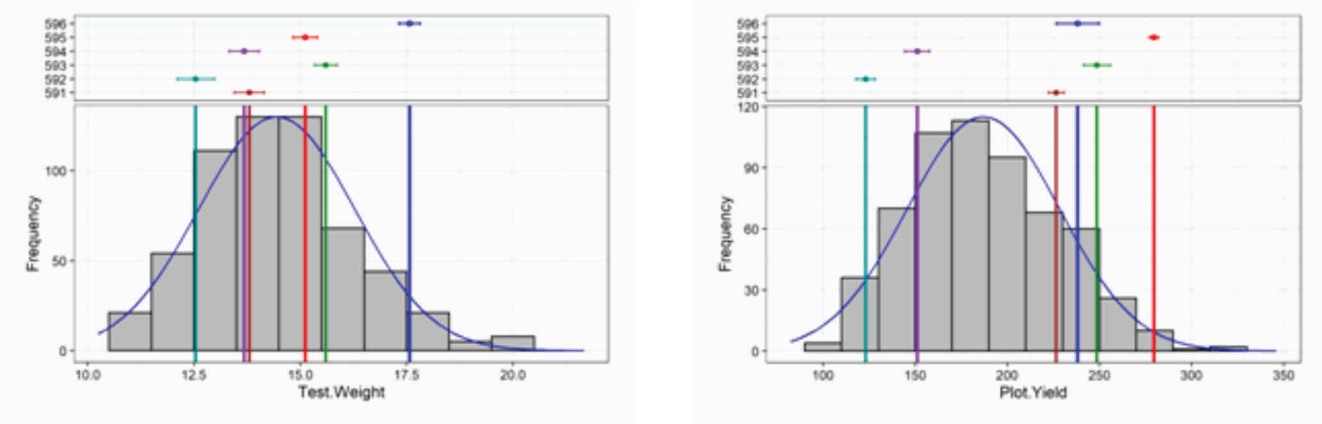
Soybean MAGIC population with 590 RILs along with six checks were phenotyped at four locations viz., Indore, Aghargar Research Institute (ARI) Pune, Adilabad and Parbhani for yield and attributing traits. 590 RILS were sown in augmented design and agronomic traits like days to flowering, days to maturity, no. of nodes per plant, no. of pods per plant; seed yield per plant and seed yield per plot were recorded in all the four testing centres. The significant variability was obtained for most of the parameters studied and frequency distribution for some of these traits is presented below for each four testing centre. a) Adilabad b) Indore c) Parbhani d) ARI Pune.



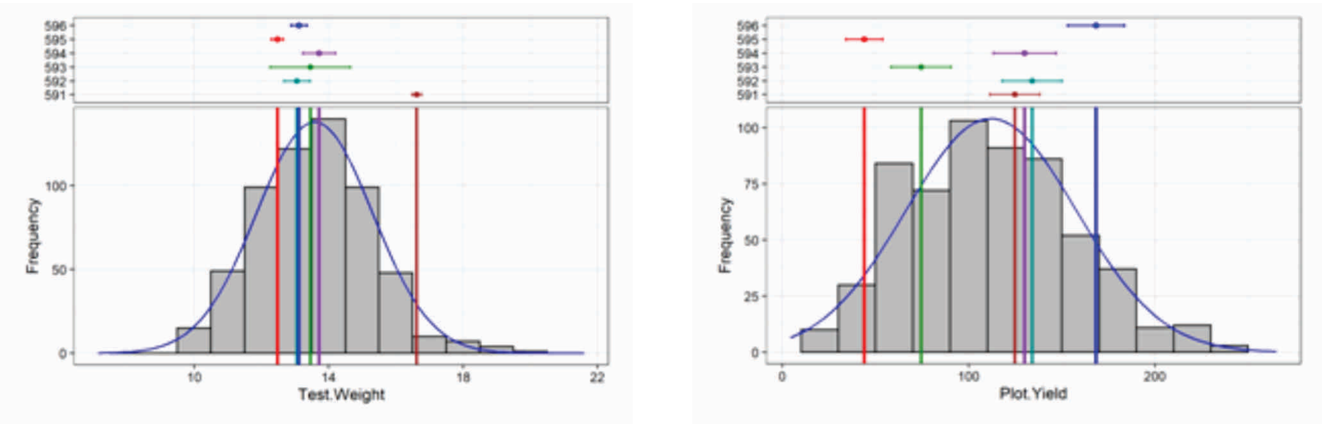
A. Frequency distribution of Test weight (100 seed weight) and Plot yield (g) in 590 MAGIC RILs at AICRP centre Adilabad, AP.



B. Frequency distribution of Test weight (100 seed weight) and Plot yield (g) in 590 MAGIC RILs at ICAR-IISR, Indore.



C. Frequency distribution of Test weight (100 seed weight) and Plot yield (g) in 590 MAGIC RILs at AICRP centre Parbhani.



D. Frequency distribution of Test weight (100 seed weight) and Plot yield (g) in 590 MAGIC RILs at AICRP centre ARI, Pune.

Hybridization, Selection and generation advancement

New crosses were attempted aimimg at development of high yielding; early maturity and hybridization were also carried out among bold seeded soybean accessions with Karune to develop vegetable type soybean genotypes. Thirty-five diverse cross combinations of F_2 populations having several agronomic traits viz., early maturity, insect resistance, anthracnose resistance, drought and water logging tolerance were advanced to F_3 generation. Selections and advancement of these crosses were made based on single plant yield, number of pods per plant and desirable plant height.

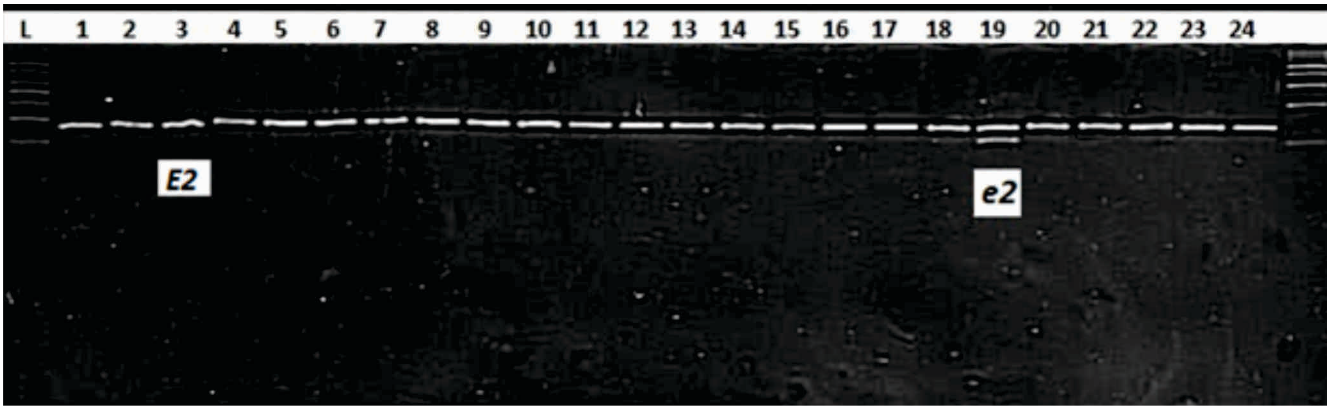
Breeding Soybean for Wider Adaptability using Photoperiod response and Growth Habit

Development of genetic stocks for *e2, e3, e4, e1-as* and Dt1 alleles

True F_1s for E_2 locus and heterozygotes were identified through for ground selection in BC1s and BC2s for *e3, e4, e1-as* and *Dt1* using CAPS, dCAPS and FLP markers. Identified plants were backcrossed with SL 958. Heterozygous BC2s were genotyped for recipient genome recovery and were found to have 92-94% genome from SL 958.

Identification of Hybridity confirmation of F_{1s}, BC_1F_{1s} and BC_2F_{1s}

Cross	Generation	Allele	Number of heterozygous plants	Marker Used
SL958 × JS 20-34	F_1	*e2*	6	dCAPS (*e2*)
SL958 × EC 538828	F_1	*e2*	2	dCAPS (*e2*)
SL958 × (SL958 × JS 20-34)	BC_1	*e2*	2	dCAPS (*e2*)
SL958 ×SL958 (SL958 × JS 95-60)	BC_2	*e1-as*	8	dCAPS (*e1-as*)
SL958 × SL958 (SL958 × EC 390977)	BC_2	*e4*	3	FLP (*e4-SORE*)
		e3	4	FLP (*e3-tr*)
		Dt1	7	dCAPS (*dt1-bbI*)



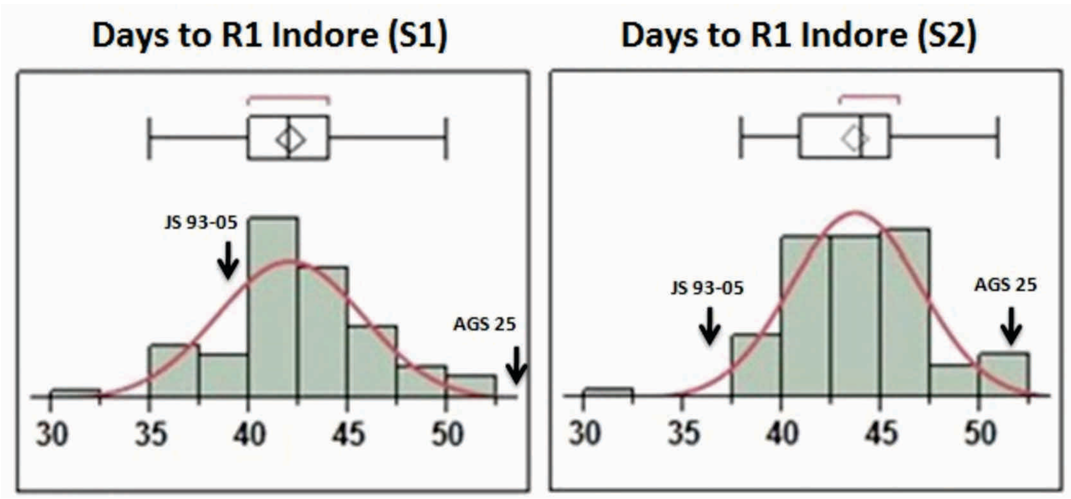
Identification of true hybrid for E_2 locus in F_1 and for heterozygotes in BC_1s and BC_2s for *E3*, *E4*, *E1* and *Dt1* loci.

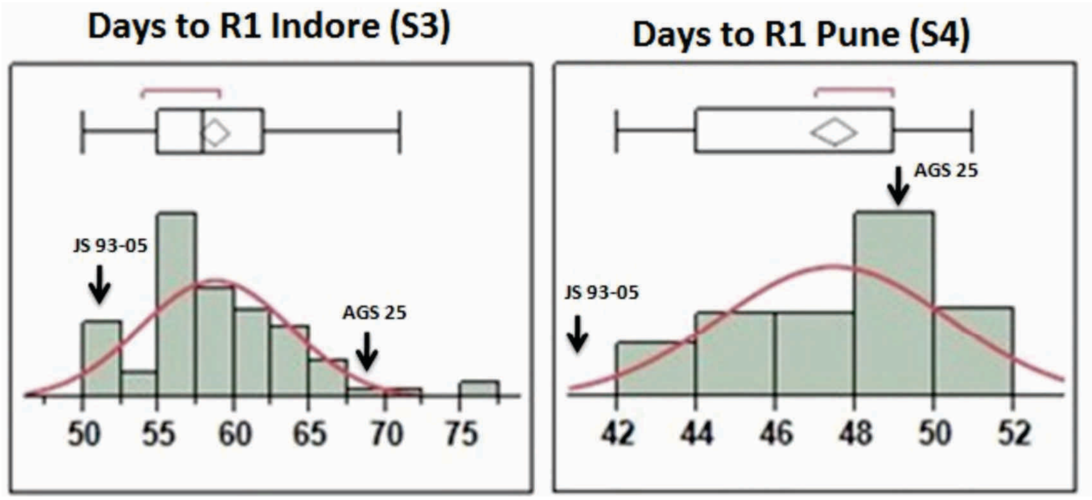
Background selection in heterozygous BC_2 plants.

Cross	Allele	Number of plants	Rang of recipient genome (%)	Mean (%)	Plants number with maximum recipient genome
SL 958 × SL 958 (SL958 × JS 95-60)	*e1-as*	8	91.5-96.7	94.1	3
SL 958 × SL 958	*e4*	3	91.0-92.9	91.95	1
(SL 958 × EC 390977)	*e3*	4	91.4-95.8	93.6	3
SL 958 × SL958 (SL 958 × EC 390977)	*Dt1*	7	91.5-97.0	94.25	1

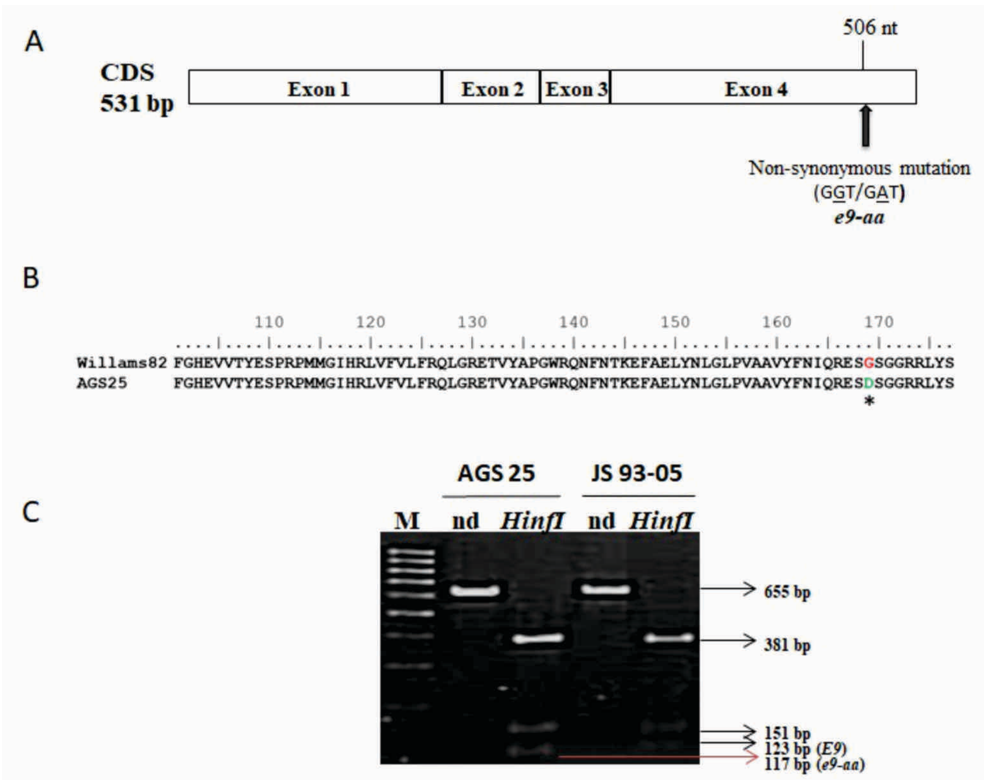
Identification of new allele of long juvenility locus e9

Recessive allele at E9 locus confers long juvenility. A RIL population developed from the cross of long juvenile line AGS 25 and conventional juvenile variety JS 93-05 was evaluated under four sowing environments (S1: Indore 4th July, S2: Indore 21st July, S3: Indore 18th December and S4: Pune 15th July). Variation for days to R1 was observed in all of the four environments. Single marker analysis and inclusive composite interval mapping identified a QTL on chromosome 16. This QTL was delimited between SSR markers BARCSOYSSR_16_1012 and BARCSOYSSR_16_1014 and explained up to 27% of phenotypic variance for days to flower. AGS 25 contributed for late maturing QTL with the additive effect of up to 3.6 days. The BARCSOYSSR_16_1014 with the highest LOD peak was very close to Glyma.16g150700, a previously reported long juvenile gene E9. Sequencing of entire CDS of AGS 25 for Glyma.16g150700 and its alignment with William 82 identified a single mis-sense base mutation at 506 position which resulted in the non-synonymous substitution of Glycine with Aspartic acid at 169th position in the fourth exon. Bioinformatic tools predicted this mis-sense mutation (G169D) to have deleterious effects on FT2a protein function. This mutation resulted in reduced melting temperature of the product and created a new restriction site. Two new markers, e9-HRM and e9-CAPS were developed for molecular breeding. QTL analysis using e9-HRM identified the QTL between this marker and BARCSOYSSR_16_1014. Results from RIL were validated in two independent F2s in two environment using newly developed markers.

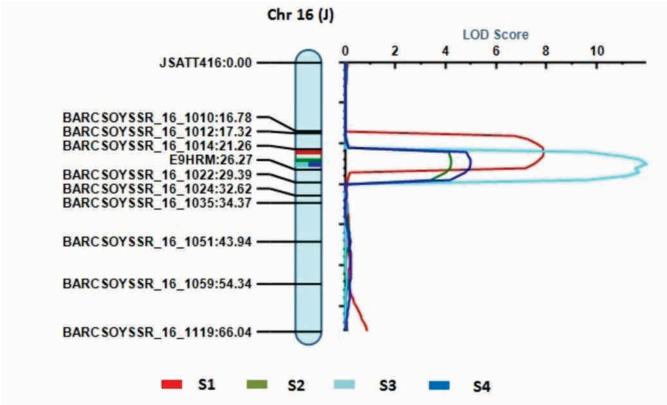




Distribution of days to R1 in RILs. (A) days to R1 Indore (S1) sown on 4th July, 2018; (B) days to R1 Indore (S2) sown on 21st July, 2018; (C) days to R1 Indore (S3) sown on 18th December, 2018; (D) days to R1 Pune (S4), sown on 15th July, 2018



Novel allele (*e9-aa*) of E9 locus in long juvenile soybean genotype AGS 25. (A) Position of *e9*-aa (B) Predicted changes in amino acid sequence, asterisks indicate substituted amino acid.
(C) CAPS marker distinguishing recessive allele of long juvenile genotype AGS 25 (*e9-aa*) from conventional juvenile genotype JS 93-05 (*E9*), nd-not digested.



Detection of QTL for long juvenility determined by SSR markers and newly developed *e9-HRM* marker on LG J using JS 93-05 x AGS 25 RILs. Days to R1 (S1) sown on 4th July, 2018 at Indore; (S2) sown on 21st July, 2018 at Indore; (S3) sown on 18th December, 2018 at Indore and (S4) sown on July, 2018 at Pune. Genetic linkage map, marker names and genetic distances (cM) are displayed on the left side of the graph.

QTL analysis results of inclusive composite interval mapping (ICIM) in RILs population

Sowing Environments	Left marker name	Right marker name	LOD value	% Phenotypic variance	Additive effect
S1: Indore sowing 4th July 2018	BARCSOYSSR_16_1012	BARCSOYSSR_16_1014	6.72	26.51	2.18
S2: Indore sowing 21st July 2018	BARCSOYSSR_16_1012	BARCSOYSSR_16_1014	3.53	14.68	1.28
S3: Indore sowing 18th December 2018	BARCSOYSSR_16_1010	BARCSOYSSR_16_1012	11.96	18.61	3.53
S3: Indore sowing 18th December 2018	BARCSOYSSR_16_1012	BARCSOYSSR_16_1014	12.43	19.50	3.62
S4: Pune sowing 15th July 2018	BARCSOYSSR_16_1012	BARCSOYSSR_16_1014	4.00	16.25	1.34

QTL analysis results of inclusive composite interval mapping (ICIM) in SL 958 x AGS 25 population after including newly developed gene specific marker e9-HRM

Traits	Linkage group	Left marker name	Right marker name	LOD value	% Phenotypic variance	Additive effect
S1	J	e9-HRM	BARCSOYSSR_16_1012	12.87	26.67	-2.02
S3	J	e9-HRM	BARCSOYSSR_16_1014	4.25	11.94	-2.42

Breeding for food grade characteristics

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.

Following are the crosses attempted to develop soybean genotypes having food grade character along with high oil content.

(JS 95-60 ×SL958) × (JS 95-60 × NRC101)
AMS5-18 × NRC101 *(titi)*
AMS5-19 × NRC101 *(titi)*
AMS5-8 × NRC127 *(titi)*
AMS100-39 × NRC127 *(lx2lx2titi)*
AMS100-39 × NRC142 *(lx2lx2titi)*
NRC127 *(titi)* × RAUS 5
NRC 7 × NRC142 *(lx2lx2titi)*
JS 20-34 × VKlox15 *(lx2lx2)*
JS 20-98 × VKlox15 *(lx2lx2)*

Number of genotypes are being evaluated under AICRP trials viz., NRC 132, a lipoxygenase 2 free genotype and NRC142, a genotype free from lipoxygenase 2 and Kunitz trypsin inhibitor is the first soybean genotype free from antinutritional factor KTI with reduced beany flavour. NRC150, an early lox 2 free and high oil genotype and NRC 151, an extra early high protein and lox3 free genotype were evaluated in IVT, 2019. One more genotype NRC 152, a extra early and free from lox2 and KTI genotype was evaluated in IVT, 2019. Similarly, for oil content NRC148 genotype has been evaluated in AVT I in Central Zone and Eastern Zone. NRC 153, a extra early and free from lox2 and Lox3 genotype has developed and being evaluated in IVT, 2019.

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

F_6 generation of the crosses IC 210 × P4-19, NRC 106 × NRC 105, IC 210 ×NRC 105; NRC 106 × IC 210, NRC 106 × HO2 (Hardee × NRC7), LSb1 × NRC7 × IC210, NRC 105 × LSb1 × IC210, HO31 (Hardee × NRC 7) × IC210, IC210 × H3-9, LSb1 × IC 210, IC 210 × P4-4 (derived from LSb 1 × NRC7); NRC 106 × LSb 1 × NRC 7; H3-9 (derived from Hardee × NRC 7) × AGS 191 were raised in the field in the cropping season (2019).

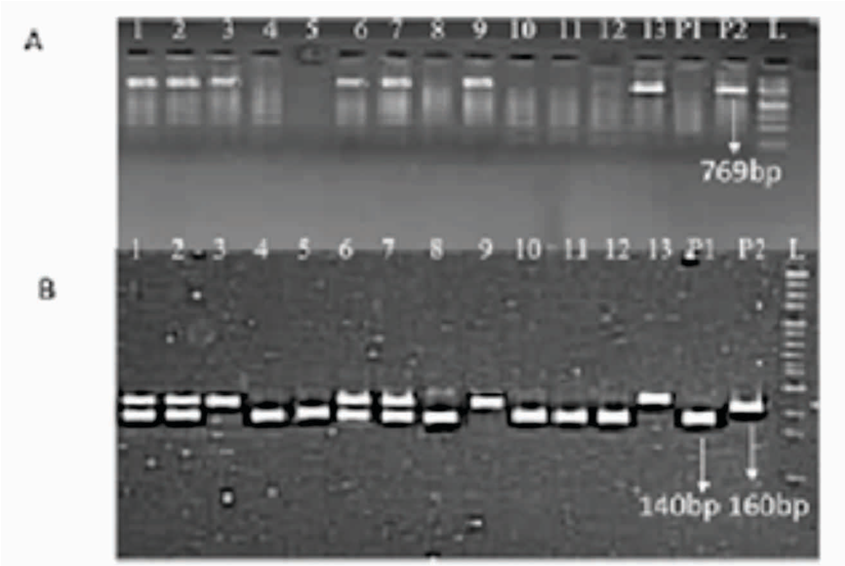
Field data showed significant variation inthe morphological traits, namely, days-to-flowering and days-to-maturity of these breeding lines. Gas chromatographic analysis of F6:7 seeds of IC 210 × P4-19 and NRC106 × IC210 revealed lines with 60%±5 % oleic acid content. Only those soybean lines of the above-mentioned crosses from the previous generation were sown which showed oleic acid content 60±5 %. Some of the F5:6lines of the each of the above crosses showed oleic acid about 60%. Genotypes P4-19 and P4-4 used in these crosses as one of the parents are the recombinant inbred lines with high oleic acid content derived from LSb 1 × NRC 7. F4 generation of the crosses effected between pair of RILs (P6-13, P4-19, P4-4, P3-21) derived from LSb 1 × NRC 7 were raised this year also and the analysis of F5 seeds so obtained for oleic acid content is underway.

Accelerated development of Kunitz trypsin inhibitor (KTI) free soybean genotypes with charcoal rot resistance

The objective of the project is to introgress null allele of Kunitz trypsin inhibitor into charcoal resistant lines AMS 5-18 and AMS 5-19. Crossing has been been attempted for the cross combinations AMS 5-18 × NRC 101 and AMS 5-18 × NRC 127. Hitherto, parental polymorphism survey of the parental combinations AMS 5-18 × NRC 101, AMS 5-19 × NRC 101, AMS 5-18 × NRC 127, AMS 5-19 × NRC 127 has been carried out using 47 SSR markers of the Ti locus chromosome 8 (linkage group A2), which revealed 10, 9, 21 and 17 polymorphic SSR markers respectively.

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

In *Kharif* 2019, BC_2F_2 seeds for JS 97-52-derived KTI free line × NRC 109 and NRC 7-derived KTI free line × NRC 109 were sown in the field and the plants carrying null alleles of Lox2 and KTI were confirmed using null allele specific marker for Kunitz trypsin inhibitor and lipoxygenase-2 gene. Homozygous recessive (titilx2lx2) plants were confirmed using linked SSR markers Satt228 (Ti locus) and Satt656 (Lox2 locus) for Kunitz trypsin inhibitor and lipoxygenase-2, respectively. Recovery of recurrent parent genome (RPG) in homozygous recessive BC_2F_2 plants for both traits is being assessed using polymorphic SSR markers.



Amplification of null lox2 allele specific marker (A) and lox2 linked SSR marker, Satt656 (B) in BC_2F_2 plants of NRC 7-derived KTI free line×NRC 109. Lane 1, 2, 6 and 7 corresponds to heterozygous plants and lane 3, 9 and 13 corresponds to homozygous recessive BC_2F_2 plants. P_1 and P_2 corresponds to NRC 7 and NRC 109, respectively; lane L corresponds to 50bp ladder.

5. ABIOTIC STRESSES

Breeding for drought tolerant varieties

Hybridization

Multi-parent hybrids having drought tolerant parent(s) were crossed with a charcoal rot resistant genotype AMS 5-18 for incorporating resistance to charcoal rot, a prominent disease which appears under drought or drought like conditions. Earliness being a prime objective in Central India, hybridizations were realized by crossing four-way hybrids having drought tolerant parent(s) with early maturing genotypes (JS 20-34, JS 95-60 and NRC 7).

Hybridization for developing varieties with earliness, charcoal rot resistance, wider adaptability and enhanced drought tolerance traits

Details of the crosses	Targeted trait (s)
[(JS 335 × PI 416937) × EC 538828) × SL 958]×AMS-MB-5-18	charcoal rot and drought
[(PK 472 × JS 335) x (EC 602288 × EC 390977)) × JS 20-38] × AMS-MB-5-18	charcoal rot and drought
[(NRC 37 × JS 97-52) × EC 572154) × VP 1165] × DSb 32	Anthracnose and drought
[(NRC 37 × JS 97-52) × EC 572154) × SL 958] × JS 20-34	Earliness and drought
[(C-2797 × JS 71-05) x JS 20-34) × SL 979] × JS 20-34	Earliness and drought
[(EC 602288 x EC 390977) × JS 20-34) × SL 979] × JS 20-34	Earliness and drought
[((EC 602288 x JS 90-41) × PI 416937) × DS 3105] × JS 95-60	Earliness and drought
[(EC 602288 x JS 71-05) × EC 538828) × DS 3106] × JS 95-60	Earliness and drought
[(EC 602288 x JS 90-41) × EC 572086) × DS 3105] × NRC 7	Earliness and drought
Line 104-2# (JS97-52 × JS 90-41) × JS 335	Wider adaptability
(EC 602288 × Young) × NRC 7	Drought tolerance

#Line 104-2: F_7 (JS 97-52xJS 90-41)

Early generation advancement

Given the potential benefits of MAGIC populations, eight-way inter-cross hybrids were advanced to segregating F_2 generation. These multi-parent inter-cross hybrids were derived from drought tolerant parents EC 602288, Young and C-2797, photo-insensitive parent EC 390977 and five varieties viz. JS 97-52, JS 71-05, PK 472, JS 335 and JS 90-41.

Pedigree of F_2 generation of eight-way cross combinations

Cross combinations
[(PK 472×JS 335)×(EC 602288×EC 390977)] ×[(Young × JS 335)×(JS 97-52×JS 90-41)]
[(JS 335×Young)×(EC 602288×JS 90-41)] × [(C-2797×JS 71-05)×(PK 472×JS 335)]
[(C-2797×JS 71-05)×(PK 472×JS 335)] × [(PK 472×JS 335)×(EC 602288×EC 390977)]
[(Young ×JS 335)×(EC 602288 × JS 90-41)] × [(Young × JS 335)×(JS 97-52×JS 90-41)]
[(PK 472×JS 335)×(EC 602288×EC 390977)] × [(Young × JS 335)×(EC 602288×JS 90-41)]

A total of 50 four-way crosses were advanced to F_2 generation to achieve suitable combinations of traits of MYMV resistance (SL 958, SL 979, DS 3105, DS 3106), insect tolerance (VP 1165), earliness (EC 572086, EC 572154, EC 771186, JS 20-34, EC 538828, EC 77147, RVS 2001-18), photoinsensitivity (EC 390977), wider adaptability (JS 335) and drought tolerance (JS 71-05, EC 602288, EC 538828, PI 416937, JS 97-52, C-2797, Young, PK 472, lines 107-70, 104-57rt, 70-4 and 20-2Drt).

Chemical desiccation as a method of advancing generations

Stem reserve mobilization (SRM) trait contributes to drought tolerance during low soil moisture stress at seed filling stage. Spraying potassium iodide (KI 0.2%) during seed filling, as a chemical desiccant, disintegrates photosynthesis assembly in plants and promotes mobilization of stem reserves determining seed size. This phenomenon was used as a method of advancing generations. F_2 populations of 13 biparental, 17 three-way and 5 four-way crosses, derived from drought tolerant parents C-2797, EC 602288, JS 71-05, PI 416937, PK 472, Young, JS 97-52, EC 538828, Hardee, NRC 7, lines 70-4, 104-32rt, 104-57rt, 20-2Drt, (wider adaptability parent) JS 335, EC 390977 (photo-insensitivity parent), DT 21 (photo-insensitivity and long juvenility parent) and varieties NRC 2, NRC 37, JS 90-41, RVS 2001-18, JS 20-38, were advanced to F_3 generation by selecting for SRM trait based on larger seed size.

Earliness and SRM traits were explored in 7 F_2 populations, derived from three-way crosses of drought tolerant parents (JS 97-52, EC 602288, JS 71-05, C-2797), photoinsensitivity parent (EC 390977), early maturing parents (EC 572086, EC 572154, EC 771186, JS 20-34) and varieties (NRC 2, NRC 37 and JS 90-41). These populations were advanced to F_3 generation. Four advanced backcross populations were screened for SRM trait during generation advancement.

Advancing F_3 and advanced backcross populations for earliness and SRM traits

F_3 populations	**Trait**
(NRC 37 × JS 97-52) × EC 572086	SRM, earliness
(NRC 37 × JS 97-52) × EC 572154	
(EC 602288 x JS 90-41) × EC 771186	
(NRC 2 × JS 71-05) x EC 771186	
(C-2797 × JS 71-05) × JS 20-34	
(EC 602288 × EC 390977) × JS 20-34	
(EC 602288 × NRC 2) × JS 20-34	
Backcross populations	
BC1F4 (AGS 25 × PK 472) × PK 472	SRM
BC1F4 (Line 70-4 × JS 71-05) × JS 71-05	
BC2F5 [PK-472 × (PK 472 x AGS 25)] × PK 472	
BC2F5 [(JS 90-41 × Hardee) x JS 90-41] × JS 90-41	

Line 70-4: F_5 (JS 71-05 × C 2797)

Elite lines in coordinated trial

Two elite drought tolerant lines NRC 136 and NRC 137, derived from a cross JS 97-52 × NRC 37, have been evaluated in AVT-II of coordinated trial in Eastern Zone during kharif 2019.

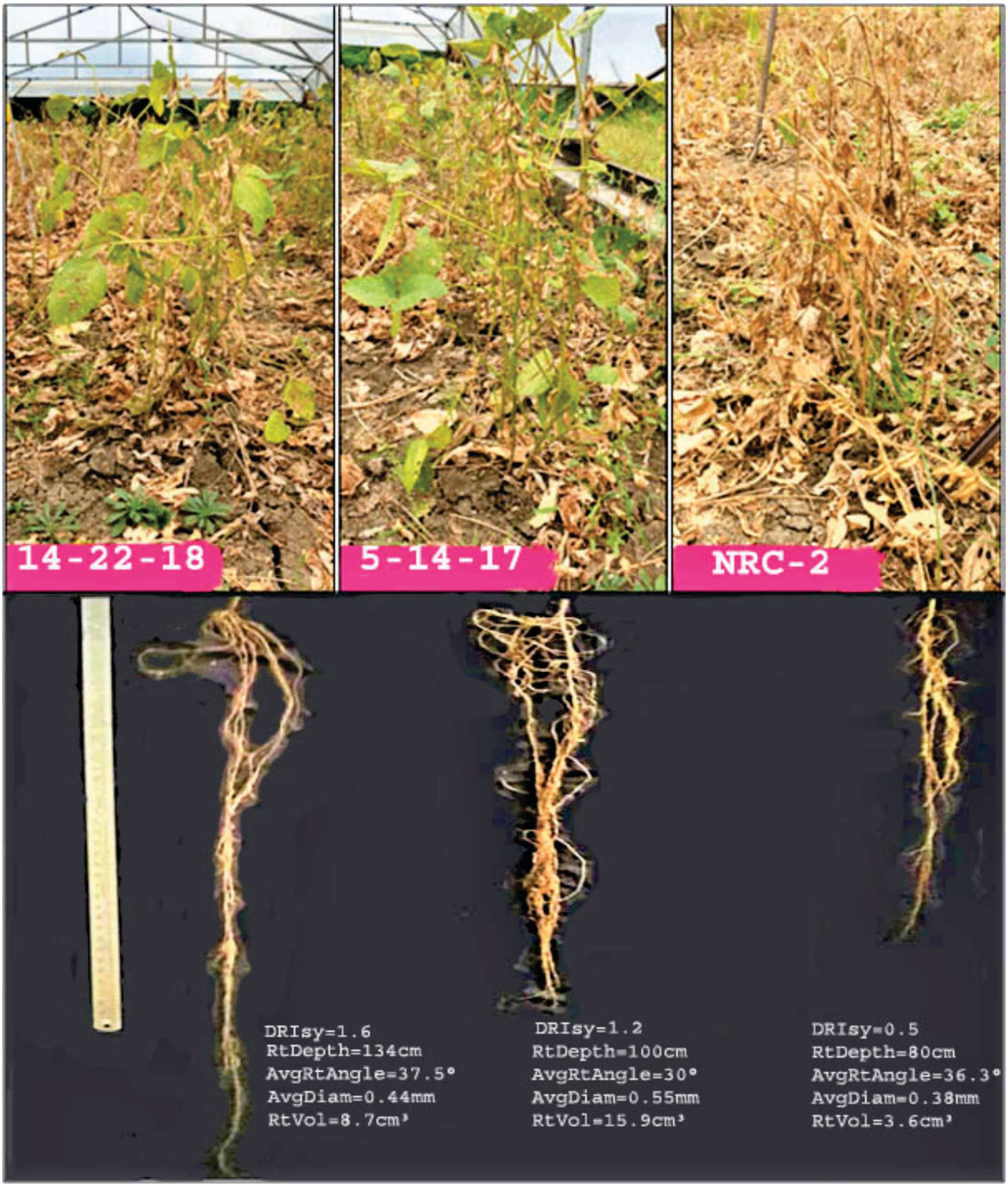
Evaluation for drought tolerance related traits

Soybean varieties having root systems extended around one meter limit their access to water during drought. Carbon through carbon dioxide from air is stored in the roots and leaves. The more carbon locked away in soil down to 2 meters, the more the croplands could reduce the annual rise in global CO_2 levels in the atmosphere, helping fight global warming. Doubling root biomass to a nominal two meters would make crops more drought resistant. A total of 37 genotypes (29 lines and 8 accessions) were evaluated. Variation was captured with a wide range in constitutive root system architecture (RSA) traits viz. rooting depth (45–162cm), root length (708–7907cm), root length density (RLD) (0.01–0.16cm/cm3), root thickness (AvgDiam = 0.39–0.58 mm), surface area (110–1441cm2), root volume (1.4–21.0cm3), forks (2462–61212), crossings (368–9026), root dry weight (0.460–5.470gm), avg. root angle (21.3–57.5°), root:shoot ratio (on dry weight basis 0.1–0.3 and on length basis 1.2–4.3) under irrigated condition in 5ft long PVC pipes. In low soil moisture regime expressed by plant stress (66.7% RWC) under rainout shelter vis-à-vis control irrigated field, drought tolerance related traits showed high range for drought resistance indices (for seed yield 0.5–2.0 and 100-seed weight 0.7–2.7), canopy temperature depression (-0.7–7.2°C), and percentage increase in number of pods (-59.4–54%), in plant height (-13.2 - 45.3%) and in number of nodes (-15.2–51%). Variation between the sensitive and the tolerant genotypes was visibly distinct for delayed senescence trait.

Genotypes showing high index values (more than zero), as derived from principal component analysis for correlation matrix, and high drought resistance indices (DRI≥0.9).

Genotype	Cross	Index value (>zero)	Rooting depth (≥100 cm)	Avg. root angle (°)	Avg Diam (mm)	Root Vol. (cm^3)	DRI (seed yield)	DRI (100 Seed wt.)	δT (°C)	No. of pods increase (%)	Plant height increase (%)	No. of nodes increase (%)
15-31-14	JS 335×JS 97-52	2.67	162	32.5	0.58	21.0	1.0	1.0	5.2	-4.8	16.5	13.2
32-105-1	JS 93-05×JS 97-52	0.88	150	45.0	0.51	6.0	0.9	0.8	7.2	-2.1	12.1	18.5
14-22-18	JS 97-52×Kaeri 651-6	0.50	134	37.5	0.44	8.7	1.6	1.0	4.8	44.4	2.5	19.1
5-14-9	Davis×Kaeri 651-6	0.08	132	45.0	0.43	4.3	1.1	1.1	2.9	-1.5	5.5	7.3
AMS 100-39	Mutant of JS 93-05	0.70	130	33.8	0.48	9.3	1.0	1.0	-0.6	-19.1	5.6	-4.4
22-8-131 #	JS 97-52×JS 335	0.70	120	21.3	0.49	10.9	2.0	2.7	3.9	-15.5	26.9	4.5
30-8-195	JS 97-52×JS 335	0.22	119	46.3	0.47	5.2	1.0	1.1	2.8	-16.5	14.7	14.5
26-74-135*	JS 95-60×Young	0.24	119	23.8	0.52	4.0	1.3	1.0	3.3	35.1	27.5	13.3
30-8-98	JS 97-52×JS 335	0.26	105	35.0	0.49	7.2	0.9	1.0	1.4	-10.3	5.7	5.7
12-58-43	JS 335×C-2797	0.09	100	53.8	0.49	4.8	1.7	1.0	4.0	54.0	25.3	17.6
5-14-17	Davis×Kaeri 651-6	1.26	100	30.0	0.55	15.9	1.2	1.1	2.5	-7.7	16.0	51.0
26-74-139**	JS 95-60×Young	-0.27	120	28.8	0.43	3.2	0.9	0.9	6.4	-19.5	4.7	16.0
36-18-3	JS 335×Young	-0.35	100	31.3	0.40	6.7	1.0	0.9	0.9	-2.3	8.1	-2.2
4-10-18	JS 97-52× NRC 7	0.05	81	26.3	0.47	10.0	1.2	1.1	5.6	26.6	-7.2	6.9
JS 97-52	Tolerant Check	0.32	83	42.5	0.59	4.5	0.9	0.9	6.5	-27.7	22.8	21.0
NRC 2	Susceptible Check	-0.95	80	36.3	0.38	3.6	0.5	0.7	-	-51.8	-7.2	-7.8
Mean		0.0	96	39.7	0.47	6.1	1.1	1.0	3.6	- 3.6	16.8	10.2
CV%		-	28.2	22.5	10.5	72.6	32.1	32.0	56.2	-	83.7	125.9

Retest entry for DRI, *, ** Retest entries for Canopy temperature depression



Constitutive expression of root system architecture as delayed senescence response in lines 14-22-18 and 5-14-17, having Kaeri 651-6 as a common drought tolerant parent, Vs in sensitive check NRC 2, under low soil moisture stress in rainout shelter

Molecular analysis of drought tolerant genotypes

Ten soybean genotypes were chosen for drought study, viz., NRC 2, 6A-58, (drought susceptible); JS 97-52, CAT 3293 (drought tolerant), EC 291448, PI 159923, J 732, EC 107407, TGX-70950E, and MACS 345 (putatively Drought tolerant). These genotypes were grown at in rain out shelter and in IISR field and were subjected to the drought stress (Crop Relative Water Content, RWC= 67.8 %) at the stage R_5 + 10 days in rainout shelter to identify the drought tolerant genes. Leaf samples were taken before (78th day) and after (83rd day) the application of drought stress. Each time three biological replications were taken and immediately immersed in liquid nitrogen and stored at -20°C for the further molecular analysis.

RNA isolation and purification

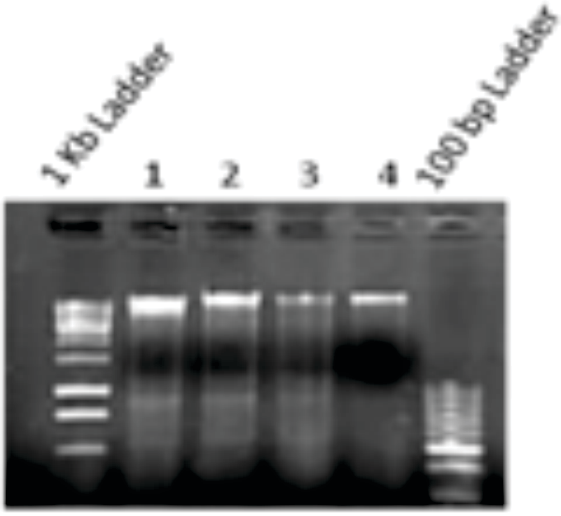
A good quality of RNA was isolated from sixty soybean plants by Trizol method. Quantitatively it ranged from 337 to 2507.21 ng/mL with $A_{(260/280)}$ 1.987 to 2.1 signifying its high quality parameter. Quality of RNA was determined by nanodrop reading and by running through 1% Agarose in 1x Formaldehyde RNA gel.

RNA sequencing of putative drought tolerant genotypes

Two soybean genotypes JS 97-52 and NRC 2 were selected for RNA sequencing analysis. RNA was isolated through Plant RNA purification kit, Sigma from the leaf samples taken before (78th day) and after (83rd day) the application of drought stress from drought tolerant JS 97-52 and drought susceptible NRC 2. Quantitatively it ranged from 238.74 to 407.90 ng/mL with $A_{(260/280)}$ 2.07 to 2.15 signifying the high quality parameters of purified RNA samples.

Qualitative (Absorbance at (260/280) and (260/230)) and quantitative parameters of RNA samples

Well no	Sample names	ng/mL	$A_{(260/280)}$	$A_{(260/230)}$
1	JS 97-52 (Before drought stress)	238.74	2.07	2.17
2	JS 97-52 (After drought stress)	407.90	2.15	2.17
3	NRC 2 (Before drought stress)	282.24	2.09	2.28
4	NRC 2 (Before drought stress)	100.72	2.07	2.28



RNA gel electrophoresis representing the RNA samples

To study the cumulative effect of all genes in response to the drought condition, RNA sequencing by Oxford Nanopore sequencing was also carried out. Around 11GB sequenced data has obtained which is under *in-silico* analysis to identify DEG (Differentially Expressed Genes) in response to drought stress. Then, for the further sequencing steps, RNA samples were diluted to 50 ng/ 100µL. for cDNA-PCR bar-coding of each sample reverse transcription and strand switching was performed. Full length transcripts were selected by PCR and bar-coding. Then after a DNA adapter mix added to the amplified cDNA library which were subjected to AMPure XP bead binding. These all steps were followed according to cDNA PCR barcoding (SQK-PCS108 with SQK004) manual's instructions. Finally priming and loading of SpotON flow cell was carried out and it allowed progressing the MinKNOW sequencing for almost 24 hr. This generated sequencing data of around 10 GB. The rough draft sequence was further processed through *in-silico* tools eg. Demultiplex, LAST, GMAP, Cuffdiff, Cufflink.

Validation of putative drought tolerant genes by qRT PCR

Nine different drought responsive genes were identified through previous transcriptome sequencing experiment and were selected for validation through qRT-PCR using Agilent technologies (AriaMx Real Time PCR System). The experiment was planned carefully to select genes which are showing differential and contrasting expression pattern between the two genotypes used in this study. Gene specific primers were designed for the selected transcripts using Primer3 software. Total RNA was isolated from leaves of control and drought stressed plants of JS 97-52 and NRC 2 and subsequently, RNA was converted into single stranded cDNA using full length cDNA Synthesis kit (NEB, #E6421) as per the manufacturer's instructions. qRT-PCR was performed using equal quantity of single stranded cDNA of all the four samples under specific cycling conditions (3 min at 95 °C, 40 cycles of 5 s at 95 °C and 10 s at 58 °C, 15 s at 72 °C) followed by melt curve analysis (30 s at 95°C, 30 s at 65°C, 30 s at 95°C) to check the specificity of amplification. The details of gene regulation is presented in below graphs.

Breeding for water logging and high temperature tolerance

Hybridization, generation advancement, yield evaluation and selection

A total of fifteen new crosses were attempted to develop populations with the objective of recombining water logging tolerance and high temperature tolerance along with high yielding traits. The list of crosses attempted were present below.

Hybridization programme	Objectives/ targeted traits
JS 20-38 × AMS 5-18	Water logging tolerance
JS 20-34 × Hardee	
JS 20-38 × PK 327	
Hardee × AMS 5-18	
NRC 128 × AMS 5-18	
JS 20-38 × NRC 128	
NRC 128 × RSC 10-52	
NRC 128 × MACS 1520	
Hardee × JS 20-69	High temperature tolerance
Hardee × RSC 10-52	
JS 20-98 × NRC 7	
JS 20-98 × AMS MB 5-18	
NRC 146 × AMS MB 5-18	
NRC 146 × JS 20-69	
JS 20-69 × NRC 146	

Thirty eight advance breeding lines derived from three different crosses [JS 97-52 × JS 88-66 (F_6), JS 97-52 × JS 335(F_6), and JS 97-52 × JS 90-41(F_9)] were evaluated for yield in augmented design. In comparison with adaptive checks viz., JS 97-52, JS 20-69, JS 20-29 and NRC 86, ten prominent breeding lines among three crosses have out yielded all checks. Sixteen half sib populations (JS 97-52 derived crosses) were advanced from F_4 to F_5 generation in *kharif* 2019 through single pod descent method and single plant selection were made in each cross on the basis of number of pods. Five different crosses involving water logging tolerant genotype JS 20-38 viz., JS 20-38 × JS 95-60, JS 20-34 × JS 20-38, NRC 7 × JS 20-38, VP 1165 × JS 20-38, JS 20-38 × DS 31-05 and JS 20-34 × Harder(S) were advanced from F_2 to F_3 generation. Ninety eight early generation breeding lines (F_4) derived from different JS 97-52 crosses were advanced to their next generation based on per plant yield.

Details of high yielding prominent advance breeding lines

Prominent lines	Pedigree	Yield per plant (kg/ha)
Sel 1-34	JS 88-66 × JS 97-52	2474.44
Sel 3-12	JS 97-52 × JS 335	2266.66
Sel 3-79	JS 97-52 × JS 335	2260.37
Sel 3-21	JS 97-52 × JS 335	2144.81
Sel 1-70	JS 88-66 × JS 97-52	2132.59
104-84	JS 97-52 × JS 90-41	2089.26
Sel 3-10	JS 97-52 × JS 335	1970.74
104-15	JS 97-52 × JS 90-41	1964.81
Sel 1-52	JS 88-66 × JS 97-52	1799.63
Sel 1-61	JS 88-66 × JS 97-52	1739.26
JS 20-69 (Check)	-	1574.70
JS 20-29 (Check)	-	1366.08
JS 97-52 (Check)	-	1354.82
NRC 86 (Check)	-	1182.33

Phenotyping of RIL Population for water logging tolerance

A RILs population (115 lines; F_9) derived from JS 97-52 × JS 90-41 was evaluated for water logging tolerance at vegetative stage. Water stagnation conditions were provided at V_2-V_3 stages for 10 days in water-logging structures. Plant mortality rate, foliar damage scores (1-9) and stem elongation rate was recorded in parents and RILs after 3 days of stress period. Percent reduction in grain yield per plant, under water logged conditions in comparison to normal field conditions was also observed in parents and RILs. RILs viz., 104-102, 104-10, 104-103, 104-27, 104-23, 104-12, 104-43 were found promising for water logging tolerance on the basis of grain yield.

Details of high yielding prominent advance breeding lines

Traits/ Parameters	JS 97-52 (Tolerant parent)	JS 90-41 (Susceptible parent)	Mean	Range	Coefficient of variation (%)	Promising lines
Plant mortality rate (%)	0.00	53.00	16.06	0.00 - 72.73	114.92	104-8, 104-10, 104 -7, 104-12, 104-15, 104-23, 104-43
Foliar damage score (1-9 rating)	2	8	5.89	2 - 9	27.37	104-89, 104-7, 104-8,104-9, 104-25, 104-17, 104-27
Stem elongation rate (%)	144.50	18.10	91.10	1.45 - 255.56	46.63	104-12, 104-21, 104-25, 104-08, 104-100, 104-23, 104-13
Reduction in grain yield per plant (%)	24.45	74.78	70.42	17.44 - 98-54	26.32	104-102, 104-103, 104-10,104-27, 104-23, 104-12, 104-43

Water logging stress at vegetative stages in RILs

Evaluation of soybean accessions for water logging tolerance at vegetative stage

A total of fifty soybean accessions were evaluated for water logging tolerance along with tolerant and susceptible checks. The water logging conditions were provided in Vegetative 2-Vegetative 3 (V_2-V_3) stages of plant for 10 days by saturating the soil with water up to 10 cm above the soil surface, while counter control plot was maintained with normal irrigated conditions. Soybean genotypes were evaluated for foliar damage score (FDS; 1-9 scale on the basis of chlorosis, necrosis and plant mortality), plant survival rate (PSR), stem elongation rate (SER) in stressed plot. Several yield attributing traits, root nodules number, root nodules dry weight and SCMR (SPAD chlorophyll meter readings) were recorded from stressed plot as well as counter control plot. Water logging tolerance coefficient (WTC) was calculated with formula WTC = mean value (seed yield per plant) of treatment (genotype) in stressed plot × plant survival rate / mean value (seed yield per plant) of treatment (genotype) in control plot.

Descriptive statistics and promising lines for water logging tolerance at vegetative stage

Genotype	FDS	PSR (%)	SER (%)	Reduction in root nodule dry weight per plant (%)	Reduction in SCMR (%)	Reduction in seed yield per plant (%)	Reduction in 100 seed weight (%)	Water logging tolerance coefficient (WTC)
Hardee	3	100.00	184.93	9.04	16.99	3.55	6.32	96.45
TGX 317-37 E	1	96.74	144.55	2.54	20.29	0.92	3.45	95.84
EC 291400	2	94.29	165.91	8.89	18.68	1.07	2.39	93.28

Descriptive statistics and promising lines for water logging tolerance at vegetative stage

Genotype	FDS	PSR (%)	SER (%)	Reduction in root nodule dry weight per plant (%)	Reduction in SCMR (%)	Reduction in seed yield per plant (%)	Reduction in 100 seed weight (%)	Water logging tolerance coefficient (WTC)
EC 313974	3	96.67	114.77	24.85	7.43	3.91	21.68	92.89
Sel 1-34	2	100.00	110.19	28.46	23.94	9.69	13.43	90.31
EC 93601	3	93.75	156.94	15.00	25.60	4.64	13.33	89.40
TGX 328-049	4	90.91	184.84	14.15	16.35	2.81	2.08	88.36
TGX 825-1E	1	88.57	141.11	12.19	28.32	0.63	17.02	88.01
EC 287754	3	88.46	193.59	10.51	22.67	0.74	14.68	87.81
EC 241712	3	90.32	143.44	9.80	18.95	2.79	3.45	87.80
EC 391181	1	85.71	99.22	11.54	18.44	4.86	5.77	81.55
DS 321	3	80.00	153.26	27.67	14.29	0.74	20.41	79.41
EC 241715	3	92.31	145.12	9.28	23.49	9.15	0.50	83.86
NRC 128	2	95.59	103.57	6.45	14.92	18.77	2.15	77.65
NRC 131	2	96.88	93.33	8.10	18.01	21.52	3.12	76.03
JS 20-38	2	96.62	120.55	3.37	19.27	21.37	4.62	75.97
JS 97-52 (Check)	1.67	97.37	118.81	5.92	15.40	25.96	8.75	72.12
JS 71-05 (Check)	2.33	92.26	129.77	13.31	25.63	32.83	0.31	62.10
JS 95-60 (Check)	4.83	82.39	109.02	33.12	37.01	61.18	17.40	32.08
JS 90-41 (Check)	5	75.19	85.00	52.30	26.85	45.51	12.12	40.97
Mean	3.18	89.09	113.53	25.38	22.85	32.40	13.24	61.11
Range	1-8	43.75 - 100	1.31 - 93.59	1.16 - 92.66	5.53 - 38.54	0.63 - 86.76	0.16 - 41.86	11.55 - 96.45

Soybean genotypes showing variability for Foliar Damage Score (FDS) after water logging stress

Similarly, out of 50 soybean accessions above studied above 40 genotypes were again evaluated for water logging tolerance at ICAR Research Complex for NEH Region, Umiam, Meghalaya. The water logging conditions were provided in stages of plant for 10 days up to 10 cm above the soil surface, while counter control plot was maintained with normal irrigated conditions and yield traits were recorded from both plots. On the basis of percentage reduction in seed yield per plant in stressed plot in comparison to control plot, genotypes EC 357998, EC 313974, EC 93601, EC 241712, TGX 825-1 E and JS 20-38 showed water logging tolerance (< 25 % yield reduction) in comparison to tolerant checks JS 97-52 (28.30%) and JS 71-05 (25.54%).

Screening of soybean accession for high temperature tolerance

A set of thirty soybean genotypes including tolerant and susceptible checks were evaluated in hot weather conditions (max temperature (average): 39.8°C and minimum temperature (average): 27.7°C) at reproductive stages during summer season of year 2019. Several physiological parameters associated with high temperature tolerance viz., delayed leaf senescence score, specific leaf weight (SLW), canopy temperature differential (CTD) and (SPAD readings were recorded. In this genotypes NRC 146, JS 20-38, 6A-58-5 and JS 20-98 performed better in high temperature conditions while genotypes CAT 2065, JS 95-60, JS 90-41 were highly sensitive to high temperature.

Screening of soybean accession for high temperature tolerance

Parameters related to high temperature tolerance	Range	JS 97-52 (Tolerant Check)	JS 95-60 (Susceptible Check)	NRC 146	JS 20-98	JS 20-38	6A-58-5
Delayed leaf senescence score/rating	1-5	4.5	1.5	4.5	4.2	3.2	4.3
SPAD Chlorophyll Meter Reading (SCMR)	31.10 - 47.20	43.60	39.80	45.60	42.40	46.00	44.00
Specific Leaf Weight (mg/cm^2)	3.58 - 8.65	6.47	5.56	7.49	6.30	6.53	6.56
Canopy Temperature Depression (°C)	-3.57 °C to 3.79 °C	2.03	-1.77	3.79	2.20	1.01	3.23

Phenotyping of GWAS panel for Yield, Drought tolerance, Root System Architecture, Water logging and High temperature tolerance

Yield: A GWAS (Genome Wide Association Studies) panel consisting around 300 diverse soybean accessions was multiplied and evaluated for yield and attributing traits at AICRP center, UAS, Bengaluru during off-season of year 2018-19. Genotypes exhibited variabilty for seed yield with mean value of 2308.44 kg/ha (Range: 269.44 kg/ha - 4791.11kg/ha). Same Panel was evaluated at Indore location during *kharif* 2019 indicated high variability for yield and attributing traits at Indore location.

Descriptive statistics of yield and attributing traits of GWAS panel

Yield attributing traits	Mean	Range	CV (%)	Top five genotypes #
Biomass (total dry matter) per plant (g)	14.29	5.22 - 33.60	35.30	**Type 49**, M 1085, **EC 602288, TGX 855-53 D**, CAT 1258
Seed yield per plant(g)	4.31	0.76 - 15.36	56.45	**EC 602288, Type 49,** Hardee, EC 538807, **AGS 25**
Harvest index (%)	28.50	8.43 - 59.92	29.01	Kaeri 651-6, EC 100804, NRC 12, JS 95-52, **EC 602288**
100 seed weight (g)	9.49	5.00 - 21.60	23.70	EC 538828, EC 358009, EC 547464, JS 20-29, EC 528622

Yield attributing traits	Mean	Range	CV (%)	Top five genotypes #
Plant height (cm)	80.30	39.20 - 117.25	13.64	EC 287460, EC 241712, M 1085, EC 456620, Lee
Number of reproductive nodes per plant	9.28	1.75 - 14.60	29.85	EC 241712, EC 291400, EC 250591, EC 103334, **AGS 25**
Number of branches per plant	4.28	1.60 - 8.75	27.55	AGS 110, Bragg, **TGX 855-53D**, EC 291399, **Type 49**
Number of pods per plant	37.06	13.60 - 94.80	40.56	**EC 602288, Type 49**, **TGX 855-53D, AGS 25**, B 1667

#Genotypes in bold found promising for more than two traits

Drought Tolerance: GWAS panel consisting around 300 diverse soybean accessions along with tolerant and susceptible checks was evaluated at seed filling stage (R_5 plus 8-10 days) under rainout shelter with imposed plant stress level of 72-75% relative water content. Control plot was maintained with normal irrigated conditions.

The genotypes evaluated for drought resistance index for seed yield (DRIsy), drought resistance index for 100 seed weight (DRIsw), percentage reduction in biomass per plant (%), percentage reduction in harvest index (%), percentage reduction in plant height (%), percentage reduction in number of nodes per plant (%) and percentage reduction in number of pods per plant(%) showed a range of variation. Physiological traits viz. relative water content (%), canopy temperature differential (δ°C), SPAD chlorophyll meter reading (SCMR), specific leaf weight (SLW) ranged widely under low soil moisture stress regime. Descriptive statistics for particular traits are given below.

Descriptive statistics of traits related to drought tolerance of GWAS panel

Drought tolerance related traits	Mean	Range	CV (%)	Top five genotypes on the basis of particular parameter#
DRI for seed yield	1.00	0.10-2.87	80.96	TGX 849-143 D, JSM 288, EC 291400, VLS 75, AMS MB 100-39
DRI for 100 seed weight	1.00	0.39-1.69	20.66	Lee, JS 94-67, EC 251456, JS 95-52, TGX 825-3 D
Percentage reduction in biomass per plant (%)	43.36	0.77-84.89	42.93	**TGX 328-049**, EC 251388, EC 341822, EC 309543, EC 456620
Percentage reduction in Harvest Index (%)	31.03	0.36-89.82	69.56	**TGX 328-049**, JS 20-38, EC 343310, EC 309537, EC 393231

Drought tolerance related traits	Mean	Range	CV (%)	Top five genotypes on the basis of particular parameter#
Percentage reduction in plant height (%)	13.06	0.03 -37.33	72.70	PK 472, **JS 71-05, JS 97-52**, Cat 146, B 160-3
Percentage reduction in No. of Nodes per plant (%)	53.46	4.35-82.81	33.11	DS 321, **JS 97-52**, TGX 825-1E, **JS 71-05**, EC 592195
Percentage reduction in No. of Pods per plant (%)	50.58	1.37-91.57	37.96	Cat 1341, EC 113770, **JS 71-05**, EC 396067, EC 391181
RWC(%) under stress	75.5	23.1-98.9	21.98	MACS 708, TGX 312-012 E, PS 1029, PUSA 16, **ICAL 122**
CTD (°) under stress	1.8	-7.7 -8.8	173.55	**Cat 2797**, IC 24532A, AGS 218, Cat 1149, DS 205
SCMR under stress	34.2	16.2-56.1	18.09	TGX 854-429, TGX 239-6 D, EC 333859, TGX 239-43 D, **ICAL 122**
SLW (mg/cm^2) under stress	4.3	1.44 -9.97	28.64	TGX 573-209 E, **Cat 2797**, Improved Pelican, B 1666, PK 262

#Genotypes in bold found tolerant for more than two parameters

Water logging Tolerance: The same GWAS panel was evaluated for water logging tolerance along with tolerant and susceptible checks. The water-logged conditions were provided in growth stages of plant for 10 days by saturating the soil with water up to 10 cm above the soil surface in stressed plot while counter control plot was maintained with normal irrigated conditions. Soybean genotypes were evaluated for Foliar Damage Score (FDS; 1-9 scale on the basis of chlorosis, necrosis and plant mortality), Plant mortality Rate (PMR), Stem elongation rate (SER) in stressed plot. Several yield and attributing traits were recorded from stressed plot as well as counter control plot. Percent reduction for seed yield per plant and other yield attributing traits under water logged conditions in comparison to normal field conditions were recorded.

Descriptive statistics of traits related to water logging tolerance of GWAS panel

Water logging tolerance traits	Mean	Range	CV (%)	Top five genotypes on the basis of particular parameter#
Foliar Damage Score	3.33	1-9	66.14	**EC 95815**, RVS 2001-18, TGX 854-42 D, EC 528622, MAUS 71

Water logging tolerance traits	Mean	Range	CV (%)	Top five genotypes on the basis of particular parameter#
Plant mortality Rate (%)	12.77	0 - 65.30	95.67	TGX 854-42 D, BR 15, EC 542431, EC 457464, TGX 1016-19F
Stem elongation rate (%)	121.16	1.30 - 340.62	32.45	VLS 75, SL 295, EC 333870, **EC 95815**, TGX 824-35 E
Percentage reduction in biomass per plant	39.26	0.37-81.33	67.54	**EC 95815**, JSM 288, **Hardee**, **TGX 317-37 E, EC 456556**
Percentage reduction in seed yield per plant	35.11	0 -90.09	102.67	**EC 456556**, **EC 95815**, JSM 288, **Hardee,** JS 75-46
Percentage reduction in 100 seed weight	12.41	0 -58.45	143.50	**TGX 317-37 E**, JS 75-46, **Hardee,** **EC 95815**, MACS 124
Percentage reduction in Plant height	45.45	9.88-70.39	23.15	EC 100804, NRC -7, TGX 863-26 F, CO- soy-1, EC 291399
Percentage reduction in numbers of reproductive nodes per plant	46.80	0 -90.63	51.69	**EC 95815**, **TGX 317-37 E**, J MACS 450, 732, K 53
Percentage reduction in numbers of pods per plant	31.28	0 -83.73	98.27	TGX 312-012 E, **EC 456556, EC 95815, Hardee**, **TGX 317-37 E**

#Genotypes in bold found tolerant for more than two parameters

Root System Architecture (RSA) Traits: RSA traits act as surrogate traits in drought and water-logging tolerance. A total of 12 root system architecture traits (RSA traits) were measured using in PVC pipes grown genotypes of GWAS panel exhibited high range of variation. Root length, root length density, surface area, root volume, root thickness (Avg Diam), number of forks and number of crossings, were analyzed using WinRHIZO Arabidopsis root scanner & software.

Descriptive statistics of Root System Architecture traits of GWAS panel

Root System Architecture traits	Mean	Range	CV (%)	Top five genotypes on the basis of particular parameter#
Rooting Depth (cm)	145	25-194	20	**EC 456556**, EC 391346, **TGX 822-10 E**, Palam Soya, PI 283327

Root System Architecture traits	Mean	Range	CV (%)	Top five genotypes on the basis of particular parameter#
Length(cm)	7447	386-20351	43	**AGS 205, EC 343312, NRC 86, K 53, EC 333901**
Root Length Density (cm/cm^3)	0.15	0.01-0.41	43	**AGS 205, EC 343312, NRC 86, K 53, EC 333901**
Surface Area(cm^2)	1522	92-3952	44	**AGS 205, DS 97-12, NRC 86, EC 343312, TGX 822-10 E**
Root Volume (cm^3)	26.5	1.7-94.6	57	**DS 97-12, PS 1029**, T 49, JS 95-52, **TGX 854-60 A**
Root thickness (Avg Diam=mm)	0.6	0.37-1.30	20	EC 241756, **TGX 854-60 A**, **PS 1029**, EC 389178, EC 538802
No. of Forks	55671	1804-141535	43	**AGS 205, EC 457280, TGX 297-16 F, NRC 86, EC 343312**
No. of Crossings	8664	196-38416	67	**EC 457280**, B 471, **TGX 297-16 F**, TGX 854-42 D, **EC 250577**
Average Root Angle (°)	41.8	13.8-77.5	25	EC 242003, EC 391346, **EC 343312**, GC 12, MAUS-1
Root Dry Weight (gm)	2.69	0.22-6.65	44	**AGS 205**, WT 150, TGX 573-219 D, **EC 343312, DS 97-12**
Root:shoot ratio (on length basis)	3.57	0.83-7.14	28	EC 76759, EC 287469, TGX 824-35 E, AGS 153, JS 20-72
Root:shoot ratio (on dry weight basis)	0.25	0.08-1.85	69	Himso 175, **EC 456566**, EC 358009, AGS 156, **EC 250577**

#Genotypes in bold found tolerant for more than two parameters

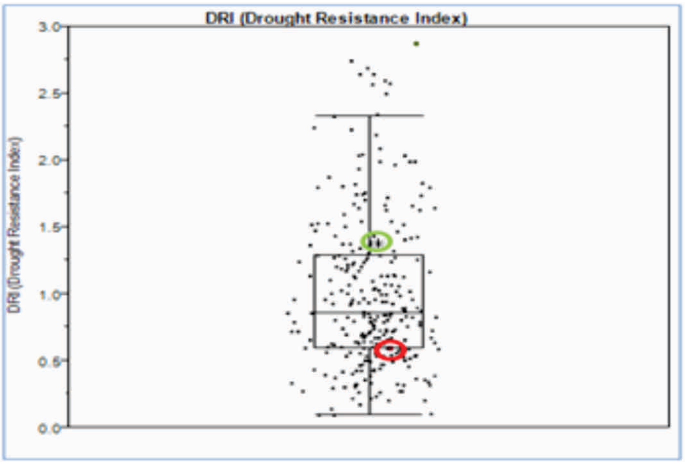
High Temperature Tolerance: The same GWAS panel was evaluated for elevated temperature tolerance along with tolerant and susceptible checks. High temperature stress (day/night temperature: 40°C/28°C) was induced during reproductive stages (R_2 to R_6) in glasshouses, with normal ambient temperature conditions in field trial during kharif 2019 as control counterpart. The genotypes evaluated for percentage reduction in biomass per plant (%), percentage reduction in seed yield per plant (%), percentage reduction in 100 seed weight (%) and percentage reduction in number of pods per plant (%), showed a range of variation. Physiological traits viz. canopy temperature differential (δ°C), SPAD chlorophyll meter reading (SCMR), specific leaf weight (SLW) ranged widely under high temperature stress situations. Descriptive statistics of these parameters and promising lines for particular traits are given below.

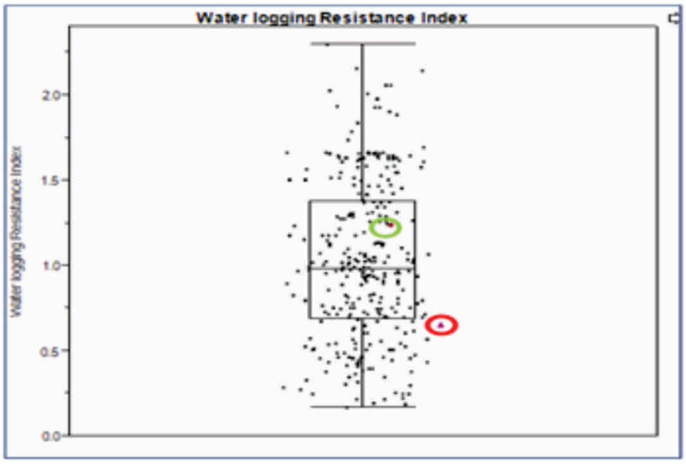
Descriptive statistics of traits related to high temperature tolerance of GWAS panel

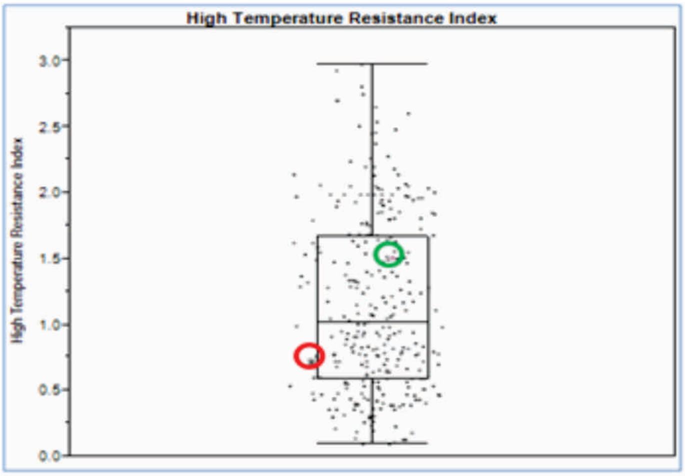
High temperature tolerance traits	Mean	Range	CV (%)	Top five genotypes on the basis of particular parameter#
Reduction in seed yield per plant (%)	41.93	0.51 - 95.48	80.78	**EC 456556,** EC 39177, EC 251388, **EC 396065, TGX 317-37 E**
Reduction in biomass per plant (%)	41.32	0.38 - 90.69	63.98	TGX 984-18 E, **EC 456556,** ACC 1026, **TGX 317-37 E, EC 396065**
Reduction in 100 seed weight (%)	35.10	0.28 - 78.95	62.25	Hardee, AGS 153, **SL 958,** TGX 802-265-D, EC 615187
Reduction in numbers of pods per plant (%)	52.71	0.30 - 93.75	51.22	**EC 456556,** EC 457305, **TGX 317-37 E, EC 396065,** EC 457052
CTD (°C) under stress	2.68	-1.92 - 5.67	56.87	EC 589400, **SL 958,** JS 20-98, JS 75-46, EC 341115
SCMR under stress	29.17	18.24 - 43.75	20.86	**SL 958,** TGX 863-2 C, AGS 153, TGX B 1435 E, **TGX 317-37 E**
Specific Leaf Weight (mg/cm2) under stress	2.22	0.13 - 4.45	52.17	EC 291397,B 160-3, NRC 86, PK 1284, JS 75-46

#Genotypes in bold found tolerant for more than two parameters

Overall, in this study, soybean genotypes revealed significant variations for tolerance for different abiotic stress tolerance related traits as shown in box plots in form of resistance index based on percentage of yield reduction.







Box plot variations for Drought Resistance Index (DRI), Water logging Resistance Index and High Temperature Resistance Index; Dot in green circle showing tolerant check while dot in red circle showing susceptible check

(a) 

(b) 

(c) 

(d) 

Box plot variations for Drought Resistance Index (DRI), Water logging Resistance Index and High Temperature Resistance Index; Dot in green circle showing tolerant check while dot in red circle showing susceptible check

6. SEED QUALITY CHARACTERISTICS

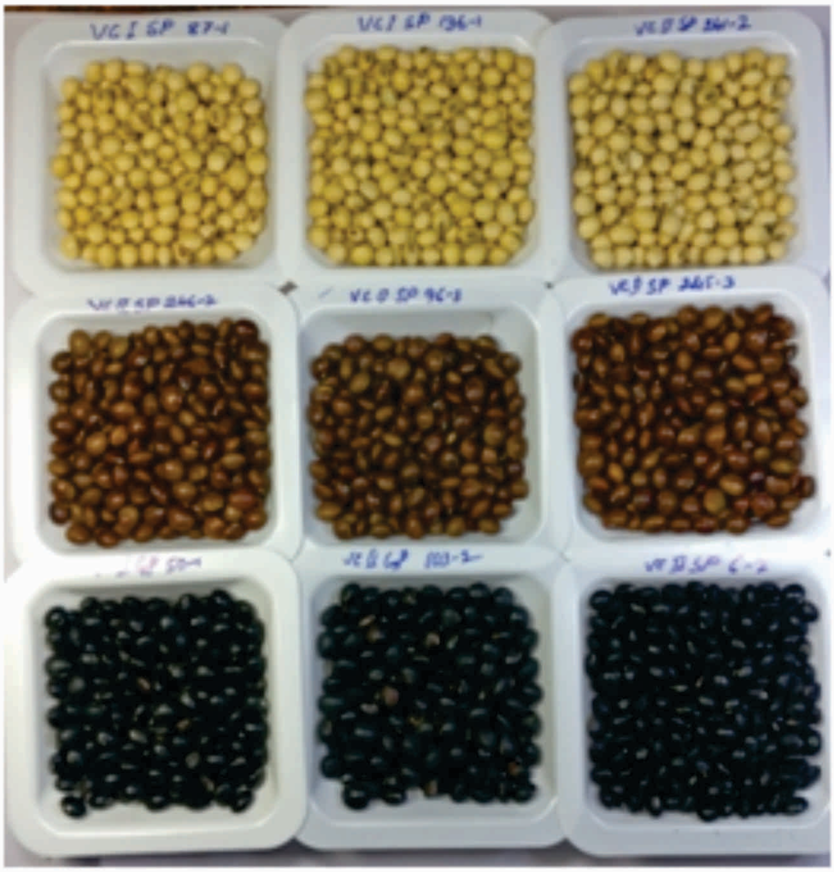
Improvement in soybean seed viability and strength of seed coat

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. A total of 857 RILs derived from VLS1x EC538828 were sown during 2019 kharif. The significant amounts of variation in the lignin content among the lines was observed in the earlier experiment. Despite of continuous rain in the season, out of 857 RILs evaluated, 11 lines yielded more than 30 quintal / hectare and about 36 lines gave yield more than 25 to 29 quintal / hectare.

A total of 490 RILs derived from NRC 7 × EC 538828 were evaluated for seed germination ability and 11 lines found to have high seed germination ability (85%) and yield potential of 25 quintal / hectare.

Seed yield of promising RILs derived from VLS1 × EC 538828

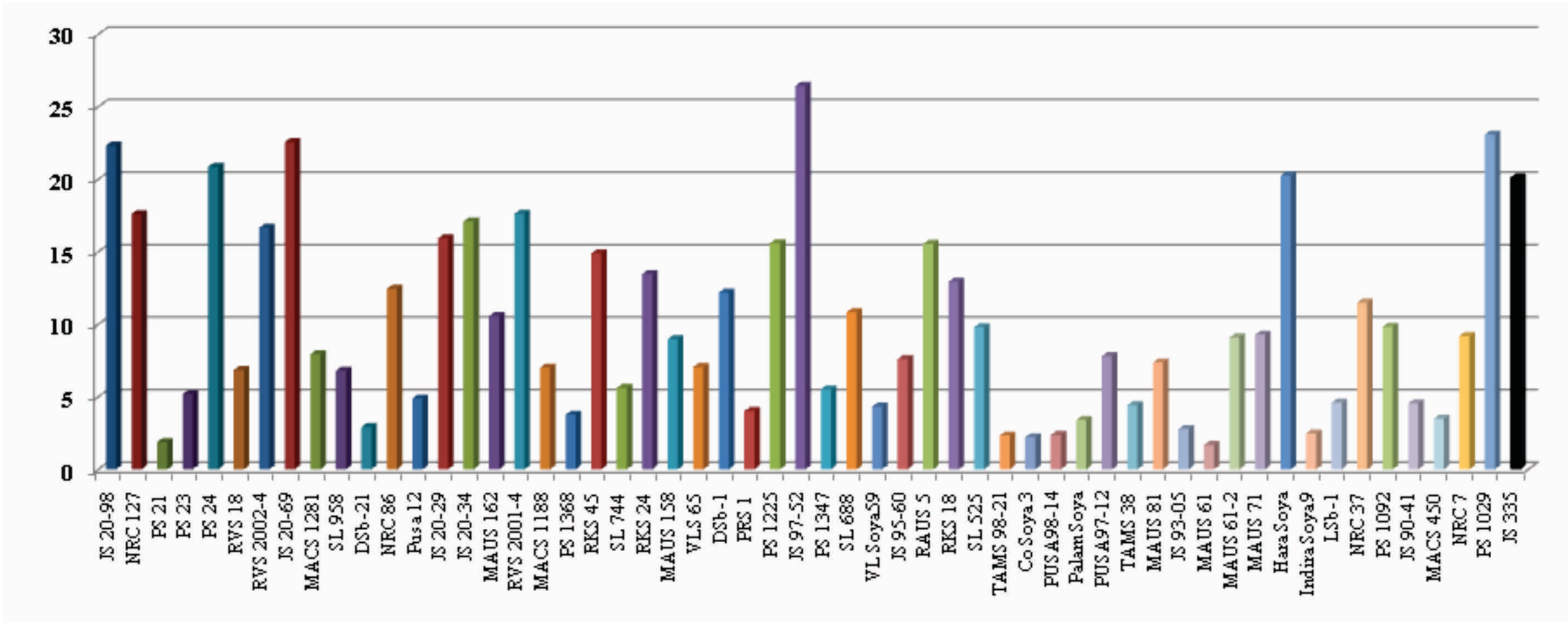
Genotypes	Seed colour	Yield(q/ha)
VCII GP 81-2	Black	36.41
VCIIGP 50-1	Black	34.19
VCI SP 214-2	Black	30.27
VCIISP 200-1	Yellow	33.00
line name/no.	**Seed colour**	**Yield(q/ha)**
VCIIGP232-1	Yellow	32.19
VCI SP 133-1	Yellow	31.89
VCIGP 63-2	Yellow	31.82
VIIGP 126-3	Yellow	31.82
VCI SP148-2-1	Yellow	31.08
VCISP207-1	Yellow	30.78
VCISP40-2	Yellow	30.56



Variation in seed color found in RILs derived from VLS1× EC 538828

DUS Testing

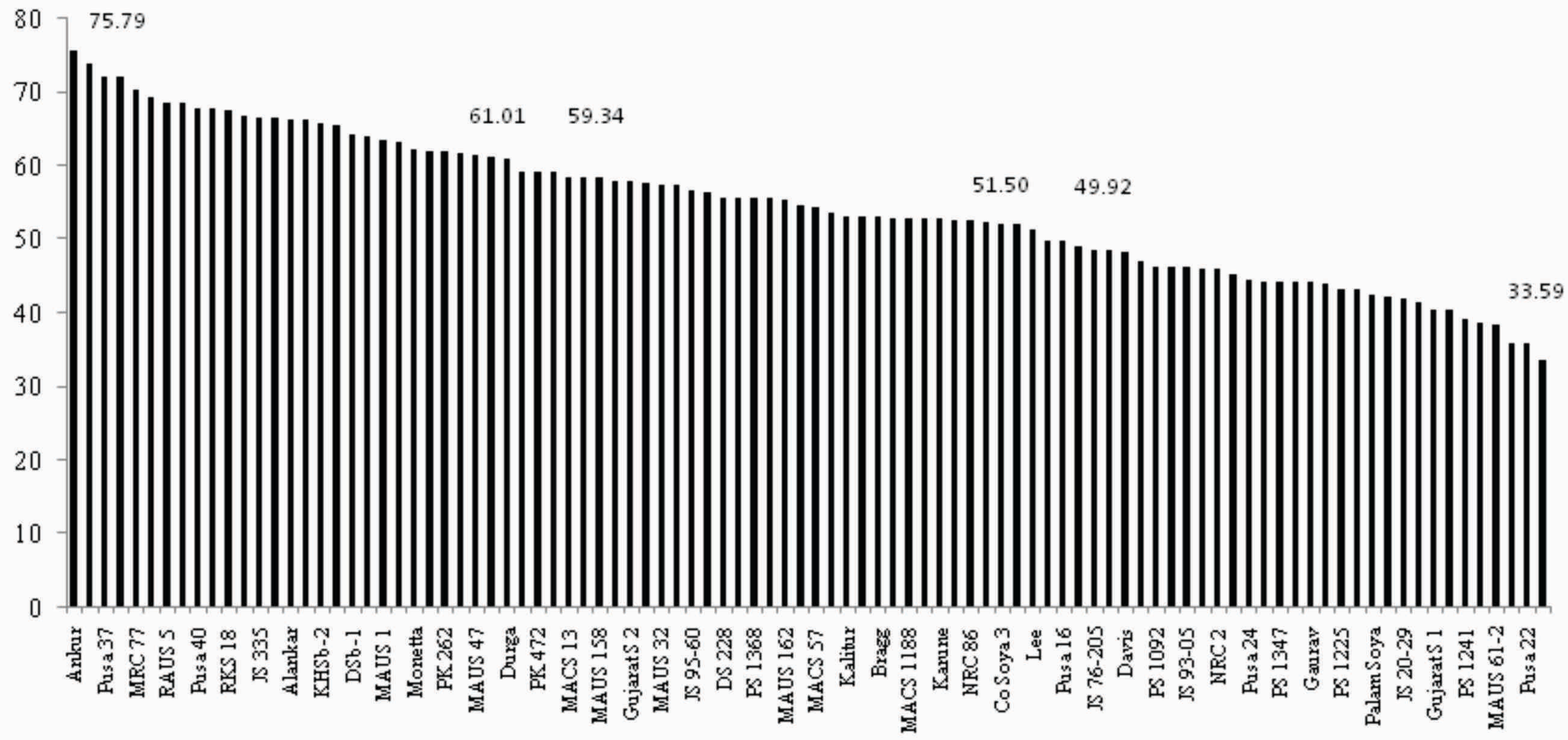
A total of 124 released and notified varieties were maintained under DUS project. The adverse climatic condition of excess rain and soil moisture caused significant yield loss in most of the varieties. The incidence of diseases like anthracnose and aerial blight in several varieties caused severe damage. Few varieties (6%) namely JS 97-52, PS 1029, JS 20-69, JS 20-98, Pant Soybean 24, JS 20-116, Hara Soya and JS 335 produced more than 20 q/ha. Twenty percent of the varieties produced yield in the range of 10-20 q/ha and 27.4 % varieties produced in the range of 5-10 q/ha and rest 44.6% varieties produced less than 5 q/ha. The average yield of the released varieties was 7.56 q/ha during kharif 2019.



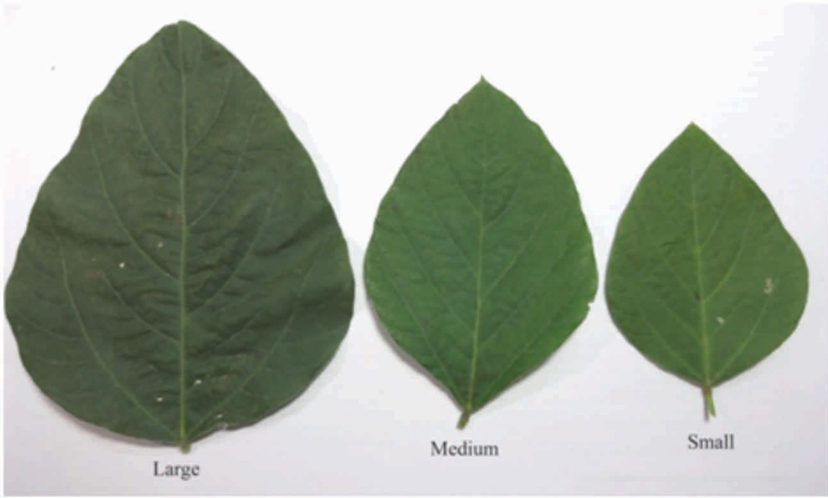
30
25
20
15
10
5
0
JS 20-98
NRC 127
PS 21
PS 23
PS 24
RVS 18
RVS 2002-4
JS 20-69
MACS 1281
SL 958
DSb-21
NRC 86
Pusa 12
JS 20-29
JS 20-34
MAUS 162
RVS 2001-4
MACS 1188
PS 1368
RKS 45
SL 744
RKS 24
MAUS 158
VLS 65
DSb-1
PRS 1
PS 1225
JS 97-52
PS 1347
SL 688
VL Soya59
JS 95-60
RAUS 5
RKS 18
SL 525
TAMS 98-21
Co Soya 3
PUS A98-14
Palam Soya
PUS A97-12
TAMS 38
MAUS 81
JS 93-05
MAUS 61
MAUS 61-2
MAUS 71
Hara Soya
Indira Soya9
LSb-1
NRC 37
PS 1092
JS 90-41
MACS 450
NRC 7
PS 1029
JS 335

Revisiting the DUS characterization of soybean varieties

Leaf Size: The most visible part of a plant is leaf. The size of leaf had not been included in the DUS descriptors. There is significant variation for leaf size among the varieties and needs to be included in DUS testing. The size may be categorized into large, medium and small. For quantification of leaf size, leaf area of all the 120 released and notified soybean varieties were estimated by leaf area meter. There was a continuous variation for this character ranging from 33.59 cm2 to 75.79 cm2. There is scope to group plant into large leaf (61 cm2 and above), medium (51 to 60 cm2) and small (less than 50 cm2).

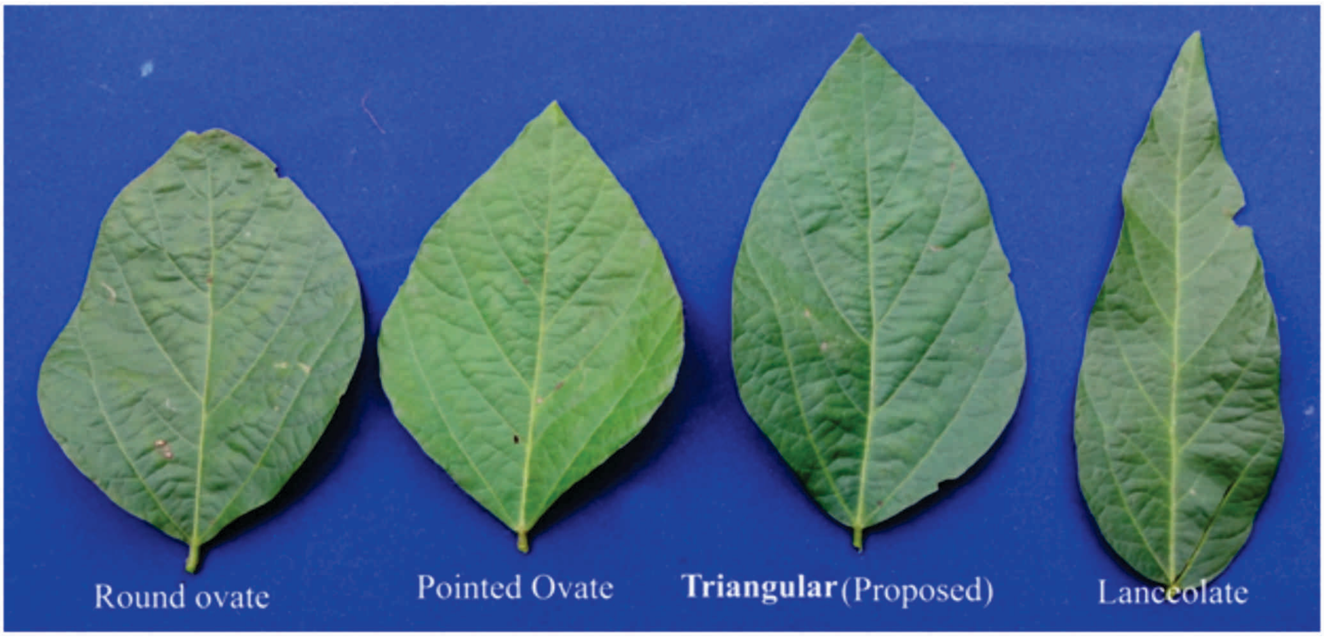


The leaf area of Indian soybean varieties



Categories leaf size of soybean varieties: large, medium and small

Leaf shape: The soybean leaf shape had been categorized as pointed ovate, round ovate and lanceolate type. However, there are some of varieties where leaf shape is neither perfectly lanceolate nor pointed ovate type, which cause confusion in classifying the variety. In such case leaf shape may be categorized as pointed ovate, round ovate, triangular and lanceolate.



Seed production

Following are the details of soybean breeder seed, foundation and certified seed production during kharif 2019 under ICAR Seed and Seed Hub Project

Categories leaf size of soybean varieties: large, medium and small

Variety	Production (q/ha)
Breeder Seed Production	
Ahilya 6 (NRC 86)	60.13
Ahilya 4 (NRC 37)	9.28
NRC 127	9.64
JS 20-69	11.74
JS 20-34	45.75
JS 20-98	4.0
Total	135.54
Foundation Seed produced during Kharif 2019	
JS 20-34	40.45
Certified Seed (Unprocessed seeds)	
JS 20-69	234.5
JS 20-34	192
Total	426.5
Grand Total	602.49

7. CROP PRODUCTION TECHNOLOGIES

System efficiency enhancement through conservation technologies

A long term field experiment (initiated during 2009) was undertaken during 2019 involving 7 rotational tillage systems i.e. Conventional-Reduced (CR-CR-CR-CR),CR-RR-CR-RR, CR-RR-RR-CR, CR-RR-RR-RR, RR-RR-RR-RR, SRR(single reduced tillage) and sub soiling and 3 soybean based cropping systems [Soybean-wheat (S-W) , Soybean-chickpea (S-C) and Soybean - mustard (S-M). Among the cropping systems, soybean-wheat was found to be most productive, remunerative and energy efficient. Soybean did not influence by previous crops. The maximum system efficiency in terms of soybean equivalent ratio (SEY) and economic viability was recorded with CR-RR-RR-CR. The highest B:C ratio was noted with SS and CR-RR-RR-CR, the similar pattern was also recorded as was observed in economic parameters.

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

The three management systems namely 100% organic, 100% inorganic and 50% organic and 50% inorganic under soybean-wheat and soybean chickpea were evaluated under strip plot designs with 5 replications. Soybean yield variability was more when grown after chickpeas compared to wheat. The soybean sustainability was higher when grown after wheat. Wheat yield showed less variation over the years with higher sustainability index. The total system productivity of soybean – wheat cropping system (SEY), less yield variability over the years, more sustainable, stable, higher gross and net energy output as compared to soybean – chickpea. Soybean – wheat system produced maximum energy output. The maximum energy efficiency and energy productivity with low energy intensiveness was recorded with integrated 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.

Agronomic biofortification of micronutrients

Crop establishment techniques and micronutrients application methods significantly influenced on system productivity and economic parameters of agronomic biofortification of conservation agriculture-based soybean-wheat cropping system. Among crop establishment techniques significantly highest system productivity (4.22%), gross returns (₹ 231284 ha^{-1}), net returns (₹ 145169 ha^{-1}) and B: C ratio (1.69) were observed with conservation tillage. Similarly, statistically highest system productivity (12.85%), gross returns (₹ 239376 ha^{-1}), net returns (₹ 150419 ha^{-1}) and B:C ratios (1.69) were recorded with foliar application of Zn+Fe as compared to control. The seed inoculation microbial strain, foliar application of Fe, Zn and soil application of Zn+Fe were the next best treatments and following same trend for soybean-wheat system productivity and economic parameters.

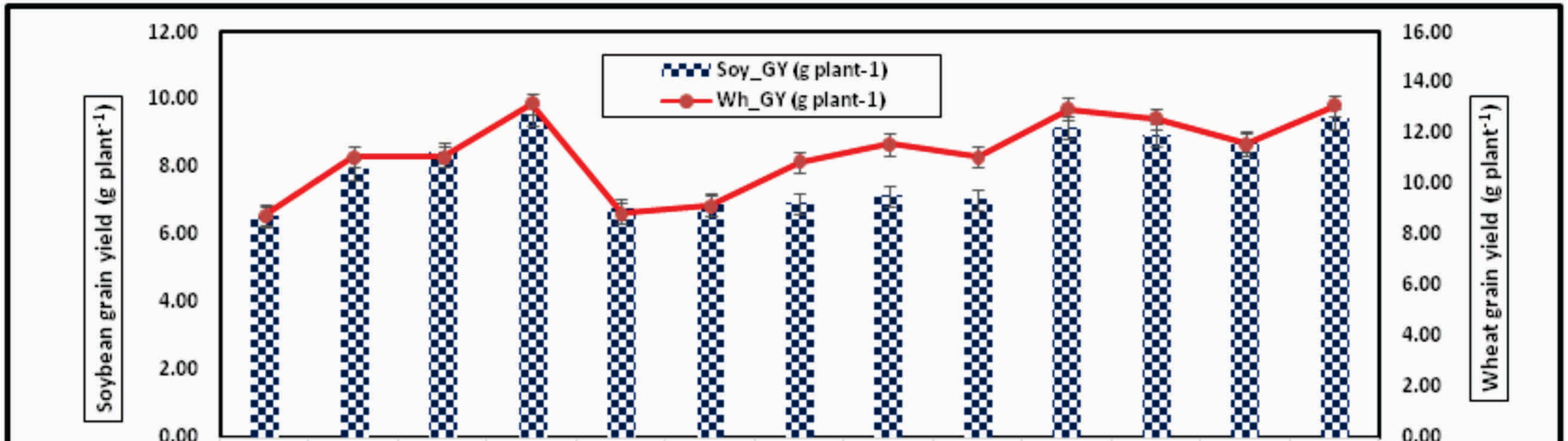
Sustainable zinc and iron management strategies

The grain yield of soybean and wheat significantly influenced by different micronutrients management practices. Highest grain yield of soybean and wheat found in 100% Zn+Fe applied pot compared to control and was statistically non significant with 50%Zn+Fe+MDSR14+MDSR34, MDSR14+MDSR34 and 50% Zn + MDSR 14. However, single inoculation of both strains (MDSR14, MDSR34) and reduction of 50% Zn, 50% Fe found ineffective in significant improvement of soybean and wheat grain yield over their co-inoculation of microbial strains and 100% application Zn and Fe but were comparable with control.

Effect of crop establishment techniques and micronutrients application methods on soybean-wheat system productivity and economics under conservation agriculture-based soybean-wheat cropping system

Treatments	System productivity	System economics			
	(kg ha^{-1})	*Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Crop establishment techniques (CET)					
Conservation tillage	5900^{A}	86114	231284^{A}	145169^{A}	1.69^{A}
Conventional tillage	5661^{B}	86670	222229^{B}	135559^{B}	1.56^{B}
Micronutrient application methods (MAM)					
Control	5422^{H}	82393	213748^{H}	131355^{E}	1.59^{D}
Soil application of Zn	5560^{G}	85681	218725^{G}	133045^{E}	1.55^{E}
Foliar application of Zn	5919^{C}	88033	231731^{C}	143698^{C}	1.63^{C}
Soil application of Fe	5757^{E}	86645	225641^{E}	138996^{D}	1.60^{D}
Foliar application of Fe	5994^{B}	88381	234681^{B}	146300^{B}	1.66^{BC}
Soil application of Zn and Fe	5833^{D}	88245	228505^{D}	140260^{D}	1.59^{D}
Foliar application of Zn and Fe	6119^{A}	88957	239376^{A}	150419^{A}	1.69^{A}
Microbial strain	5640^{F}	82805	221645^{F}	138839^{D}	1.68^{AB}
ANOVA					
CET	$<.000^{1}$		<.0001	<.0001	<.0001
MAM	$<.000^{1}$		<.0001	<.0001	<.0001
CET x MAM	0.049^{5}		0.0838	0.0838	0.1456

Data are mean values of three replicates; Values followed by same capital letters are not significantly different among crop establishment techniques and micronutrients application methods at P=0.05. Tukey's range test was used to separate the treatment means. Values under ANOVA are the probabilities (P values) of the source of variation. *Data area statistically not analysed.



	Control	100%Zn	100%Fe	100% Zn+Fe	50%Zn	50%Fe	50% Zn+Fe	MDSR 14	MDSR 34	MDSR14 +MDSR34	50%Zn+ MDSR14	50%Fe+ MDSR34	50% Zn+Fe+ MDSR14 +MDSR34
Soy_GY (g plant-1)	6.54	7.94	8.46	9.54	6.79	6.91	6.95	7.15	7.07	9.19	8.97	8.79	9.45
Wh_GY (g plant-1)	8.80	11.10	11.10	13.20	8.90	9.20	10.90	11.60	11.10	13.00	12.60	11.60	13.10

Micronutrient management practices

p<0.0001

Effect of zinc and iron management practices on grain yield of soybean and wheat

Effect of tillage practices and agronomic biofortification methods on grain yield and quality parameters of soybean under soybean-wheat cropping system

Treatments	Grain yield (kg ha^{-1})	Zn uptake in grain (g ha^{-1})	Fe uptake in grain (g ha^{-1})	Phytic acid/Zn molar ratio	Phytic acid/Fe molar ratio	Protein yield (kg ha^{-1})
Tillage practices (TP)						
M1-CA-T	2403^{A}	151^{A}	192^{A}	16.41^{A}	11.01^{A}	903A
M2-Con-T	2273^{B}	136^{B}	177^{B}	16.44^{A}	10.84^{A}	842B
Agronomic biofortification methods (ABM)						
S1-Control	2194^{D}	116^{G}	153^{F}	19.69^{A}	12.77^{A}	794^{D}
S2-Soil application of Zn	2222^{D}	144^{D}	162^{EF}	15.54^{CD}	12.85^{AB}	823^{CD}
S3-Foliar application of Zn	2417^{B}	162^{B}	181^{CD}	15.01^{CD}	11.57^{AB}	905^{AB}
S4-Soil application of Fe	2324^{C}	127^{F}	188^{BC}	18.70^{AB}	10.79^{BC}	862^{BCD}
S5-Foliar application of Fe	2439^{AB}	134^{E}	210^{A}	16.64^{BC}	9.14^{D}	921^{AB}
S6-Soil application of Zn and Fe	2378B^{C}	155^{C}	195^{B}	16.08^{CD}	10.99^{BC}	886^{ABC}
S7-Foliar application of Zn and Fe	2492^{A}	171^{A}	215^{A}	14.35^{D}	9.76^{CD}	955^{A}
S8-MDSR14+MDSR34	2240^{D}	138DE	174DE	15.41^{CD}	10.51^{BCD}	835^{CD}
ANOVA						
TP	<.0001	<.0001	<.0001	0.9394	0.4805	<.0001
ABM	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
TP x ABM	0.0288	0.103	0.88	<.0001	0.0004	0.9177

Data are mean values of three replicates; Values followed by same capital letters are not significantly different among tillage practices and agronomic biofortification methods at P=0.05. Tukey's range test was used to separate the treatment means. Values under ANOVA are the probabilities (P values) of the source of variation.Initial soil DTPA-Zn content (0.6 mg kg^{-1}) and DTPA-Fe content (2.15 mg kg^{-1}).

Evaluation of residue management practices under changes in land configurations/crop establishment methods

The field experiments were conducted during kharif and rabi of 2018-19 to evaluate the effect of cropping systems, crop establishment's method/land configuration and residue management practices on yields of crops. In this context, the experiment comprised of three cropping systems namely, soybean-wheat, soybean-maize and soybean-chickpea (main plot) and four crop establishments method/land configuration methods namely, permanent broad bed furrow with residue (PBBF + R), permanent broad bed furrow without residue (PBBF + WR), conventional tillage as per farmers practices with residue (CTFP + R) and conventional tillage as per farmers practices without residues (CTFP + WR) (sub plot). Residue retention practices follows, 50 % soybean residue retained during kharif season in the respective treatments, and 30 % of each of wheat and maize and 50 % of chickpea residue retained during rabi season in the respective treatment. During kharif season, the results revealed that number of pods/plant, grain, straw and biological yield of soybean were did not vary significantly among the different cropping systems. However, crop establishment methods/land configurations were significantly influenced the pods/plant, grain yield. Significantly the highest pods/plant, grain yield of soybean was observed under permanent broad bed furrow as compared to crop sown under conventional tillage as per farmer's practices. The grain yield was increased by 12.1 % under PBBF + R as compared CTFP + R. Similarly, the grain yield was increased by 11.6 % under PBBF + WR as compared CTFP + WR.

Similarly, a field experiment was also conducted during rabi, 2019 to evaluate the effect of cropping systems, crop establishment method/land configuration and residue management practices on yields of rabi season crops namely; wheat, maize and chickpea. The results revealed that the sowing of wheat crop on permanent broad bed furrow (PBBF) significantly influenced the grain and biological yield. The higher yields of wheat were observed under PBBF + R followed by PBBF + WR. However, CTFP + R found statistically identical with PBBF + R and PBBF + WR. The lowest yield was observed under CTFP + WR treatment. The grain yield was increased by 22.4 % under PBBF + R, 21.7 %, under PBBF + WR, 16.0 % under CTFP + R as compared CTFP + WR. The maize grain yield was significantly influenced by the different crop establishment methods. Significant the highest maize yield was registered under the PBBF + R compared to other crop establishment methods. However, non-significant difference was found under PBBF + WR and CTFP + R with respect to yield. The lowest maize yield was recorded under CTFP + WR. The grain yield was increased by 28.2 % under PBBF + R, 13.0 %, under PBBF + WR, 14.5 % under CTFP + R as compared CTFP +

WR. The chickpea yields were significantly influenced by different crop establishment methods and residues management practices during the rabi season. Significantly the highest chickpea yield was observed under PBBF + R and remained statistical identical with CTFP + WR. While, the lowest chickpea yields were observed under residue retention practices with PBBF and CTFP.

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

Treatment	Pods/plant	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)
Cropping Systems (CS)				
Soybean-maize	63.7[a]	2256[a]	2701[a]	4958[a]
Soybean-chickpea	64.5[a]	2311[a]	2713[a]	5024[a]
Soybean-wheat	64.0[a]	2293[a]	2699[a]	4993[a]
Crop establishment methods/land configurations (LC)				
PBBF + R	68.2[a]	2535[a]	2668[a]	5203[a]
PBBF + WR	64.3[a]	2295[b]	2744[a]	5039[b]
CTFP + R	64.3[a]	2261[b]	2684[a]	4945[b]
CTFP + WR	59.6[b]	2057[c]	2721[a]	4778[c]
ANOVA				
CS	0.8066	0.1847	0.8809	0.3800
LC	0.0001	<.0001	0.0988	<.0001
CS*LC	0.7258	0.0087	0.9356	0.3909

Effect of cropping systems, crop establishment's method/land configuration and residue management practices on yields of rabi season crops

Treatment	Wheat		Maize		Chickpea	
	Grain yield (kg/ha)	Straw yield (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)
Crop establishment methods/land configurations (LC)						
PBBF + R	5870±34[a]	7474±282[a]	6278±126[a]	9461±234[a]	312±15[b]	921±83[c]

Treatment	Wheat		Maize		Chickpea	
	Grain yield (kg/ha)	Straw yield (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)	Grain yield (kg/ha)	Stover yield (kg/ha)
PBBF+WR	5834±104[a]	7436±183[a]	5535±195[b]	9515±321[a]	549±48[a]	1301±72[a]
CTFP+R	5567±196[a]	7240±210[ab]	5606±119[b]	9516±598[a]	289±16[b]	756±20[c]
CTFP+WR	4795±64[b]	6745±55[b]	4897±67[c]	9454±474[a]	438±76[a]	1104±79[b]

Nutrient uptake of soybean

The results revealed that the total uptake of N, P, K, S, Zn and Mn were did not vary significantly among the different cropping systems. However, the higher uptake of N, P, K, S, Zn and Mn were observed under soybean-chickpea system. The total uptake of Fe was found higher under soybean-maize cropping system. Among the crop establishment methods, significantly the highest total uptake of N, P, K, S, Zn and Mn were observed in PBBF + R treatment followed by PBBF + WR as compared to CTFP with or without residue retention.

Effect of cropping systems, crop establishment's method/land configuration and residue management practices on total nutrient uptake

Treatment	Total N uptake	Total P uptake	Total S uptake	Total Zn uptake	Total Fe uptake	Total Mn uptake
Cropping Systems (CS)						
Soybean-maize	159.00[a]	12.06[a]	5.40[a]	253.8[a]	573.2[a]	114.5[a]
Soybean-chickpea	162.37[a]	12.26[a]	5.47[a]	255.9[a]	565.7[a]	115.2[a]
Soybean-wheat	159.63[a]	12.27[a]	5.39[a]	250.5[a]	567.2[a]	111.6[a]
Crop establishment methods/landconfigurations (LC)						
PBBF+R	182.75[a]	13.89[a]	6.44[a]	268.5[a]	808.2[a]	125.7[a]
PBBF+WR	167.48[b]	12.38[b]	5.16b[c]	256.8[b]	585.8[b]	114.0[b]
CTFP+R	153.89[b]	11.89[b]	5.17[b]	248.7[c]	498.5[c]	111.6[b]
CTFP+WR	137.21[c]	10.63[c]	4.92[c]	239.7[d]	382.3[d]	103.8[b]
ANOVA						
CS	0.7297	0.7898	0.4818	0.1077	0.7314	0.5413
LC	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
CS*LC	0.2947	0.8927	0.0004	0.1847	0.0083	0.7561

Rhizospheric properties in soil at R_5 stage

The rhizosphere properties such as dehydrogenase, β-glucosidase, acid phosphatase, alkaline phosphatase, microbial respiration and substrate induce respiration significantly influenced by different cropping systems as well as crop establishment techniques. Among different cropping systems, the β-Glycosidase and dehydrogenase activity were higher under soybean-wheat system, acid phosphatase and alkaline phosphatase activity were higher under soybean-chickpea system and microbial respirationand substrate induced respiration were higher under soybean-maize system.Among the different establishment techniques,significantly the highest dehydrogenase activity, β-glycosidase, acid phosphatase, alkaline phosphatase, microbial respiration and substrate induce respiration were registered under PBBF + R followed by PBBF + WR than CTFP with or without residues retention.

Effect of cropping systems, crop establishment's method/land configuration and residue management practices on microbial properties during *kharif*

Treatment	β-Glycosidase (µg p-nitrophenol/ gsoil/hr)	Dehydrogenase activity (µg triphenyl formazon/ g soil/24 hrs)	Acid Phosphatase	Alkaline phosphatase	Microbial respiration (mg CO_2 / kg soil/day)	Substrate induced respiration (mg CO_2 / kg soil/hr)
			(µg p-nitrophenol/g soil/hr)			
Cropping system						
Soybean-maize	419.8[b]	238.7[a]	240.2a[b]	497.1[a]	17.6[a]	30.2[a]
Soybean-chickpea	427.8[a]	235.6[a]	247.0[a]	498.3[a]	17.4[a]	30.1[a]
Soybean-wheat	433.4[a]	252.9[a]	237.1[b]	497.2[a]	16.6[a]	29.4[a]
Crop establishment methods/land configurations (LC)						
PBBF + R	483.7[a]	259.2[a]	259.9[a]	555.4[a]	21.13[a]	34.58[a]
PBBF + WR	451.8[b]	250.3[a]	250.2[a]	532.7[b]	16.43[b]	31.28[ab]
CTFP + R	385.6[c]	244.5[a]	237.7[b]	451.9[c]	17.79[b]	27.74[b]
CTFP + WR	387.0[c]	215.6[b]	217.9[c]	450.1[c]	13.38[c]	25.91[b]
ANOVA						
CS	0.0002	0.4227	0.0162	0.9163	0.5484	0.9065
LC	0.0001	0.0632	0.0001	0.0001	0.0001	0.0020
CS*LC	<0.0001	0.0514	0.0019	0.0017	0.4475	0.9716

Soil physical properties, available nutrient status and pH at the end of two-year cropping cycle

The results revealed that the soil organic carbon, carbon stock, bulk density, available N, available P and soil pH significantly influenced by different cropping systems and crop establishment's method/land configuration and residue management practices. The lowest bulk density and highest organic carbon and carbon stock were registered under soybean-maize system followed by soybean-wheat. However, the lowest soil pH and higher available N and P status in soil were recorded under soybean-chickpea system.Among the crop establishment methods, significantly the lowest bulk density and lower pH were observed in PBBF + R treatment. Similarly, significantly the highest organic carbon, available N and P status were found under PBBF + WR as compared to CTFP with or without residue retention.

Effect of cropping systems, crop establishment's method/land configuration and residue management practices on soil physical properties, available nutrient status and pH at the end of two-year cropping cycle

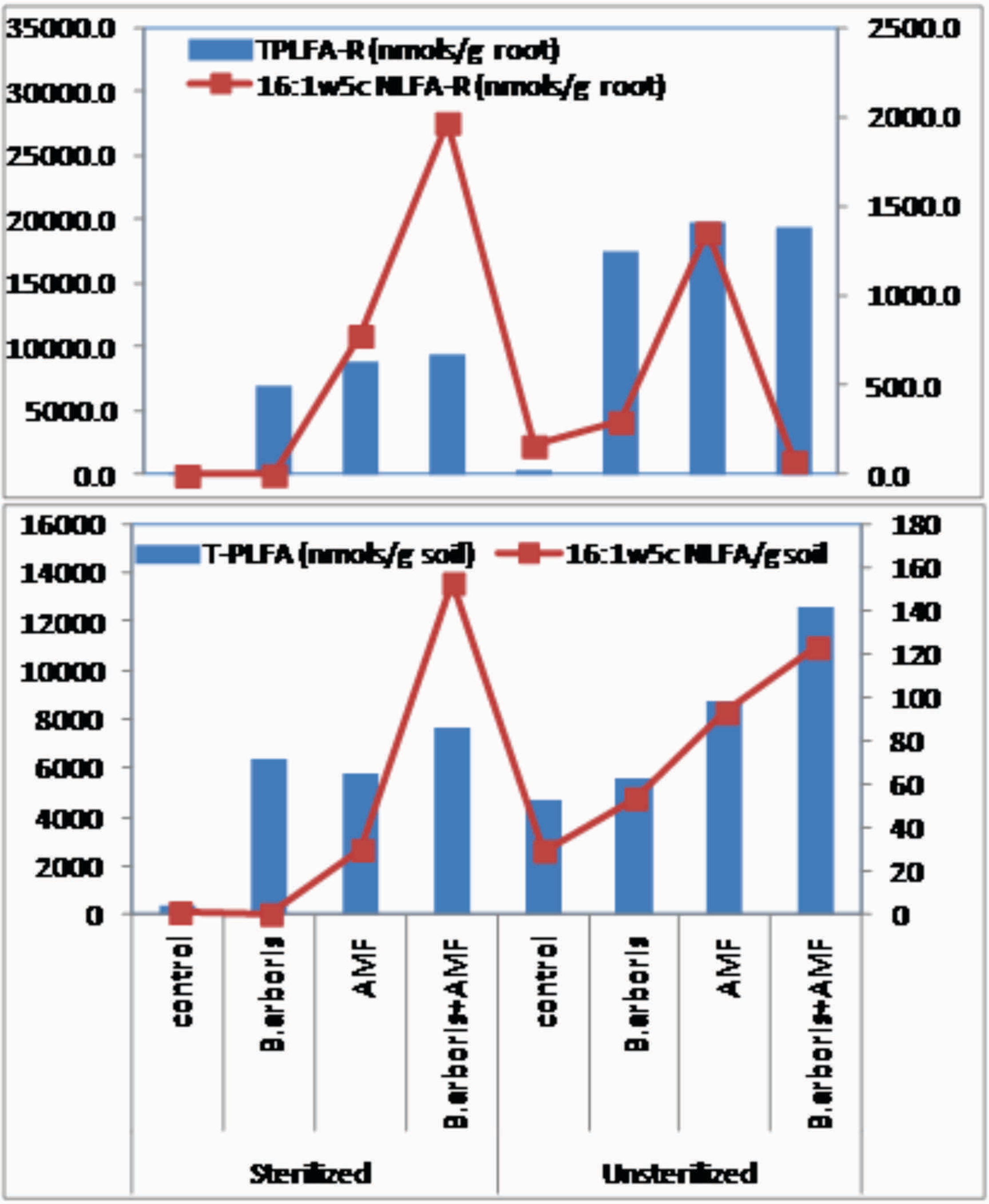
Treatment	Bulk density	Organic carbon	Carbon stock (mg/ha)	Available N	Available P	PH
Cropping system						
Soybean-maize	1.43[b]	0.62[a]	13.5[a]	335.8[c]	23.9[b]	7.53[a]
Soybean-chickpea	1.45[a]	0.58[b]	12.6[b]	368.5[a]	24.5[a]	7.47[b]
Soybean-wheat	1.43[b]	0.60[ab]	13.1[ab]	345.0[b]	21.0[b]	7.51[a]
Crop establishment methods/ land configurations (LC)						
PBBF+R	1.40[c]	0.64[a]	13.4[a]	364.1[a]	25.3[a]	7.41[c]
PBBF+WR	1.42[b]	0.60b[c]	12.7[a]	345.0[bc]	24.5[a]	7.50[b]
CTFP+R	1.43[b]	0.61[ab]	13.2[a]	350.2[b]	23.0a[b]	7.52[b]
CTFP+WR	1.50[a]	0.57[c]	12.8[a]	339.7[c]	19.8[b]	7.59[a]
ANOVA						
CS	0.0031	0.0020	0.0107	<.0001	0.0156	<.0001
CEM	<.0001	0.0003	0.0883	<.0001	0.0031	<.0001
CS*CEM	<.0001	0.0107	0.0042	<.0001	0.0153	<.0001

Development of AM fungi mass production technology

During 2019, at IISR, Indore research on mass production of AM fungi was attempted in soil-sand pot cultures on sorghum co-inoculated with *Burkholderia arboris* (mycorrhiza helper bacteria) and amended with hulls (soybean processing mill wastes) and vermicompost under sterilized and unsterilized conditions. The role of *Burkholderia arboris* was evaluated and validated for enhanced production of AMF in pot cultures on sorghum as host.

Mass production of AMF in potting substrates co-inoculated with *B. arboris*

- Out of all combinations, incorporation of AMF with *B.arboris* in the soybean hulls with vermicompost amended with sand-soil substrate has produced significantly higher amounts of 16:1ω5c neutral lipid phospholipid (NLFA, AMF specific NLFA representing spore biomass-ranges from 123.1 to 152.5 nanomoles/g in soil) under sterilized and unsterilized conditions as compared to control, *Burkholderia arboris* and AMF alone pots.
- In roots, under unsterilized conditions, inoculation of *Burkholderia arboris* in either AMF or without AMF applied pots significantly enhanced AMF NLFA biomass when compared to control. The invariable and exceptionally lower NLFA observed in *Burkholderia arboris*+AMF than the *Burkholderia arboris* and AMF pots has some error and hence will be re-analysed/re-examined. However, under sterilized conditions, inoculation of *Burkholderia arboris* in AMF pots further enhanced significantly 16:1ω5c NLFA biomass over the AMF alone pots indicates that incorporation of *Burkholderia arboris* in AMF applied pots (under both sterilized and unsterilized conditions) stimulated the AMF production in soil and roots.
- Under both the conditions, the total PLFA (represents the microbial biomass carbon) a indicator of microbial biomass C analysed in soil and roots found to increase the total PLFA (nmoles/g) biomass when AMF pots inoculated with *Burkholderia arboris*. It means *Burkholderia arboris* inoculation not only enhancing AMF-NLFA biomass but also maintaining total microbial C in terms of total PLFA analysed both the roots and soil.



Effect of *B. arboris* on AMF production in organic amended substrate on sorghum under sterilized and unsterilized microcosms. T-PLFA is total phospholipids where as NLFA is 16:1ω5c neutral lipid phospholipid (NLFA) assessed in roots and soil samples

Identification of most frequently occurring AM fungi harboring in the areas polluted by fly ash and solid wastes dumps of Assam.

The waste dumping site1-Deepor Beel Ramsar located near Guwahati and site 2-Ash contaminated soils adjoining to brick klin in Borghat, Tezpur was examined to undertake remediation work though AMF and biochar application. Site 1 was found to harbour highest spore density in D1 (7.00 spores/g soil), D2 (6.33 spores/g soil) and D4 (6.13 spores/g soil) covering perennial herb species and in D17 (6.83 spores/g soil) covering vetiver grass. Whereas the site 2-Ash contaminated site had highest spore density only in one site i.e., in B7 (7.67 spores/g soil) covering fern vegetation. These sites were used for exploring the occurrence of AMF and their further exploitation for reclamation work. Two most AMF genera mainly belonging to Glomus type1 and Rhizophagus sp. were found to be predominant across all the locations of two sites observed in the study (Images-1to 4). The most frequently occurring (dominant) species of AM inhabiting across all sampling locations and having higher density (more than 6 spores/ g soil) were selected for the enrichment, rapid retrieval of spores, multiplication and preparation of AM inocula for further experimentation (biochar-AMF microcosm trial and field evaluation thereon).

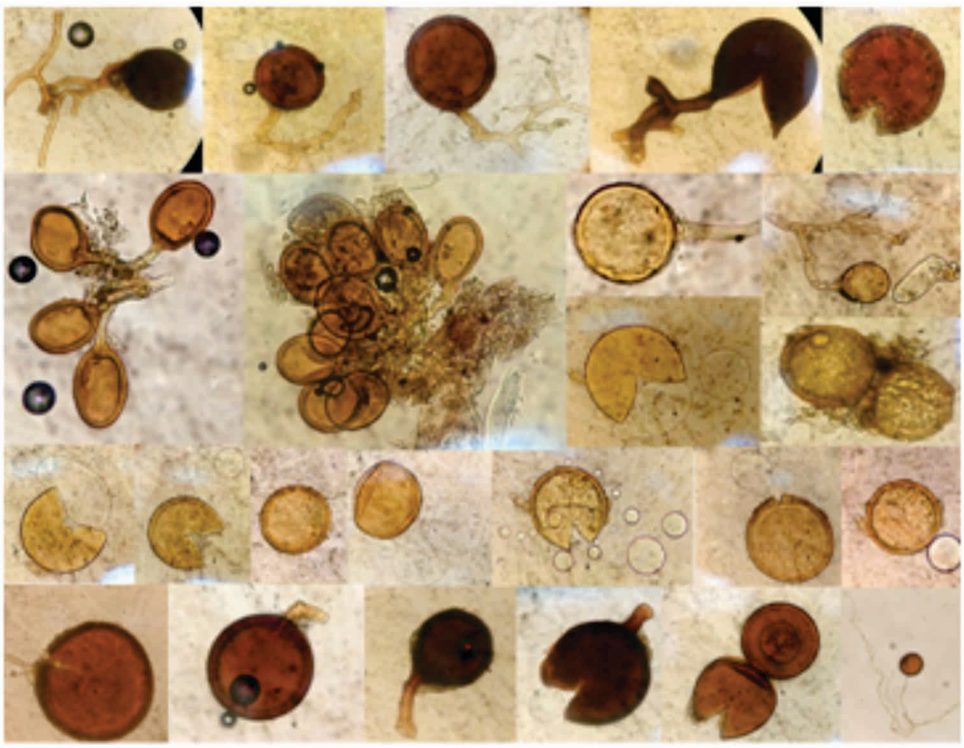


Image 1 : Diversity of spores recovered from site 1

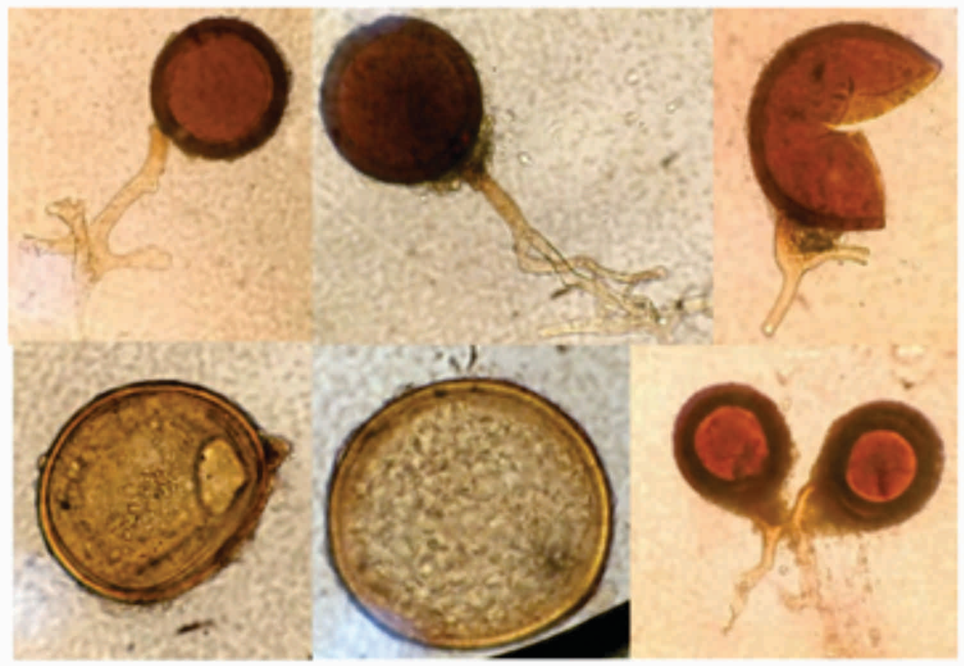
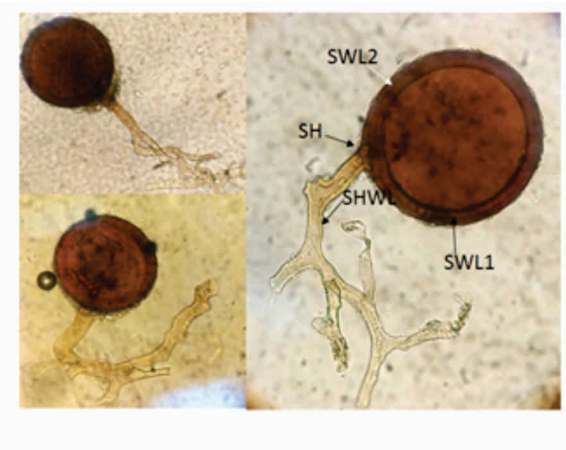


Image 2 : Diversity of spores recovered from site 2

Glomus type 1 (Image-3)



Spore colour : dark brown

Spore diameter : 110-140 µm

Spore shape : globose to subglobose

Sporecarp : yes

Spore wall layers (SWL) : Three (SWL1, SWL2 and SWL3)

Subtending hyphae (SH): Glassy/transparent hyphae

Septation : A septate with two wall layers that are in a continuation of the spore wall

Rhizophagus/Glomus type 2 (Image-4)

Spre colour : Straw colored/pale (variable)

Spore diameter : 110-140 µm

Spore shape : globose to subglobose

Sporocarp : yes

Spore wall layers (SWL) : Three (SWL1, SWL2 and SWL3)

Subtending hyphae (SH):
Color : yellow brown (similar to spore wall)
Septation : Aseptate with two wall layers that are in a continuation of the spore wall.

Field evaluation of drought tolerant soybean rhizobia

The potential rhizobial strains were evaluated for conferring drought tolerance in soybean during second consecutive year both under pots in field during kharif 2019. The strains were evaluated and their efficacy was compared with commercial culture and AM fungi for improving the productivity of soybean (JS 95-60) during Kharif 2019.

- During field evaluation, compared to 100% RDF, the inoculation of soybean with Bradyrhizobium daqingense (B. daqingense) was found to be best in terms of having higher nodulation, leghaemoglobin content in nodules, chlorophyll content in leaves, and grain yield followed by Bradyrhizobium liaoningense (B. liaoningense), Bradyrhizobium japonicum (B. japonicum) and AMF when applied with 75% RDF. The local soybean commercial rhizobia did not perform well as compared to strains recovered from soybean varieties which are currently in seed chain.
- The application of *B. daqingense, B. japonicum and B. liaoningense* at 75% RDF significantly improved, chlorophyll and yield, over the control (100% RDF, conventional practice) and commercial strains of rhizobia and AMF. However, the co-inoculation of AMF with rhizobia with 75% RDF although had significantly higher yield than control and commercial strains of rhizobia but the yield was still lower than *B. daqingense* inoculated plants.
- The inoculation of soybean with *B. daqingense* was found to be best in terms of having higher nodulation,

Leghaemoglobin content in nodules, chlorophyll content in leaves, and grain yield followed by *B. liaoningense, B. japonicum* and AMF when applied with 75% RDF. The local soybean commercial rhizobia did not perform well as compared to strains recovered from soybean varieties which are currently in seed chain during field evaluation, when compared with 100% RDF and conventional farmer's technique.

- In conclusion, *B. daqingense, B. japonicum and B. liaoningense* at 75% RDF significantly improved (*B. daqingense* was superior) yield, LegHb, chlorophyll over other combinations including consortia therefore these rhizobial strains are identified as a potential strains as N biofertilizer for increased sustainability and productivity of soybean

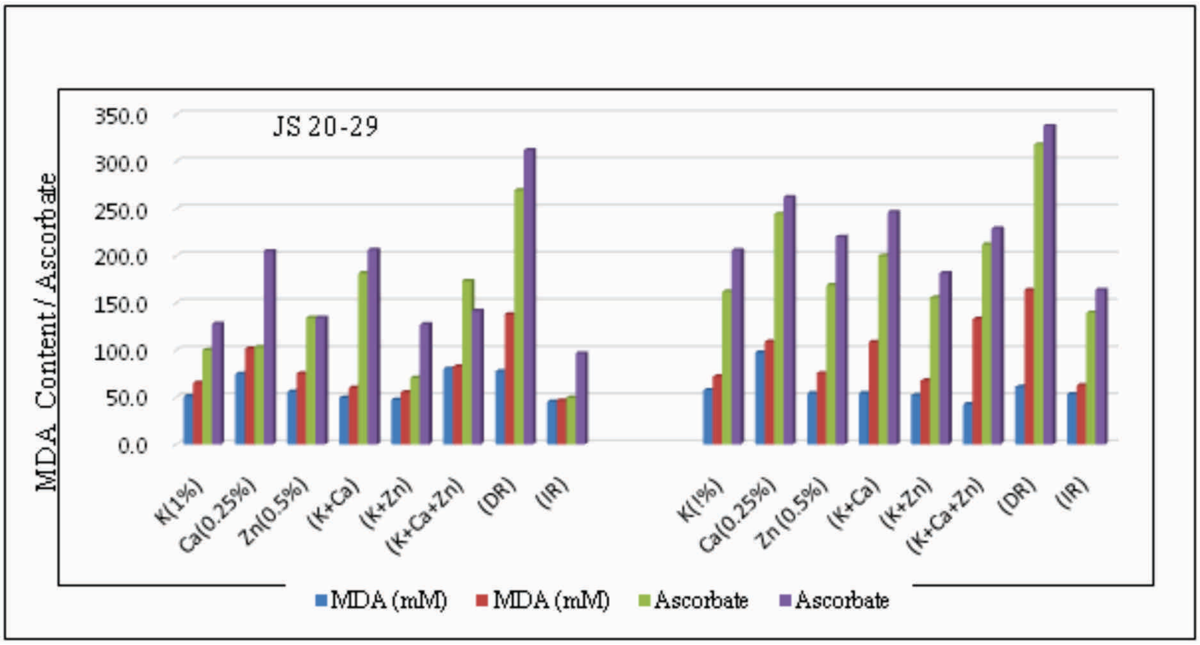
Effect of microbial inoculants on soybean nodulation, (nodules per plant, nodule dry weight, and leghaemoglobin content in nodules), chlorophyll content in leaf, and soybean yield assessed under field conditions

Treatment	Nodules per plant	Nodule dry mass (g plant^{-1})	LegH in nodules (mg gm^{-1})	Chlorophyll in fresh leaves (mg gm^{-1})	Grain yield (kg ha^{-1})
Control +100% RDF	30.44^{f}	0.1^{c}	9.59^{c}	2.81^{bc}	1076.11^{d}
AMF+75% RDF	53.55^{d}	0.13^{b}	10.46^{bc}	3.23^{bc}	1251.85^{cd}
B. japonicum+75% RDF	43.89^{e}	0.13^{b}	11.51^{ab}	2.89^{bc}	1520.37^{ab}
B. liaoningense +75% RDF	75^{c}	0.15^{ab}	11.44^{ab}	3.29^{ab}	1453.15^{abc}
B.daqingense+75% RDF	94.5^{a}	0.17^{a}	12.25^{a}	3.7^{a}	1597.59^{a}
T5+AMF+75% RDF	81.5^{b}	0.15^{ab}	11.68^{ab}	3.43^{a}	1366.85^{bc}
Local/commercial rhizobial strain+75% RDF	30^{f}	0.09^{c}	10.76^{abc}	2.85^{bc}	1269.63^{cd}
Local/commercial AMF strain+75% RDF	32.83^{f}	0.09^{c}	9.76^{c}	2.52^{c}	1243.33^{cd}
LSD (P=0.05)	5.899	0.025	1.554	0.491	203.937

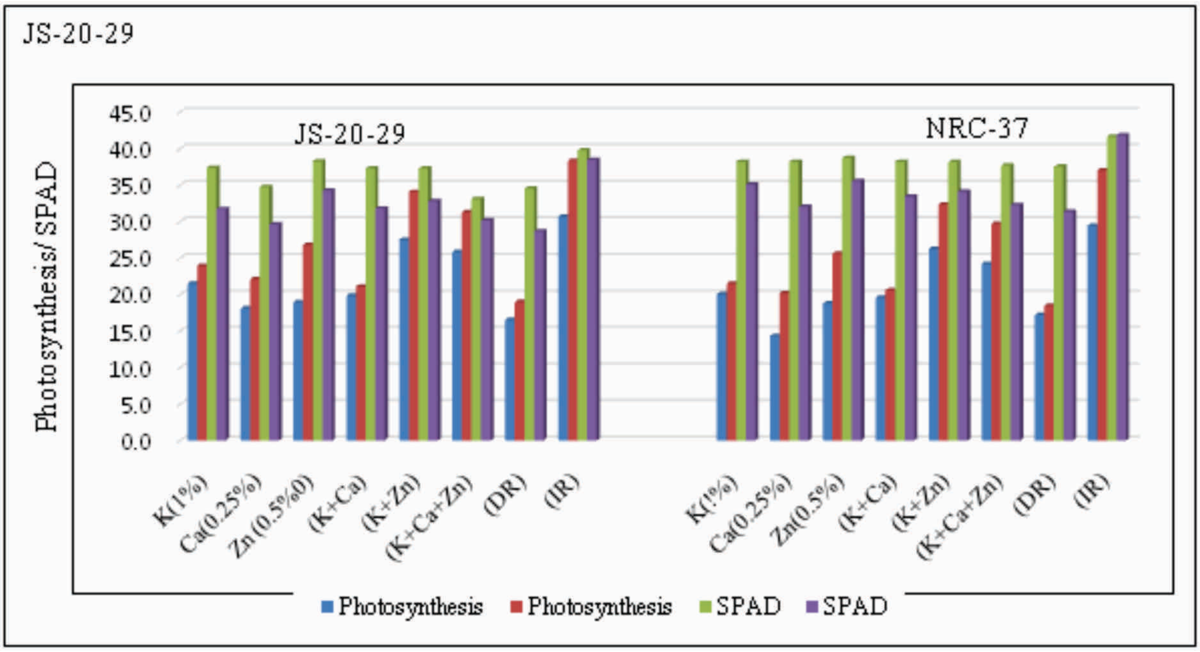
Data are average of 3 replications; LSD, least significance difference at 5% level of significance by Duncan's multiple range test of ANOVA.

Drought Amelioration through foliar application of Nutrients

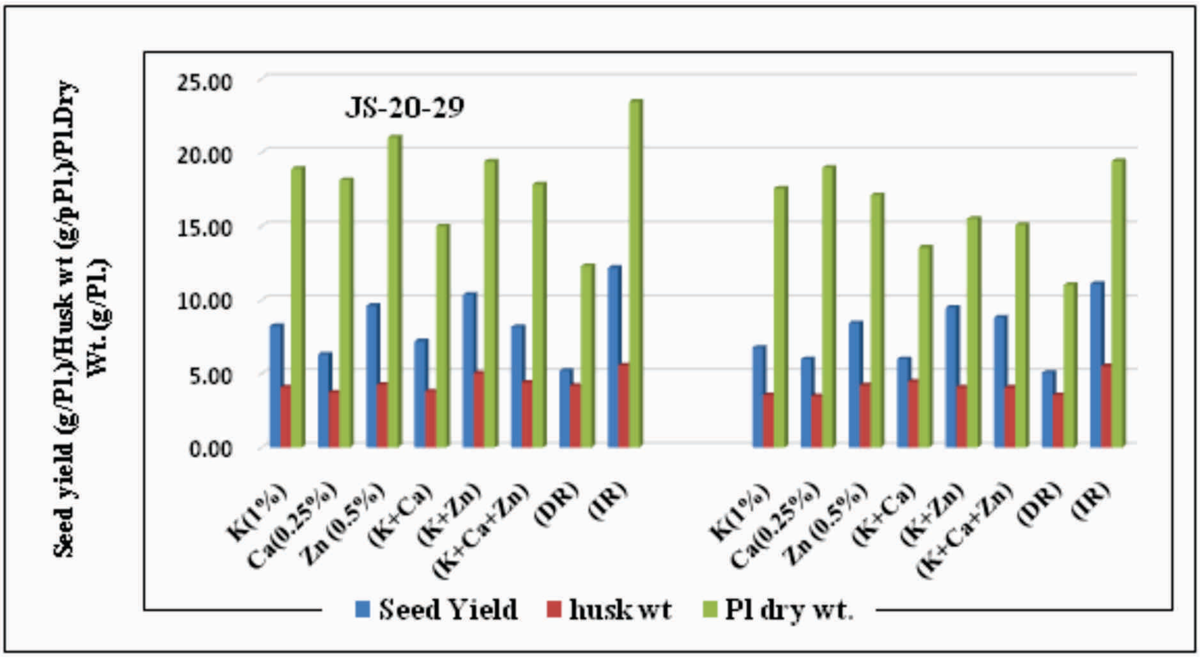
Drought amelioration study in soybean were carried out with three different nutrients i.e., K, Ca and Zn and their combinations during the kharif season of 2019 in poly house condition. The drought given for 7 days at two times flowering (R_1) and at grain filling (R_5) resulted in 57 and 54% reduction in yield of JS 20-29 and NRC 37 genotypes. The nutrient spray given two days after withholding irrigation ameliorates drought effect and showed increase in yield over drought. The increase in yield was up to 99 % in JS 20-29 and 87 % in NRC 37 over the drought. The application of K (1%) with Zn(0.5%) showed maximum increase in yield over the drought followed by Zn (0.50%) and K (1%) in JS 20-29. While in case of NRC 37 the best treatment K (1%) + Zn (05%) is followed by K(1%) + Ca (0.25 %)+ Zn (0.5%) and Zn (0.5%). The ameliorating effect of nutrient was mainly because of increase in different physiological parameters i.e, gas exchange parameters, RWC, MSI, SPAD and yield attributing characters. Besides this, the nutrient treated leaves were capable of scavenging excessive ROS, and keeping lower MDA and Ascorbate contents under drought stress condition.The decreased photosynthesis rate in JS 20-29 (46 %) and NRC 37(42%) under drought condition got increased by the application of nutrients. The maximum 66 % and 53 % increase in photosynthesis of JS 20-29 and NRC 37 was achieved by the spray of K(1%) + Zn (0.5%) followed by spray of K (1%) + Ca (0.25%) + Zn (0.5%) and K (1.0%) in both the genotypes. The nutrient spray also increased SPAD (relative chlorophyll) value and maximum SPAD was measured with (Zn, 0.5%) in both the genotypes. The membrane stability index was also increased by the application of nutrient at both the stages and the maximum increase in MSI at stage-I was observed with (K,1% +Zn, 0.5%) in both the genotypes followed by K(1%). Proline serves during the osmotic stress as a mediator of osmotic adjustment, a stabilizer of sub-cellular structures, a collector of free radicals, a sink of energy and a stress signal. Proline accumulated under drought stress and it was further increase by the nutrient spray. The maximum accumulation of proline were measured with the treatment K(1%)+Zn(0.5%) at both the stage in both the genotypes. The leaves were capable of scavenging excessive ROS, and keeping lower MDA and ascorbate contents under drought stress condition. Drought has high MDA content and it decreased with different nutrient spray. The treatment K(1%) + Zn(0.5%) maintained low MDA and Ascorbate content as compared to drought in both the genotypes. On the basis of study it revealed that the treatment K(1%) + Zn(0.5%) found best to ameliorate the drought effect on soybean crop.



Effect of different nutrient spray on MDA (nmol g^{-1}dry wt) and Ascorbic Acid (micro mol g^{-1}dry wt.) content at stage-I and stage-II of soybean genotypes grown under drought condition.



Effect of different nutrient spray on photosynthesis rate (µmol CO_2 $m^{-2}s^{-1}$) and SPAD values at stage-Iand II of soybean genotypes grown under drought condition



Effect of different nutrient spray on seed yield (g/plant), husk wt. (g/plant) and plant dry wt. (g/plant) of soybean genotypes grown under drought condition

Design, development and validation of machines

The design and specifications of Tractor PTO operated root stock cutting/shaving machine and Tractor PTO operated root stock breaking/picking machine to prevent burning of root stock for Vertisols and associated soils for the Indian farmers have been submitted for manufacturing. The combination of both machine will ensure more than seventy percent picking/uplifting of root stock and straw from the fields of wheat. Therefore, these machines have a potential to provide the facility to the soybean farmers to pick the wheat straw and root stock of the wheat crop. The proposed machines are the better solutions to manage the crop root stock and help easier tillage/sowing of subsequent soybean crop. Study shows that crop burning has not stopped rather become a serious habit/practice/ issue particularly after the introduction/spread adoption of combine harvester threshers in different parts of India which has become a big reason of pollution in big and small cities/villages of India.

Wheat crop on permanent BBF (Broad bed and furrow)

Crop sown by Zero tillage sowing of wheat on permanent BBF (Broad bed and furrow)

8. BIOTIC STRESSES

Development of YMV resistant genotypes

Following crosses were attempted to combine charcoal resistance, YMV resistance, high yield and KTI and lypoxygenase free (double null) genotypes.

Categories leaf size of soybean varieties: large, medium and small

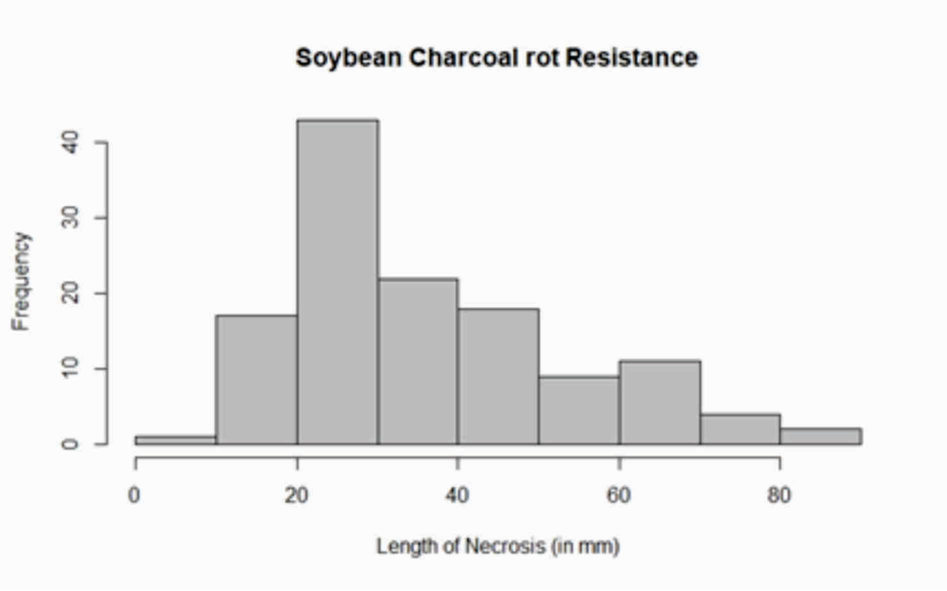
Cross combination	Target traits
AMS5-18 × NRCSL 2 AMS100-39 × NRCSL 2 NRC149 × AMS 5-18	Charcoal rot and MYMIV
LNS 33A × NRCSL 2 LNS 98 × NRCSL 2 LNS 72-75× NRCSL 2	MYMIV and double null
JS 93-05 × (BC2 JS 93-05 × SL 525) NRC 7 × (BC2 NRC 7 × SL 958)	MYMIV and high yield

All the segregating lines were tested with MYMIV resistance linked markers Satt 322 and GMAC7L for selection of MYMIV resistant plants. All the homozygous recessive plants for MYMIV resistance gene based on PCR results of linked markers were raised at hot spot Ludhiana for validation and homozygous recessive plants showed resistance to MYMIV at Ludhiana. Three genotypes NRCSL 1 NRCSL 2 and NRC 149 developed with MYMIV resistance are being evaluated under AICRP trial.

Screening of RIL population for charcoal rot resistance

A RIL population of size 125 derived from JS 97-52 × JS 90-41 along with parents was screened for charcoal rot resistance using cut-stem inoculation technique using Jabalpur isolate. Trial was conducted in RBD design with three replications in a net house during kharif 2019. Average min temperature and Average max temperature during experiment were (24.6°C) and (34.3°C) respectively. Disease severity was measured in terms of linear necrosis length 15 days after inoculation. Average necrosis length in JS 97-52 and JS 90-41were 20.3 mm and 28.6 mm respectively. Length of necrosis across population ranged from 7.78 mm (104-49) to 83.11 (104-11) with a mean of 36.13 mm. Heritability of the trait was 52.6 %. Medium heritability is attributed to its complex mode of inheritance confounded with high environmental sensitivity. Though parents did not differ significantly for the trait, several transgressive segregants were observed across the population indicating polygenic mode of inheritance (additive and additive x additive interactions). Lines 104-49, 104-38, 104-67, 104-59, 104-30, 104-1, 104-105, 104-52, 104-53, 104-115, 104-52, 104-53, 104-115, 104-68, 104-31, 104-93, 104-29, 104-3, 104-54, 104-32 and 104-15 are found to be resistant than the better parent (JS 97-52). These lines would further be confirmed under field conditions for their resistance at adult plant stage (R_7).

Screening for charcoal rot resistance in net house



Frequency distribution of linear length of necrosis across the population

Genetics of soybean anthracnose resistance

During 2018, a total of 230 soybean germplasm accessions were evaluated for anthracnose resistance. Six genotypes viz., EC 538828, EC 34372, EC 457254, KARUNE, AKSS 67 and AGS 155 found to be immune and identified as potential sources for resistance. During 2019, genetics of anthracnose resistance in three F_2 populations derived from the crosses EC 34372, EC 457254, AKSS 67 and a common susceptible parent JS 95-60 revealed that the resistance in all the three resistant parents was governed by two major genes interacting in complementary fashion. The χ^2 test for goodness of fit revealed that F_2 plants in each of the three populations segregated in 9 resistant: 7 susceptible ratio. This is the first report on genetics of anthracnose resistance in soybean, enabling soybean breeders to develop a strategic anthracnose resistance breeding program and to map the genes governing disease. The resistant plants obtained in the segregating populations of three crosses will be helpful in development of anthracnose resistant soybean genotypes.

Disease reaction in parents and corresponding F_2 populations

Inheritance pattern of soybean anthracnose resistance in three different F_2 populations

Cross	F_2 Population size	Observed		Expected		Observed ratio	Expected ratio	χ2 (9:7)	P-value
		R	S	R	S	R:S	R:S		
EC 457254 × JS 95-60	336	182	154	189	147	8.7 : 7.3	9:7	0.58	0.44
EC 34372 × JS 95-60	487	266	221	274	213	8.7 : 7.3	9:7	0.47	0.49
AKSS 67× JS 95-60	89	53	36	50	39	9.5 : 6.5	9:7	0.39	0.53

Following crosses were made for charcoal rot and anthracnose resistance

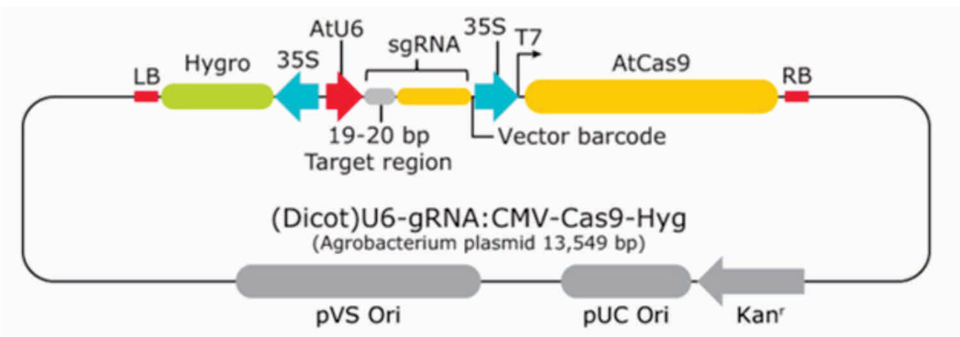
Charcoal rot resistance	Anthracnose resistance
AMS-5-18 × JS 90-41	DSb 23 × DSb 32
JS 90-41 × DS 9712	Karune × EC 572136
AMS-5-18 × Brag	Karune × DSb 32
(NRC 128 × AMS-5-18) × (P 501 × DS 3106)	Karune × JS 93-05
(JS 20-69 × NRC 128) x (DS 9712 × AMS-5-18)	Karune × EC 391336
(JS 97-52 × AMS-5-18) × (JS 20-69 × NRC 128)	-

Frog eye leaf spot resistance

Crosses have been made between VLS 89 (resistant to frog eye leaf spot) and Shivalik (susceptible to frogeye leaf spot) during kharif 2019. F1 seeds will be advanced during off-season and F2 population will be screened at Palampur to study genetics of resistance.

Development of CRISPR vectors and gene silencing

Two CRISPR (clustered regularly interspaced short palindromic repeats) vectors were designed for targeted silencing of the RPG1B and PDH1 genes which are involved in bacterial blight resistance and seed shattering mechanism respectively.



CRISPR Vector harboring RPG1B and PDH1 sgRNA and hygromycin resistance gene as a selection marker

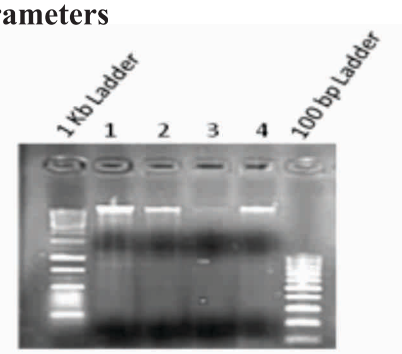
A 20-bp gRNA sequence was selected as target site by using the BreakingCas tool and confirmed by manual analysis. The 20-bp sequence is having tri nucleotide PAM sequence i.e., 5'-NGG-3' on its 3' end. The gRNA sequence was inserted to into binary vector CMV-Cas9-Hyg under *A. thaliana* U6 promoter using BsaI restriction enzyme.

RNA sequencing and transcriptome analyses

A good quality of RNA isolated from four soybean genotypes by Plant/fungal RNA isolation kit, Sigma Aldrich. The integrity of RNA was assessed by formaldehyde agarose gel electrophoresis. Total RNA was quantified using Nanodrop ND-1000 spectrophotometer. Quantitatively it ranges from 15.70 to 373.20 ng/mL with A(260/280) 2.07 to 2.48 signifying its high quality parameter.

Soybean genotypes used for Transcriptome study and its quality parameters

Sr. No.	Sample names	ng/mL	$A_{(260/280)}$	$A_{(260/230)}$
1	JS 2098 (Charcoal Rot Tolerant, Infected)	373.20	2.15	2.30
2	JS 2098 (CRT, Control)	121.38	2.14	2.50
3	JS 9560 (Charcoal Susceptible, Infected)	15.70	2.48	2.14
4	JS 9560 (CRS, Control)	97.90	2.07	2.02



Transcriptome analysis of JS 20-98 (putative charcoal rot tolerant Soybean genotype) and JS 95-60 (putative charcoal rot susceptible Soybean genotype) were conducted by using Oxford Nanopore Technologies, UK and the generated raw data were further Processed for various purposes like base-calling were performed using Guppy and for De-multiplexing by QCAT; Sequence alignment by Minimap 2; SAMtool for file conversion (SAM ↔ BAM); GFOLD for Differential gene expression study. The whole transcriptome cDNA library was prepared using Native barcoding genomic DNA PCR Barcoding (SQK-PCS108 with SQK004) kit, Oxford Nanopore Technologies, UK. Double stranded cDNA was ligated to barcoded adapters and was sequenced using MinIon flow cell (Oxford Nanopore technologies, UK) in the lab. The raw reads were subjected to quality check using MinKnow Oxford Nanopore Technologies, UK to derive information on distribution of average sequence quality scores.

Breeding for collar rot disease

Collar rot caused by *Sclerotium rolfsii* is the major threat for the successful production of soybean in India. Its severity is aggravated in heavy soils and especially rampant in the tropics and subtropic climate. Seedling mortality of even up to 65% has also been reported under high soil moisture conditions. Due to its 30–40% yield loss potential, it is a major obstacle in harnessing full potential of soybean production in most soybean growing areas. Till date, none of the soybean cultivars are reported as immune/highly resistant to Sclerotium blight. However, PK 327, NRC 37 and AMS 5-18 were reported as slightly tolerant/resistant thus, following crosses viz., JS 20-69 × PK 327, AMS 5-18 × Bragg and PK 327 × AMS 5-18 were made to develop new breeding material resistant to collar rot disease. Further, for artificial screening against collar rot, the causal organism *Sclerotium rolfsii* was isolated and maintained in laboratory.

Biochemical, functional and molecular characterization of potential endophytes

Endophytes have ability to produce certain enzymes such as chitinase, cellulose, amylase and protease. For selection of potential endophytes these enzymes were estimated.

Chitinase production assay

Chitin detection media was prepared with 0.3 g $MgSO_4$, 3 g $(NH_4)_2SO_4$, 2 g KH_2PO_4, 1 g Citric acid monohydrate, 15 g agar, 200 µL tween 80, 4.5 g colloidal chitin, 0.15 g bromocresol purple dye for detection of chitinase enzyme activity. 15 endophytic fungi was cultured on chitin detection media and incubated for 27°C for 7 days. The presence of colour change from yellow to purple colour around the colony indicates positive chitinase enzyme activity. Among the isolates EP 3 (Aspergillus flavus), EP Se7 (Fusarium falciforme) and EP N1 (Macrophomina phaseolina) having high chitinase activity.

Cellulase production assay

Production of cellulase enzyme was estimate in minimal synthetic media comprising of 0.2% $NaNO_3$, 0.8% K_2HPO_4, 0.1% $MgSO_4.7H_2O$, 0.8% KCl, 0.2% peptone, 0.1% glucose, 0.5% carboxymethyl cellulose. 15 endophytic fungi was cultured on minimal synthetic media and incubated for 27°C for 7 days. After 7 days culture plates was flooded with 1% iodine in 0.5% KI solution for few second and drain out to observe clear halo zone around the colony determining the positive enzyme production. The zone diameter was determined by subtracting the diameter of the fungal colony from the diameter of the total halo zone. Among the isolates EP 1 (*Fusarium* sp), EP Se7 (*Fusarium falciforme*) and EP 29 (*Fusarium* sp) having high cellulose activity.

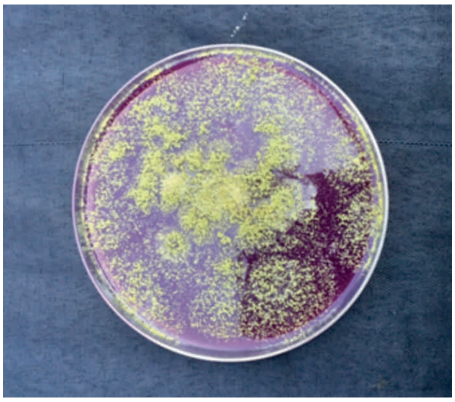
Amylase production assay

Glucose yeast peptone agar comprising of

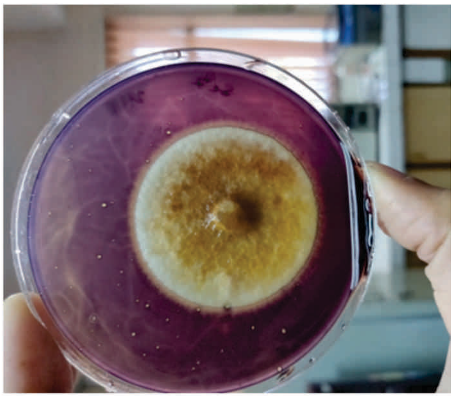
1% glucose, 0.2% yeast extract, 0.5% peptone with the addition of 2.5% soluble starch was used to determined amylase activity. 15 endophytic fungi was cultured on minimal synthetic media and incubated for 27°C for 7 days. After 7 days culture plates was flooded with 1% iodine in 0.5% KI solution for few second and drain out to observe clear halo zone around the colony determining the positive enzyme production. The zone diameter was determined by subtracting the diameter of the fungal colony from the diameter of the total halo zone. Among the isolates EP 57 (unknown), EP Se7 (*Fusarium falciforme*) and EP N2 (*Fusarium falciforme*) having high cellulose activity.

Protease production assay

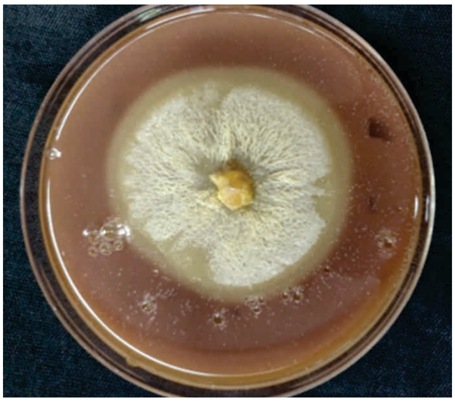
The skimmed milk agar (HiMedia, India) was used for estimation of protease activity. 15 endophytic fungi was cultured on minimal synthetic media and incubated for 27°C for 7 days. Visible clearance around the colony has qualitatively indicated protease activity. The zone diameter was determined by subtracting the diameter of the fungal colony from the diameter of the total halo zone. Among the isolates EP 07 (*Fusarium sp*), EP and 42 (*Fusarium* spp) having high protease activity.



Screening of endophytes for highest chitinase activity



Screening of endophytes for highest cellulase activity



Screening of soybean endophytes for highest amylase activity

Screening of endophytes for highest protease activity

Screening of soybean germplasm for resistance against major foliar diseases

During Kharif 2019, a total of 1220 soybean germplasm lines have been screened for anthracnose resistance under field conditions. Germplasm comprised of indigenous genotypes and exotic genotypes including vegetable soybean genotypes. Disease scoring was done based on pod infection during pod filling stage using 0-5 scale. Out of 1220 genotypes screened, 429 germplasm lines showed highly succeptible reaction, 744 lines were moderately susceptible, 39 lines showed resistance reaction while 8 lines were highly resistant for anthracnose disease. Genotypes, EC 389160, EC 41318, EC 993294, DS 3105, DS 3106, RSC 10-46, JS 20-69 and IC 391443 were found to be highly resistant. Myrothecium leaf spot of soybean is another disease occurring in major soybean growing areas of India. For this disease scoring was done by using 0-9 scale. Out of 1220 genotypes screened, 474 germplasm lines showed highly susceptible reaction, 635 lines were moderately susceptible, 79 lines showed resistance reaction while 32 lines were highly resistant for Myrothecium leaf spot of soybean. However, three lines RSC 10-46, EC 993294, IC 391443 showed highly resistant reaction for both the diseases.

Molecular characterization of isolates of *M. phaseolina*

Total 42 isolates of *Macrophomina phaseolina* were molecularly characterize through ITS 1 and ITS 4. The DNA of 42 isolates of *M. phaseolina* were isolated using CTAB method and were amplified using conserved gene primer of ITS region. Primer pair ITS 1 and ITS 4 were used to amplify the 5.8S gene. The sequence of primer ITS 4 is 5´- TCC TCC GCT TAT TGA TAT GC -3´ and ITS 1 is 5´- TCCGTAGGTGAACCTGCGG - 3´. Amplification was performed in a 12.5 µL reaction volume containing 1.5 µL of 10X PCR buffer, 3 µL of 25 mM $MgCl_2$, 1.2 µL of 2.5 mM deoxyribonucleotide triphosphates (dNTPs), 0.7 µL of 10 pM each primer (ITS 4 and ITS 5), and 1 µL of DNA template, 0.3 µL of 1 units of Taq DNA polymerase. The thermal cycle consisted of 4-minute for initial denaturation at 94°C, followed by 35 cycles of 1-minute for denaturation at 95°C, 30-second for primer annealing at 53°C, 1-minute extension at 72°C, and a final 10-minute for extension at 72°C. The PCR products were examined by electrophoresis in 1.2% (w/v) agarose gel and checked for size and purity. Purified PCR products were then directly sent for sequencing. Aligned sequences of ITS 1 and ITS 4 from 42 isolates of *M. phaseolina* were submitted and published through NCBI gene bank.

Soybean diseases, insect pest monitoring, and pathogen prolifing

To assess the extent of soybean disease and pest severity, on the request of state agriculture department intensive roving survey was conducted during Kharif 2019 in major soybean growing districts *i.e.,* Indore, Ujjain, and Dewas. At least five villages of each district were randomly selected on both sides of road when the crop was in flowering stage or pod formation stage. Such fields were assessed for disease and insect severity. In every district due to continuous raining, gram pod borer severity was increased up to 50-90 % of according to leaf area damage. The farmers were advised to spray indoxacarb 14.5SC@ 0.5 L /ha or Chlorantraniliprol 18.5 SC @ 0.15 L /ha by using 500 L of water per hectre. Soybean anthracnose severity was less to moderate. The farmers were advised to spray thiophenate methyl @ 1 kg/ha or tebuconazole @ 625 ml/ha or tebuconazole + sulphur 1 lit/ha or hexaconazole @ 500 ml/ha or pyroclostrobin @ 500 g/ha using 500 litre of water for effective magement of the soybean anthracnose diseases. The farmers were also advised to use seed treatment with thiophenate methyl + pyroclostrobin @ 3 mL/kg of seed for management of seed borne diseases and mix zinc sulphate 25 kg and borax 0.5 kg in soil at time of field preparation.

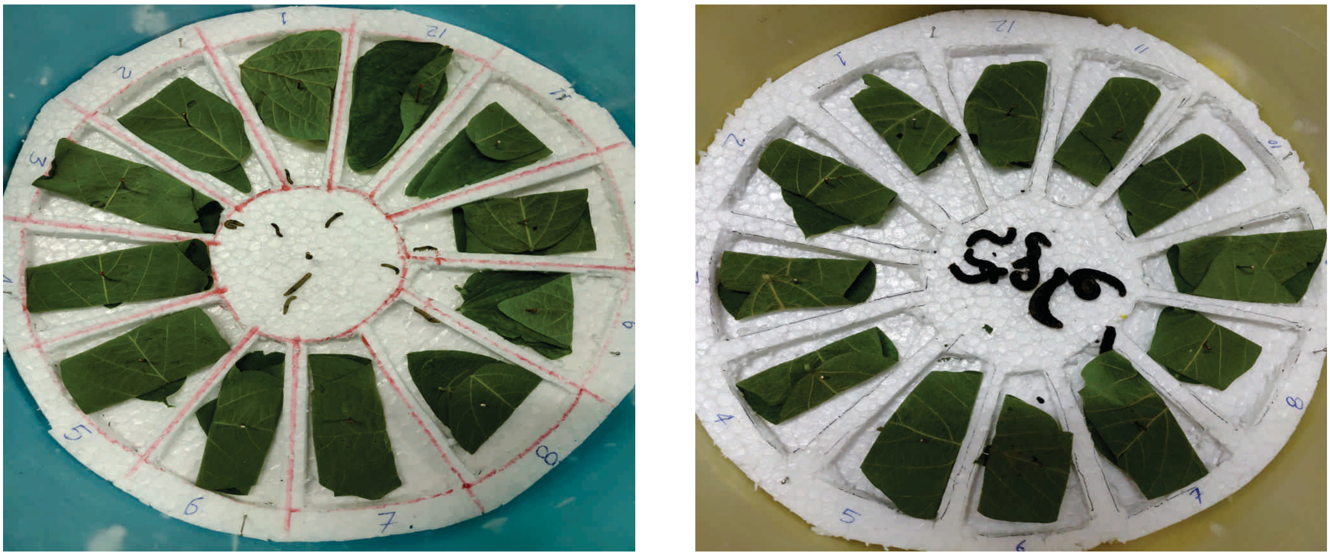
Breeding for insect resistance/ tolerance

During Kharif-2019, 100 soybean genotypes along with checks (resistant and susceptible) were screened for defoliating insects in field condition and antixenosis (for *Spodoptera litura*) in lab conditions. Recorded data on damage caused by defoliating insects, yield and yield contributing characters. For antixenosis, the experiment was conducted in three replications for each of the genotype and data was recorded. Based on the preference index (C), in comparison with susceptible check JS 335, out of 100 screened soybean genotypes, 2 genotypes *viz.*, Hara Soya and G5P22 exhibited strong antixenosis, 11 genotypes exhibited moderate antixenosis. Whereas, 40 genotypes and 42 genotypes expressed slight antixenosis and preference host respectively. Based on this classification, genotypes exhibiting strong and moderate antixenosis can be considered as resistant sources.

Soybean genotypes exhibiting strong and moderate antixenosis

Genotypes	'C' Values	Interference
Hara soya	0.37	Strong antixenosis
G5P22	0.44	Strong antixenosis
MACS 1460	0.61	Moderate antixenosis
PS 1613	0.61	Moderate antixenosis
PK 472	0.64	Moderate antixenosis
PS 1611	0.65	Moderate antixenosis
RVS 2001-4	0.68	Moderate antixenosis

Genotypes	'C' Values	Interference
TAMS 98-21	0.68	Moderate antixenosis
MAUS 47	0.7	Moderate antixenosis
197 (522P4)	0.73	Moderate antixenosis
NRC 86	0.73	Moderate antixenosis
MACS 1520	0.73	Moderate antixenosis
RSC 1046	0.74	Moderate antixenosis



Screening of soybean genotypes for antixenosis against Spodopteralitura in lab conditions.

The following crosses were attempted for defoliating insects resistance (Spodoptera)

Name of Crosses
AGS 155 × AKSS 67
JS 93-05×AKSS 67
JS 93-05 × AGS 155
JS 335 × AKSS 67
JS 20-69 × AKSS 67
AKSS 67× JS 20-34
JS 20-69 × SL 1104
SL 1104 × JS 9560
JS 335 × SL 1104

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

Diversity of spider fauna of soybean ecosystem

There were 238 individuals of 14 families of spiders were found in *kharif 2019*. These 14 families were, Amaurobiidae, Araneidae, Clubionidae, Gnaphosidae, Linyphiidae, Lycosidae, Miturgidae, Oxyopidae, Philodromidae, Salticidae, Thomisidae, Pisauridae, Scytodidae and Hersiliidae. The highest number of individuals were found of family, salticidae (37) which shares 15.55 % followed by Thompisidae (35) shares 14.71% of total populations of spiders. Rest of the individuals belong to different families were given in descending order below- Lycosidae (31) > Gnaphosidae (25) > Linyphiidae (23) > Philodromidae (21) > Clubionidae (15) > Araneidae (12) > Miturgidae (11) > Amaurobiidae (10) > Oxyopidae (9) > Scytodidae (4) > Hersiliidae (3) > Pisauridae (2).

Guild structure of spider fauna of soybean ecosystem

There were 6 guilds viz., Orb weavers, Stalkers, Sheet webs, Ambushers, Ground runner and Foliage runner were found of spiders based on identified spider families. Orb weavers included Araneidae and Amaurobiidae families of spiders, Stalkers Oxyopidae and Salticidae, Sheet webs Amaurobiidae, Linyphiidae and Clubionidae, Ambushers Philodromidae, Pisauridae and Thomisidae, Ground runner Lycosidae, Gnaphosidae and Scytodidae and Foliage runner, Clubionidae, Miturgidae and Hersiliidae. The highest numbers of individuals belong to the Ground runner guild (60) which shares 22.81 % followed by Ambushers (58) shares 22.05 %. Rest of the belong to different guilds were given in descending order below- Sheet webs (48) > Stalkers (46) > Foliage runner (29) > Orb weavers (22).

Vertical stratification spider fauna of soybean ecosystem

The spiders of soybean ecosystem were divided into 5 vertical strata viz., <15 cm, 16-30 cm, 31-45 cm, 46-60 cm and > 60 cm based on their activity and foraging behaviours with respect of relative height of soybean plant. Lycosidae, Gnaphosidae, Linyphiidae, Amaurobiidae

Hersiliidae and Salticidae were abundantly present at <15 cm height from soil surface. Philodromidae, Clubionidae Miturgidae, Oxyopidae and Scytodidae (4) > Hersiliidae (3) > Pisauridae (2) were abundantly presented at 16-30 cm height. Araneidae was abundantly presented at 46-60 cm and >60 cm height.

Vertical distribution of different family of spiders of soybean ecosystem

Family	Vertical distribution above soil surface				
	<15 cm	16-30 cm	31-45 cm	46-60 cm	>60 cm
Amaurobiidae	***	@	@	@	@
Araneidae	@			***	***
Clubionidae	*	***	**	*	
Gnaphosidae	***	*			
Linyphiidae	***	**			@
Lycosidae	***	*	*		@
Miturgidae	*	***	**	*	
Oxyopidae	*	***	**		
Philodromidae	*	***	*		
Salticidae	***	**	*		@
Thomisidae	*	***	*	*	
Pisauridae	*	*	*	*	
Scytodidae	*	***	*		
Hersiliidae	***	*			

@: rare; * : usually present; **: Fairly present; ***: Abundant

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 compare to single varietal treatments, which indicates lower densities of insect-pests. To test the effects of genotypic diversity on soybean insect-pest and their natural enemies population twenty treatments have been chosen and details of each have been given below.

Spider fauna of soybean ecosystem

Treatment	Details of treatments	Treatment	Details of treatments
T1	JS 95-60, JS 20-34, MAUS 47 and MAUS1460	T11	NRC 86, JS 335, JS 20-98 and RKS 45
T2	JS 95-60	T12	NRC 86
T3	JS 20-34	T13	JS 335
T4	MAUS 47	T14	JS 20-98
T5	MAUS 1460	T15	RKS 45
T6	JS 93-05, JS 20-29, RVS 2001-4 and DSb 28-3	T16	NRC 37, JS 97-52, RSC 10-46 and RKS 113
T7	JS 93-05	T17	NRC 37
T8	JS 20-29	T18	JS 97-52
T9	RVS-2001-4	T19	RSC 10-46

Diversity indices of insect fauna of soybean

Treat ments	Shanon-Winner Index	Simpson index	Prey to predators ratio	Shanon-Winner Index	Simpson index	Prey to predators ratio	Prey to predators ratio
T1	0.85	1.60	0.59	1.57	3.91	0.47	0.02
T2	1.35	2.74	1.66	1.71	4.72	0.68	0.10
T3	1.03	1.94	1.44	1.63	4.23	1.04	0.04
T4	1.35	2.65	1.71	1.60	3.98	0.81	0.07
T5	1.15	2.23	1.70	1.63	4.15	0.98	0.08
T6	1.26	2.36	0.54	1.62	3.83	0.36	0.06
T7	1.10	2.02	1.93	1.70	4.58	1.16	0.07
T8	1.18	2.22	1.84	1.59	3.81	0.99	0.07
T9	1.20	2.25	1.85	1.55	3.74	0.74	0.08
T10	1.37	2.74	6.09	1.64	4.09	2.98	0.1
T11	1.06	1.93	0.52	1.59	3.73	0.49	0.02
T12	1.24	2.31	1.50	1.66	4.20	0.72	0.07
T13	1.11	2.31	1.30	1.69	4.49	0.75	0.07

Treatments	Shanon-Winner Index	Simpson index	Prey to predators ratio	Shanon-Winner Index	Simpson index	Prey to predators ratio	Prey to predators ratio
T14	1.42	2.08	1.43	1.62	4.16	0.61	0.08
T15	1.37	2.85	1.47	1.69	4.52	0.67	0.07
T16	1.13	2.17	0.65	1.53	3.63	0.32	0.04
T17	1.19	2.07	1.39	1.75	4.95	0.53	0.09
T18	1.14	2.07	2.37	1.62	4.06	0.54	0.11
T19	1.15	2.06	1.68	1.62	3.95	0.54	0.09
T20	0.96	1.76	1.72	1.54	3.52	0.94	0.07

Identification and characterization of insect-pests and their natural enemies of soybean

The tree hopper of soybean was identified as *Otinotus oneratus* based on morphological characters such as base of posterior process contiguous with or only slightly above scutellum and tegmina; posterior process not arcuate; scutellum wider than long. Spittlebug of soybean was identified as *Clovia puncta* based on morphological characters - almost uniform pale colour, having the black spot near the apex of inner margin of tegmina.

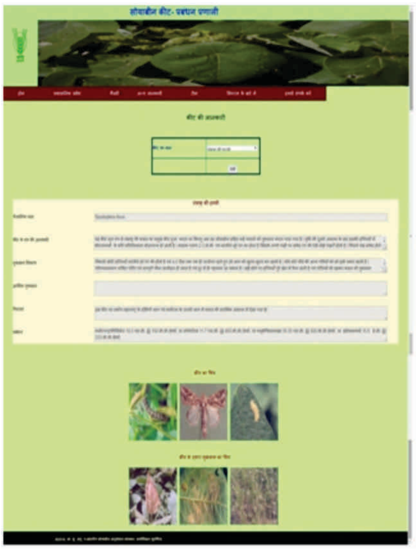
Effect of genotypic diversity on soybean diseases

Soybean genotypic diversity has significant effect on soybean anthracnose disease. In single variety, least soybean anthracnose severity was observed in RSC 10-46 (20.29 %), JS 20-98 (30.66 %) and while maximum severity was observed MAUS-47 (85.67 %) and MAUS 14-60 (81.23 %). In varietal mixture, least soybean anthracnose severity was observed in mixture of NRC 37, JS 97-52, RSC10-46 and RKS 113 (33.33 %). In single variety, least soybean myrothecium leaf spot severity was observed in RSC 10-46 (30.49 %), NRC 37 (34.32 %) and while maximum severity was observed JS 95-60 (87.67) and RVS 2001-4 (85.33 %). In varietal mixture, least soybean anthracnose severity was observed in mixture of NRC 37, JS 97-52, RSC 10-46 and RKS 113 (33.33 %).

Decision Support System for Identification of Soybean Insects and their Management

Decision support system for soybean insects is a web-based computer application developed for identification and management of soybean insects. It is developed using C# language of ASP.NET framework. It has different modules insect morphology based insect identification, damage symptom based insect identification, insect-pest management module, Insect information retrieval module, image gallery and video gallery modules. It has provision to access all the information by having links for different modes of information retrieval at one place. This makes the system easy to view particular information for novice users. The user can select insect one by one to view their details and can thus gain knowledge about 20 soybean insects stored in the system. It also has Insect Data Management subsystem for management of insect data and other important information. It has complete information in Hindi for better understandability of soybean growers across the country. It also provides information like economic losses, pre-disposing climatic condition for insect attack, Monthly outbreak of soybean pests in kharif, recommended pesticides for soybean crops, use of insect resistant or tolerant species, recommended pesticide amount for spraying, friendly insects of soybean, use of chemical pesticides and scientific recommendations of integrated pest management in soybean.

Different Menu options of Decision Support System for Soybean Insects



Different Menu options of Decision Support System for Soybean Insects

Predicting the incidence of major insect pest through Geo-spatial approach

The data of insects (Stemfly, Pod borer and Bihar hairy caterpillar) has been collected and compiled. Insect database has been designed to store the collected data. The data that the stem fly has infestation in all soybean growing areas, whereas pod borer is mainly infesting in the Dharwad region and Bihar hairy caterpillar is infesting the soybean crop in North-Eastern region of the country.

Development of forewarning model for insect incidence

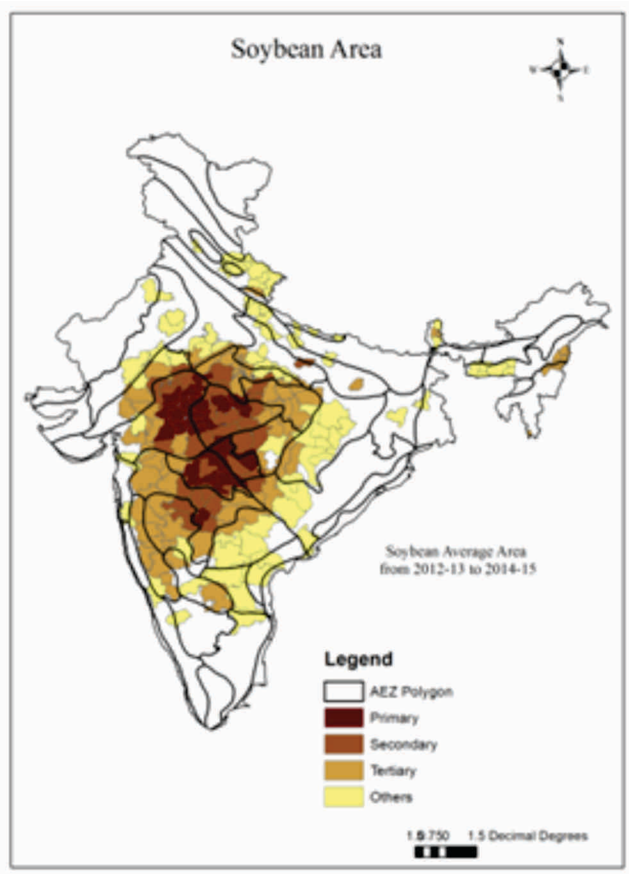
Pre-disposed Conditions: The pre-disposed conditions for current week, 1st and 2nd lag week of weather variables from peak incidence that are congenial for insect development and infestation are assessed by model developed. The pre-disposed conditions of the soybean insects were uploaded to Mobile App (SoyaGyan).

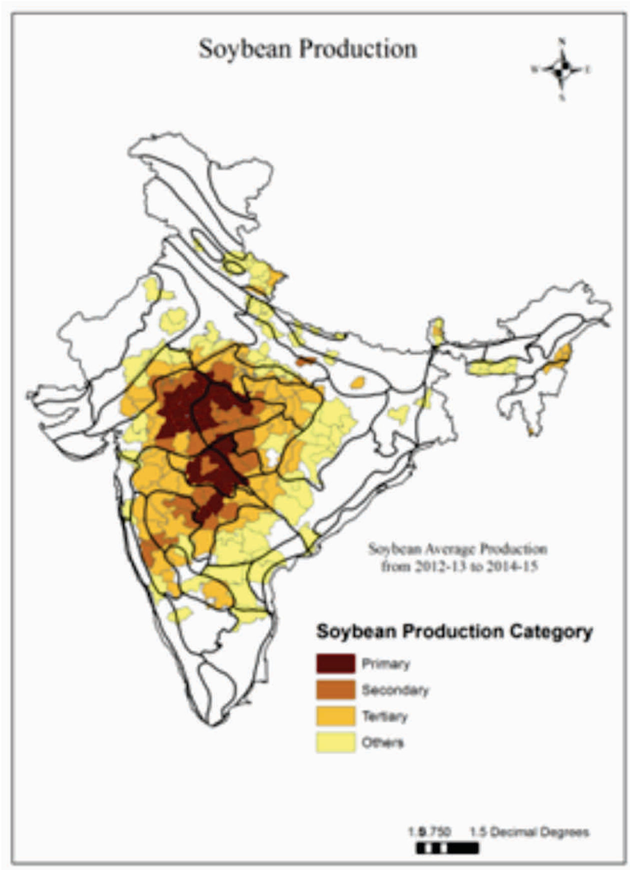
Spider fauna of soybean ecosystem

Insect	Rainfall
Gessonia gemma (Semi looper)	Low rainfall in previous weeks followed by rise in current week
H. armigera	Heavy rainfall in previous weeks followed by low rainfall in current week
Obereopsis brevis (Girdle Beetle)	High rainfall in second lag week and continuously decreasing to current week.

Agro-ecological zone based soybean district classification

Agro-ecological zone-wise spatial classification of soybean districts has been done for year 2014 TE based on decision rules. Soybean districts based on the area and production percentage contribution to the country's total area and production were grouped into primary, secondary, tertiary and other categories. The primary districts contribute more than 50%, secondary districts > 30%, tertiary districts > 13% and other districts contributed < 2% area and production. The ArcMap module of GIS software was used to prepare thematic maps of the study area.


Soybean Area
Soybean Average Area
from 2012-13 to 2014-15
Legend
AEZ Polygon
Primary
Secondary
Tertiary
Others
1.5 Decimal Degrees


Soybean Production
Soybean Average Production
from 2012-13 to 2014-15
Soybean Production Category
Primary
Secondary
Tertiary
Others
1.5 Decimal Degrees

9. SOCIAL SCIENCES AND TECHNOLOGY TRANSFER

Impact of technological interventions on socio- economic status of soybean farmers under changing climate scenario

Beneficiaries under the institute project were identified. One day trainings were conducted in Gogakheri and Ankhiya villages of Indore district to explain the climate smart technologies under Soybean –wheat system. Interaction-cum-trainings were organized in both the villages with regard to prevalent varieties, good agricultural practices and advantages of adoption of BBF establishment system in Soybean and practices for conservation of water were discussed. Around 50 farmers participated in the programmes.

Demonstrations of one acre each using JS 20-69, a longer duration variety as against the prevailing short duration varieties under the BBF establishment system were undertaken. In order to encourage farmers to adopt cafeteria approach to mitigate the problems arising due to climate change the longer duration variety was demonstrated. The results revealed that the average yield was 5.14 q/acre as compared to 3.86q/acre under the farmers' practice; which is 33.16% higher than farmers' practice.

Average production of demonstrated field and farmer's field of soybean crop in the

Particular	Demonstrated (BBF) Soybean	Conventional practice
Variety	JS 20-69	JS 95-60
Productivity (ha)	12.5 q	9.38 q

Data were also collected with regard to the expenditure on the demonstration practices, as well as, the farmer's practice along with the income under different heads. The data revealed that the average cost of cultivation was Rs 11970/acre under demonstrations plots and Rs 13480/acre under farmers' practice owing to the quantity of seed used by farmers which is more than double the recommendation. The average gross returns of demonstrations were Rs 21619/acre and Rs 15570/acre under farmers' practice with net return of about Rs 9649 per acre and Rs 2090/acre respectively. The B: C ratio realized was 1.80 under demonstrations plots and 1.15 under farmers' practice.

B:C Ratio in Soybean

Item	Soybean	
	Demo	FP
Average Expenditure		
Average field preparation cost/acre	1470	1470
Average FYM cost/acre	00	00
Average seed cost/acre	1860	2790
Average fertilizer + labour application cost/acre	2200	2800
Average seed treatment cost/acre	360	360
Average sowing cost/acre	720	600
Average weedicide + labour application cost/acre	1000	1100
Average insecticide + labour application cost/acre	1360	1360
Average fungicide cost/acre	500	500
Average Irrigation labour application cost/acre	00	00
Average harvesting cost/acre	1300	1300
Average threshing cost/acre	1200	1200
Drying, Weighing & Bagging	00	00
Transportation	00	00
Total Expenditure	11970	13480
Average Income		
Average income from Grain	19069	14320
Average income from Straw yield value	2550	1250
Gross income	21619	15570
A) Net Income=Expenditure-income	9649	2090
B) B:C ratio	1:1.80	1:1.15

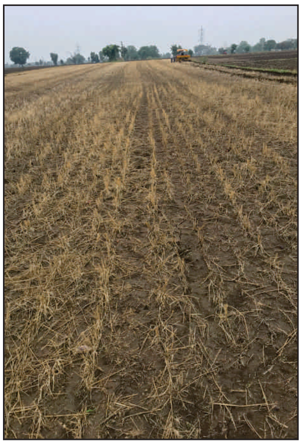
*FP - Farmer's practice

Similarly, during Rabi season wheat demonstrations were laid in one acre land each. A one day interaction meet, as well as, training were organized to disseminate information with regard to the water conservation practice for laying the sowing plan and other good agricultural practices among farmers in the period under report.

Establishment of BIOTECH-KISAN Hub at Manthan Gramin Evam Smaj Seva Samiti, Bhopal

Department of Biotechnology sponsored Biotech-Krishi Innovation Science Application Network was initiated in Sehore district of

Madhya Pradesh with ICAR-IISR, Indore as partner of the main hub established at Manthan, Amlaha, Sehore district (MP). A survey was under taken in Ichhawar and Ashta block of the district to identify beneficiaries under the project. Ten villages (Bafapur, Kothari, Lasudiya Khas, Kheri, Bhilkhedi, Naplakhedi, Sonda, Amlaha, Gajikhedi and Jamuniya Hotasingh were identified. An interaction meeting was held with farmers with regard to introduction of Broad Bed and Furrow machine for sowing of soybean. Information with regard to benefit of the BBF machine in adverse climatic condition (drought and heavy rainfall) and seed treatment were also discussed. One beneficiary each was selected from all the ten villages for conducting demonstration.

Hand harvest and machine harvested plots being inspected for demonstration

The JS 20-69 variety was introduced with the objective of promoting cafeteria approach to overcome the problem of crop failure due to adverse climatic condition. All the beneficiaries were distributed inputs (soybean seed, rhizobium culture, fungicide, insecticide, fertilizer, sulfur bentonite, zinc sulphate). Method and result demonstration were used throughout the period. Seed treatment was demonstrated to each of the beneficiaries along with other farmers registered under the Farmer's field school.

Interaction meet

Seed treatment being demonstrated at Farmer’s field school

In the conservation agricultural practice minimum tillage practice was followed and recommended. The farmers were appraised with the need to sow different varieties and not only short duration varieties which is a common practice due to paucity of water for consequent crop.

Demonstration plot ladden with pods

Farmer's practice plot showing sparse poding

Demonstration plot showing water in furrow

Water logged farmer's plot with mature cop

The results revealed that the average yield of ten demonstrations was 17.10/ha as compared to 8.74q/ha in conventional practice.

Average production of demonstrated field and farmer's field of soybean crop under DBT-Biotech KISAN project

Particular	Demonstrated (BBF)	Conventional practice
Variety	JS 20-69	JS 95-60
Average yield/ha	17.10 Q	8.74 Q

The average cost of difference in cultivation was slightly higher in the demonstrations owing to the technological package recommendations being implemented with reduced tillage i.e Rs 11576/acre under demonstrations plots and Rs 11189/acre under farmers' practice, although, input cost except seeds was higher. The average gross return of demonstrations was Rs 28908/acre and Rs 14246/acre under farmers' practice with net return of Rs 17532 per acre and Rs 3057 per acre respectively, as shown in Table 1. The B: C ratio realized was 2.43 under demonstrations plots and 1.27 under conventional practices plots. All the farmers' were convinced about the benefits of the technology and are willing to adopt it in the next cropping season.

B:C Ratio in Soybean –Wheat cropping system (CS) N-10

Item	Soybean	
	Demo	FP
Average field preparation cost/acre	00	1470
Average FYM cost/acre	00	700
Average seed cost/acre	1700	2250
Average fertilizer cost/acre	3300	1320
Average seed treatment cost/acre	810	150
Average sowing cost/acre	720	600
Average weedicide cost/acre	480	400
Average insecticide cost/acre	800	855
Average fungicide cost/acre	500	00
Average labour application cost/acre	1266	1144
Average harvesting cost/acre	1500	1300

Item	Soybean	
	Demo	FP
Average threshing cost/acre	800	1000
Total Expenditure	11876	11189
Average income from Grain	26136.95	13356
Average income from Straw yield value	2771.22	890
Gross income	28908.17	14246
A) Net Income=Expenditure-income	17032.17	3057
B) B:C ratio	1:2.43	1:1.27

* FP - Farmer's practice #Breeder seed

Under minimal tillage the consequent Rabi crop –Wheat was sown without tillage using the BBF establishment system. The wheat varieties viz; HI 8759, HI 1544 and HI 1605 were recommended according to the availability of water with each beneficiary rather than a blanket variety. In case of sufficient moisture in the field, dry sowing with irrigation after sowing was recommended and followed. The wheat crop had a good establishment.

Participation in Agricultural Exhibitions : The institute has actively participated in following seven agricultural exhibitions during the year.

Dates	Event	Organized by	Venue
25th August 2019	Wheat Day-cum-58th Annual Workshop of AICRP on wheat	IARI-Regional Wheat Research Station, Indore	Ravindra Natya Griha, Indore
31st August 2019	Krishi Mela during Jal Shakti Abhiyan	Deptt. Of Agriculture, Indore	Krishi Upaj Mandi, Laxmibai Nagar, Indore
13th September 2019	Krishi Mela during Jal Shakti Abhiyan	Deptt. Of Agriculture, Indore	Krishi Upaj Mandi, Sanwer, Dist-Indore
15th September 2019	Krishi Mela during Jal Shakti Abhiyan	Deptt. Of Agriculture, Indore	Krishi Upaj Mandi, Depalpur, Dist-Indore

Honble secretary DARE & Director General visiting the institute stall during ASC Expo, IARI New Delhi

Honble secretary DARE & Director General visiting the institute stall during AICRP Wheat Workshop, at Indore

Honble Minister of Higher Education and Sport Shri Jitu Patwari visitng the institute stall during Jal Shakti Abhiyan at Indore

Institute exhibition stall during Jal Shakti Abhiyan in Indore District

Mera Gaon Mera Gaurav

The programme is being implemented in 25 villages of Indore districts in which five multidisciplinary team of scientists are maintaining close contact with farmers. During kharif 2019, a total of 50 frontline demonstrations on improved soybean production technology have been laid out in the selected villages. Beside soybean, 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.

Distribution of inputs and seed of newly released varities by Mera Gaon Mera Gaurav

Distribution of inputs and seed of newly released varities by Mera Gaon Mera Gaurav

Interaction with MGMG farmers

MGMG team interacting with the farmers

Advisory for Soybean Farmers: During Kharif 2019, 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 using email, websites, mobile phones, television, radio and also through 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 via mKisan Portal to more than 3 lakh soybean farmers.

Farmers' field School

Farmer's field school was organised on 12/09/2019 to 13/09/2019 in the villages of Bafapur, Kothari, Kheri, Naplakhedi, and Bhilkhedi of Sehore district. Around 25-30 farmers of each village participated in the Farmer's field school. The farmers were given detail information with regard to soybean cultivation in view of the changing climate. Information about conservation tillage in Soybean crop, Good soybean Practices and benefits of BBF machine in adverse climatic condition (Drought or Heavy rainfall) were the main topics covered along with major pest and diseases and varieties to be grown.

Kisan Goshti and Input distribution under schedule caste sub-plan

The Institute organized Kisan Goshti and input distribution programme on June 4th 2019, at Amlaha, Sehore district of Madhya Pradesh under the Schedule caste sub plan. The special invitees for the Goshti were Dr Rajat Saxena, CEO, Manthan, Amlaha, Dr Gulbir Singh Pawar, Regional Manager, NSC, Bhopal (M P), Dr D K Solanki, Sr Manager (Agricultural Services) IFFCO, MP and Dr Archana Singh, Principal Scientist & Station Incharge, IIPR, Fanda, Bhopal (MP) and the programme was presided over by Principal Scientist & Director Incharge, Dr A N Sharma. Dr Nita Khandekar, Principal Scientist and Nodal officer (SCSP) welcomed the dignitaries and gave a brief of the programme initiated by the Government of India. All the dignitaries addressed the farmers and urged them to use the new technologies, diversified crops and value addition for improving the farm productivity. Emphasis was also laid on use of climate smart technologies. Interaction was held with the farmers' wherein, experts from the institute attended to their queries. A Kisan Goshti was held after the inaugural programme wherein, experts from the institute attended to the queries of the farmers. A total of 250 Q soybean seeds were distributed to 833 beneficiaries, 800 quintals of fertilizer to 800 beneficiaries, 5 quintal seeds of maize and pigeon to 250 beneficiaries and 2000 vegetable kits among 392 beneficiaries from 91 villages of Icchawar, Ashtha and Amlaha block of Sehore district of Madhya Pradesh.

Nodal officer (SCSP) addressing the audience


Input distribution by Acting Director to women beneficiary


Nodal officer (SCSP) distributing input to beneficiary


Farmer asking question during Goshti


Scientists answeringfarmers' queries during Kisan Goshti

10. TRAINING AND CAPACITY BUILDING

Training and Capacity Building of ICAR Employees

Hands on training on hybridization

ICAR- Indian Institute of Soybean Research organized three days (August 29-31, 2019) hands on training programme on soybean hybridization technique. A total of 14 participants working under AICRP on soybean attended and practiced hybridization in glass house, net house, and field. The training seession was started on 29th August 2019, 7.45 AM, by showing the hybridization videos to participants where in pollination without emasculation and protogyny nature of soybean flower was mainly focused to trainee participants. All the trainees expressed their confidence in doing hybridization without doing emasculation subsequent season.

Hands on training on hybridization in field

Participants with Director and scientific staff of ICAR-IISR, Indore

Organization of Germplasm day

Institute organized a one-day workshop on Germplasm day on 13 September 2019. Ten plant breeders from different AICRP centre participated in the event. Dr Sanjay Gupta, Principal scientist and Incharge, crop improvement section presented the details of germplasm maintained at ICAR-IISR followed by interaction among the participants with Director, IISR. Participants made visits to germplasm planted at glasshouse and net house.

Discussion of participants of germplasm day with Director ICAR-IISR

Seminar/Symposium/Conferences Organized and attended by employees

The following are the details of the scientists/staff of this institute participated in seminar/symposium or conference.

Participant	Event	Venue and date
Dr Subhash Chandra, Scientist	International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences-2019	ICAR-NAARM, Hyderabad; October 20-22, 2019
Dr. V. Rajesh	International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences-2019	ICAR-NAARM, Hyderabad; October 20-22, 2019
Dr Laxman Singh Rajput	International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences-2019	ICAR-NAARM, Hyderabad; October 20-22, 2019
Mr. Sanjeev Kumar	International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences-2019	ICAR-NAARM, Hyderabad; October 20-22, 2019

Participant	Event	Venue and date
Dr. R. K. Verma Scientist	Attended and given oral presentation in International Conference on Crop Residue Management	Gyan Bhawan, Patna, (Bihar) from October 14-15-2019
Dr. Surendra Kumar, Chief Documentation Officer	International conference on digital transformation: A cognitive Learning Towards Artificial Intelligence,	06-08 September 2019 Rajiv Gandhi National University of Law, Patiala (Punjab),
Dr. Surendra Kumar, Chief Documentation Officer	National conference on Association of Agricultural Librarians and Doumentalists if India (AALDI)	25-27 September, 2019 Navsari Agricultural University, Navsari,
Dr. G.K. Satpute, Senior Scientist	5th Intl. Conf. Plant Genetics & Genomics: Germplasm to Genome Engineering	17th – 18th October 2019 NASC, New Delhi
Dr. Milind Ratnaparkhe Senior Scientist	5th Intl. Conf. Plant Genetics & Genomics: Germplasm to Genome Engineering	
Dr. V. Nataraj Scientist	5th Intl. Conf. Plant Genetics & Genomics: Germplasm to Genome Engineering	
Dr. G.K. Satpute, Senior Scientist	State Level Sustainable Agricultural Mission Committee Meeting under NMSA (RAD)"	25-06-2019 Department of Farmers' Welfare & Agriculture Development, Madhya Pradesh Government, Bhopal

Training and capacity building for non-stake holders

During the year 2019, the institute has trained 105 field level officers belonging to private agencies as well as input dealers through following four Trainers Training Programmes.

Title of the training	Date	Sponsor/Collaborator	No. of Participants
Model Training Course on Climate resilient technologies and practices for soybean production	4- 11September 2019	Directorate of Extension, Ministry of Agriculture & Farmers' Welfare, GOI, New Delhi	23

Farmers' Training Programmes

One Day Farmers' Training Programmes on Improved Soybean Production Technology: During this year, 59 Farmers' Training

Programmes of day long duration were organized with the cumulative participation of 1943 farmers belonging to different districts of Madhya Pradesh, Maharashtra and Rajasthan. All the recommended package of practices including agronomic, moisture conservation techniques during the stress period, integrated approach of managing weeds, insect pests and diseases etc as well as processing aspects of value added soy products were covered in these training programmes which were facilitated in participatory mode.

Women's Training Programme on Processing and Utilization of Soybean: Eleven training programmes on "Processing and Utilization of Soybean for Food Uses at household level" were organized with the participation of 811 women belonging Madhya Pradesh and Rajasthan respectively.

Feedback of trainee participants during valedictory programme of MTC-2019

Inaugural session of Model Training Course-2019

Farmers' training programme on improved soybean production technologies

Farmers' training programme on improved soybean production technologies under ATMA

Visit of farmers to the institute demonstration plot

Farmers visit to the Institute

Public private partnership program (PPP mode)

ICAR-IISR Indore and ITC Bhopal organized a training programme for the farmers of 05 districts of Madhya Pradesh to adopt BBF technology, permanent BBF technology in soybean and wheat crop. This program has been taken up to sustain the soybean and wheat crops under irregular monsoon rains due to climate change. Dr D.V Singh, Principal Scientist (Farm machinery and Power) acted as Nodal officer and trainer of BBF and permanent BBF technology for farmers of 05 districts.

Overview of training programme organized at ICAR-IISR in PPP mode

DST sponsered meeting

IISR Indore hosted a DST sponsored programme advisory and monitoring committee (PAMC) of network project programme on Imaging spectroscopy & Application (NISA) during Nov 29-30, 2019. In this meeting besides DST officials there were 8 field experts and 9 theme coordinators presented the outcome of NISA network programme and prepared a future roadmap. All the projects were reviewed by the experts under the charmanship of Dr. VK Dadhwal, Director, Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram, Kerala and Dr M.P. Sharma, Principal Scientist (Agri Microbiology) was acted as organizing secretary.

Dr. S.D Billore, Director, Incharge, welcoming Dr. VK Dadhwal, Director, Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram

Guest lecture

ICAR- IISR organized number of guest lecture from eminent scientist. Dr Lee Hickey, plant breeder and crop geneticist of Queensland Alliance for Agriculture and Food Innovation at The University of Queensland, Australia. Dr Lee delivered a lecture on most relevant topic "Speed breeding to accelerate crop improvement" and he dicussed its impotrace in soybean crop. His talk emphasized that mehtodolgy of speed breeding developed for wheat, barley and other long day plants may be modified accordingly to suit soybean crop for rapid generation advancement. One more guest Dr Rajeev Varshney delivered a talk on "Genomics advances to accelerate breeding process in legumes. The talk covered important role of genomics in improvement many traits particulay in legume crops. Dr. S.P. Tiwari, Formerly DDG (Edn & CS) and Chairman RAC, urged the scientist to incorporate the speed breeding technique for speed up the generation advancement of segregating material therby reducing the time for development of ne crop varieties. Simillarly, Dr. D.M. Hegde, Ex Project Director ICAR-IIOR, Hyderabad and member RAC, Delivered a lecture on "Best Management Practices to Improve Crop Response to Fertilizers"

Dr Lee Hickey, delivered a lecture on "Speed breeding to accelerate crop improvement"

Dr Rajeev K Varshney, delivered a lecture on "Genomics advances to accelerate breeding process in legumes"

Dr Lee Hickey along with Staff of ICAR-IISR

Dr. D.M. Hegde, Member RAC, Delivered a lecture on "Best Management Practices to Improve Crop Response to Fertilizers"

11. राजभाषा–कार्यन्वयन

संस्थान में जनवरी–दिसम्बर 2019 के दौरान राजभाषा–कार्यान्वयन संबंधी विभिन्न गतिविधियाँ

भारतीय संविधान में हिन्दी को संघ की राजभाषा के रूप में स्थापित किया गया है एवं संविधान के भाग सत्रह, अनुच्छेद तीन सौ इक्यावन में वर्णित है कि राजभाषा हिन्दी को इस तरह से विकसित किया जाए ताकि वह भारत की विविध संस्कृति को व्यक्त करने में समर्थवान हो । अतः राजभाषा के रूप में हिन्दी की भूमिका अत्यंत महत्वपूर्ण तथा दायित्व–युक्त भी है । इस उद्देश्य का वहन करते हुए भा. कृ. अनु. परि.–भारतीय सोयाबीन अनुसंधान संस्थान, इंदौर में राजभाषा हिन्दी के प्रसार–प्रचार हेतु अनेकानेक कार्यक्रम किए जा रहे हैं । जिनका स्वरूप भारतीय सोयाबीन अनुसंधान संस्थान में राजभाषा कार्यान्वयन के क्षेत्र में उत्तरोत्तर प्रगति के साथ दृष्टिगोचर होते 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) राजभाषा नियम,1976 के नियम 8 का अनुपालन : संस्थान के अधिकारी एवं कर्मचारी शासकीय कार्यों हेतु राजभाषा नियम,1976 के नियम 8 के उपनियम (1) तथा (4)के अनुसार लिखे जाने वाली टिप्पणियाँ एवं अन्य कार्य हिन्दी में करते है ।

ख) राजभाषा कार्यान्वयन समिति की तिमाही बैठक

- प्रथम बैठक : दिनांक 07 जनवरी 2019
- द्वितीय बैठक : दिनांक 06 अप्रैल 2019
- तृतीय बैठक : दिनांक 06 जुलाई 2019
- चतुर्थ बैठक : दिनांक 05 अक्टूबर 2019

ग) प्रशिक्षण : संस्थान में राजभाषा के प्रचार–प्रसार हेतु कृषकों एवं प्रशिक्षणार्थियों को प्रशिक्षण संबंधित सारी सामग्रियाँ हिन्दी में भी प्रदान की जा रही है ।

घ) शब्दकोश में वृद्धि : 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 हिन्दी के कार्यालयीन उपयोग में भी सहायता प्रदान कर सके ।

ङ) अनुवाद द्विभाषी प्रपत्र : संस्थान में कार्यालयीन कार्य में प्रयुक्त होने वाले विभिन्न पत्रों, प्रपत्रों आदि का अनुवाद कार्य भी प्रगति पर है, जिससे दिनोंदिन प्रायः प्रयुक्त होने वाले सभी प्रकार के पत्रों, प्रपत्रों का द्विभाषी मुद्रित रूप सम्मिलित है। यह कार्य राजभाषा कार्यान्वयन की दिशा में स्थाई एवं आधारभूत उपलब्धि है।

च) राजभाषा तिमाही रिपोर्ट का प्रेषण : संस्थान में राजभाषा हिन्दी से संबंधित समस्त कार्यों का विवरण तिमाही हिन्दी रिपोर्ट के माध्यम से संबंधित विभागों को ऑनलाइन एवं द्रुतगामी डाक सेवा से प्रेषित किया जाता है। इस कार्य को धरातलीय रूप प्रदान करने में संस्थान के समस्त संबंधित अनुभाग का सक्रिय एवं सराहनीय योगदान होता है ।

छ) यूनिकोड की सुविधा : संस्थान के अधिकारियों तथा कर्मचारियों की हिन्दी में कार्य करने की रूचि में वृद्धि करने हेतु समस्त कम्प्यूटर में हिन्दी यूनिकोड की व्यवस्था प्रदान की गई है, ताकि एक समान फॉन्ट के माध्यम से पूरा संस्थान एक ही दिशा की ओर अग्रसर हो सके ।

ज) मौलिक लेखन कार्य का प्रादुर्भाव : संस्थान में राजभाषा संबंधी विभिन्न क्रियाकलापों के साथ मौलिक लेखन कार्य को द्रुतगामी आयाम प्रदान करने में अधिकारियों एवं कर्मचारियों की रूचि अद्वितीय है ।विभिन्न प्रतिष्ठित संस्थानों द्वारा इनकी लेखनी को स्थान प्राप्त होते हैं।

झ) मध्य एवं पश्चिम क्षेत्र का राजभाषा कार्यान्वयन संबंधी पुरस्कार : भारत सरकार, गृह मंत्रालय,राजभाषा विभाग द्वारा मध्य एवं पश्चिम क्षेत्र के राजभाषा कार्यान्वयन में उत्कृष्ट कार्य करने हेतु संस्थान को वर्ष 2018–19 हेतु प्रथम पुरस्कार प्राप्ति हेतु पत्र प्राप्त हुए हैं ।

ञ) राजभाषा अधिनियम, 1963 की धारा 3 (3) : संस्थान में राजभाषा अधिनियम, 1963 की धारा 3(3) से संबंधित दस्तावेजों जैसे : सामान्य–आदेश, अधिसूचनाएं, प्रेस विज्ञप्तियाँ, संविदा, करार, लाइसेंस, परमिट, टेंडर के फार्म और नोटिस, संकल्प नियम इत्यादि को द्विभाषी रूप (हिन्दी और अंग्रेजी) में निकाला जाता है, ताकि राजभाषा संबंधित दिशा–निर्देशों का पालन सतत होता रहे।

दिनांक	विषय	अतिथि वक्ता
18 जून 2019	राजभाषा हिन्दी का वैश्विक स्वरूप : अतित और वर्तमान परिदृश्य	डॉ. राजीव शर्मा, विभागाध्यक्ष–पत्रकारिता, श्री अटल बिहारी बाजपेयी शासकीय कला एवं वाणिज्य महाविद्यालय, इन्दौर।
07 सितम्बर 2019	विश्व स्तर पर हिन्दी भाषा का प्रभाव	श्री हरेराम बाजपेयी, प्रबंध संपादक, वीणा, इंदौर
16 दिसम्बर 2019	कृषि अनुसंधान के संप्रेषण की भाषा हिन्दी, प्रमुख आयाम	डॉ. पद्माश्री शर्मा, विभागाध्यक्ष, इंस्टिट्यूट ऑफ आर्ट्स एण्ड ह्यूमेनिटिज, सेज यूनिवर्सिटी, इन्दौर।

ट) हिन्दी कार्यशालाएं : संस्थान के अधिकारियों एवं कर्मचारियों की हिन्दी में कार्य करने के दौरान होने वाली समस्याओं के निराकरण हेतु संस्थान में हिन्दी कार्यशालाओं का आयोजन किया जाता है । इसके अतिरिक्त कार्यशालाओं के आयोजन का मुख्य ध्येय यह भी होता है कि हिन्दी का प्रयोग किस प्रकार सरल से सरलतम् की ओर बढ़ाया जा सकता है । इसलिए प्रत्येक तिमाही में कम से कम एक हिन्दी कार्यशाला का आयोजन किया जा रहा है। ताकि संस्थान के सभी सवंर्गों में हिन्दी में कार्य संपन्न करने का रूझान में उत्तरोत्तर प्रगति हो सके । इस उद्देश्य हेतु संबंधित विषयानुसार कार्यशालाएं सम्पन्न की जाती है । जनवरी–दिसम्बर 2019 में अब तक 04 कार्यशालाओं का आयोजन किया गया, जिसकी सूचि इस प्रकार से है ।

"अप्रैल–जून 2019" तिमाही हिन्दी कार्यशाला के दौरान प्रशिक्षण प्रदान करते हुए अतिथि वक्ता डॉ. राजीव शर्मा ।

"अक्टूबर–दिसम्बर 2019" तिमाही हिन्दी कार्यशाला के दौरान प्रशिक्षण प्रदान करते हुए अतिथि वक्ता डॉ. पद्माश्री शर्मा ।

12. ON-GOING RESEARCH PROJECTS

Institute funded projects

S. No	Project no.	Completion year	Project title	PI
Crop improvement				
Mega theme-1. Soybean genetic resource management- acquisition, conservation, characterization, documentation and utilization				
1	NRCS 1.1/87	1987-LT	Augmentation, management and documentation of soybean germplasm	Dr Sanjay Gupta
Mega theme-2. Genetic improvement of soybean for yield, agronomic traits, resistance to biotic stresses and improvement in quality of soybean seed				
2.	NRCS 1.6/92	1992-LT	Hybridization, selection and development of multi-parent population for genetic improvement of yield potential in soybean	Dr Shivakumar M.
3	IISR 1.31/16	2019	Development and validation of multi-trait allele specific SNP panel for high throughput genotyping of breeding populations in soybean	Dr Giriraj Kumawat
4	IISR 1.33/16	LT	Development of YMV resistant soybean varieties using marker assisted selection	Dr Anita Rani
5	IISR1.34/17	2023	Enhancing disease resistance in soybean using genomic approaches	Dr Milind Ratnaparkhe
6	IISR1.35/17	2022	Improvement in soybean seed viability and strength of seed coat by genetic amelioration of seed coat traits	Dr. P. Kuchlan
7	IISR 3.11b/18	2022	Soybean Improvement against charcoal rot and anthracnose diseases	Dr. Nataraj V.
Mega theme -3. Managing the impact of current and future climate variability in soybean				
8	DSR 5.6/09	2021	Breeding for drought tolerant varieties in soybean	Dr G. K. Satpute
9	DSR 5.6b/18	2023	Soybean breeding for waterlogging tollerance	Dr Subhash Chandra
10	IISR 5.7/17	2020	Drought amelioration in terms of morpho-physiological, biochemical characters and seed yield in soybean through foliar application of nutrients	Dr Maharaj Singh

S. No	Project no.	Completion year	Project title	PI
Mega theme -4. Development of specialty soybean varieties for secondary agriculture and industrial uses				
11	NRCS 1.12/02	LT	Breeding for food grade characters and high oil content	Dr Anita Rani
12	DSR 1.28/14	2021	Mapping QTLs for oleic acid and development of high oleic acid soybean	Dr Vineet Kumar
13	IISR 1.32/16	2018	Screening soybean germplasm for vegetable type characteristics and optimization of processing parameters	Neha Pandey
Crop protection				
Mega theme -5. Surveillance, forecasting and control strategies for insect-pest complex in soybean				
14	IISR 2.11/16	2019	Identification of defoliator resistant/non-preferred soybean genotypes through food consumption and utilization indices	Dr A. N. Sharma
15	IISR 2.12/17	2020	Effect of genotypic diversity on soybean 4 insect pest and their natural enemies population	Dr L. K. Meena
16	IISR 3.11a/18	2020	Morphological and molecular characterization of Macrophominaphaseolina causing charcoal rot in soybean	Sanjeev Kumar
17	IISR 3.11c/18	2021	Selection of potential fungal and bacterial soybean endophytes and their evaluation against major diseases of soybean	Dr L. S. Rajput
Crop production				
Mega theme -6. Development of technologies for soybean based cropping system efficiency enhancement through resource conservation technologies, nutrient management, plant growth promoting microbes and farm machineries				
18	DSR 4.10/09	2020	System efficiency enhancement through resource conservation technologies	Dr S. D. Billore
19	IISR 4.12/16	2018	Nitrogen and sulphur management for sustainable soybean productivity	Dr A. Ramesh
20	IISR 4.13/17	2022	Evaluation of tillage and crop establishment and residue management practices for sustaining/ improving resources use efficiency, soil health and crop productivity in soybean based cropping systems	Dr Rakesh Kumar Verma

S. No	Project no.	Completion year	Project title	PI
21	IISR 4.14/18	2023	Agronomic biofortification of micronutrients in conservation agriculture based soybean-wheat cropping system	Dr Raghavendra M.
22	DSR 6.8/13	2019	Inoculum development of niche AM fungi for application in soybean-based cropping system	Dr M. P. Sharma
23	IISR 6.9/17	2020	Bacterial mediated sulphur bioavailability in soybean	Dr. M.P. Sharma
24	IISR 9.9/17	2020	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
Extension				
Mega theme -7. Information digitization, technology dissemination, impact analysis and socio-economic research for soybean				
25	DSR 7.5/15	2018	Decision support system for identification of soybean insects and their management	Dr Savita Kolhe
26	IISR 8.14/16	2019	Evaluation of package of practices of improved soybean production technologies and economic feasibility of soybean growers	Dr B. U. Dupare
27	IISR 8.15/17	2020	Assessment of soybean economy and impact of technology in India	Dr P. Sharma
28	IISR 8.16/18	2021	Impact of technological interventions on socio-economic status of soybean farmers under changing climate scenario - a comparative analysis	Dr Nita Khandekar

Funding agency	Duration	External funded projects	PI	Budget (Lakhs)
DAC, Government of India	LT	DUS Project: DUS testing of soybean-Central sector scheme for protection of plant varieties and farmers right.	Dr M. Kuchlan	6.5 / year
DBT , Government of India	2020	Marker assisted elimination of off flavor generating lox II gene from KTI free genotypes	Dr Vineet Kumar	46.59
DBT, Government of India	2020	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	19.73

Funding agency	Duration	External funded projects	PI	Budget (Lakhs)
DBT, Government of India	2021	Development of genetic stocks for maturity and growth habit genes in soyabean (Glycine max (L.) Merr.)	Dr Sanjay Gupta	42.88
NASF	2022	Genomics strategies for improvement of yield and seed composition traits under drought stress conditions in Soybean	Dr Milind Ratnaparkhe	219.00
ICAR Network Project	2020	Identification of high trehalose -producing soybean rhizobia and their integration with AM fungi for enhanced drought tolerance in soybean	Dr M.P. Sharma	20.00
CSIR, Government of India	2020	Development of an Efficient Scalable Clustering Algorithms for Big Data and investigation of Integrated system for Protein Sequence Classification	Dr Milind Ratnaparkhe	30.00
IITM, Ministry of Earth Science, Govt. of India	2018-2021	Strategies for enhancing yield of soybean (Glycine max L) and pigeonpea (Cajanus cajan, L) in India using climate variability information and crop growth simulation models	Dr. Raghavendra M	80.94
DAC, Minister of Agriculture	2018-2020	Creation of Seed Hubs for enhancing quality seeds availability of major oil seed crops under NFSM-Oil Seeds	Dr. Mrinal K. Kuchlan-PI	150.00
DBT, Government of India	2019-2021	Establishment of BIOTECH-KISAN Hub at Manthan Gramin Evam Smaj Seva Samiti,	Dr. Nita Khandekar	27.00
DBT, Government of India	2019-2021	Expansions of Activities of Biotech -KISAN Hub in Seven Aspirational districts in Madhya Pradesh under Biotech-KISAN Hub	Dr. Nita Khandekar	40.00
Science & Engineering Research Board (SERB) Govt. Of India	2019-2022	Development of Laser Biospeckle Technique for Applications in Agriculture	Dr. Laxman Singh Rajput	30.00

13. PUBLICATIONS

Research article

Anita Rani, Vineet Kumar, Vaishali Mourya and Trupti Tayalkar (2019) Genomic regions governing the biosynthesis of unsaturated fatty acids in recombinant inbred lines of soybean raised across multiple growing years. Journal of the American Oil Chemists Society (Willey Science) 96 :1337- 1346 DOI 10.1002/aocs.12298

Dupare BU, Purushottam Sharma and Billore SD (2019) Break even soybean yield analysis under frontline demonstrations. Indian Journal of Extension Education. 55(1): 103-108

Bhardwaj Y, Sharma MP, Pandey J and Dubey S (2019) Variations in microbial community in a tropical dry deciduous forest across the season and topographical gradient assessed through signature fatty acid biomarkers. Ecological Research. DOI: 10.1111/1440-1703.12066

Billore SD (2019) Regional analysis of the response of soybean to planting date. Soybean Research 17(1&2): 83-88

Billore SD (2019) Weeds in soybean vis-a-vis other crops under climate change- a review. Soybean Research 17(1&2): 01-21.

Gaurav Singh, Ratnaparkhe MB and Anil Kumar (2019) Comparative analysis of transposable elements from Glycine max, Cajanus cajan and Phaseolus vulgaris. Journal of Experimental Biology and Agriculture Sciences. 7 (2) pp167-177

Dupare BU, Purushottam Sharma, Verma SK and Billore SD (2019) Adoption of soybean production technology by the farmers in malwa plateau of Madhya Pradesh. Soybean Research 17(1&2): 62-76.

Jumrani K and Bhatia V S (2019) Interactive effect of temperature and water stress on physiological and biochemical processes in soybean. Physiology and Molecular Biology of Plants 25 (3): 667-681

Jumrani K and Bhatia V S (2019) Identification of drought tolerant genotypes using physiological traits in soybean. Physiology and Molecular Biology of Plants. 25 (3): 697-711

Meena LK and Dey D (2019) Annotated checklist of non-apis bees of the genus Andrena (Hymenoptera: Andrenidae) from India. Indian Journal of Entomology, 81(3): 443-452.

Padhana K, Bhattacharjya S, Sahu A, Manna MC, Sharma MP, Singh M, Wanjari RH, Sharma RP, Sharma GK and Patra AK (2019) Soil N transformation as modulated by soil microbes in a 44 years long term fertilizer experiment in a sub-humid to humid Alfisol. Applied Soil Ecology. DOI: 10.1016/j.apsoil.2019.09.005

Patel RM, Sharma P and Sharma AN (2019) Prediction of girdle beetle (Oberiopsis brevis) infestation through pest-weather model in soybean. Journal of Entomology and Zoology Studies 7(4): 718-723.

Patel RM, Sharma P and Sharma AN (2019) Weather-based forewarning model to predict semilooper population in soybean. Soybean Research 17(1&2): 46-53.

Sharma P, Dupare, BU and Khandekar N (2019) economic impact assessment of broad-bed furrow seed drill for soybean. Agricultural Research https://doi.org/10.1007/s40003-019-00444-4

Patel RM, Sharma AN and Purushottam Sharma (2019) Prediction of Helicoverpa armigera (Hubner) larval population using weather based forewarning model in soybean. Journal of Agrometeorology 21(4).

Ramesh SV, Shivakumar M, Chouhan BS and Chand S (2019) Transient expression of small interfering RNAs (siRNAs) targeting AC2 gene of mungbean yellow mosaic India virus (MYMIV) for antiviral resistance in soybean. 3 Biotech. 9:334. doi.org/10.1007/s13205-019-1865-7

Shivakumar M, Kumawat G, Nataraj V, Gireesh C, Gupta S, Satpute GK, Ratnaparkhe MB and Yadav DP (2019) NAM population- A novel genetic resource for soybean improvement: Development and characterization for yield and attributing traits. Plant Genetic Resources: Characterization and Utilization. 1–9. doi:10.1017/S1479262119000352

Shastry, A, Ahula, K, Ratnaparkhe, MB, Ahah, A, Gagrani, A and Lal, A (2019) Vector Quantized spectral clustering applied to whole genome sequences of plants. Evolutionary Bioinformatics 15: 1-7

Vinayagam, SS and Dupare BU (2019) Monetary benefits of integrated pest management in Soybean [Glycine max (L) Merrill] cultivation. 20019. Soybean Research 17(1&2): 89-94

Yashpal, Rathod, DR, Chandra Subhash, Kumar Anil, Yadav Raju Ratan and Talukdar A (2019) Deploying wild-type (Glycine soja Sieb. and Zucc.) derived RILs to map QTL for yield-related traits in Soybean. Indian Journal of Genetics and Plant Breeding 79(4): 693-703

Popular article

Chandra Subhash, Nataraj V, Nagar S and Vangala Rajesh (2019) Breeding strategies to mitigate abiotic stresses in Soybean. Agrobios Newsletter:17(7)

शिवानी नागर, महाराज सिंह, सुभाष चन्द्र एवं राकेश कुमार वर्मा (2019) सोयाबीन की फसल पर जलभराव का प्रभाव एवं नुकसान को रोकने के तरीकेद्य कृषक जगत, खरीफ विशेषांक, 13

महाराज सिंह (2019). बदलते परिवेश में ऐसे करे सोयाबीन की उनत खेती, कृषि गोल्ड लाइन अंक 20, पेज 5, 16—31 मई 2019, जयपुर

आर के वर्मा, एन खांडेकर, एस डी बिल्लोरे, ए रमेश, एस नागर, शिवाकुमार एम, राघवेन्द्र एम एवं सुभाष चन्द्र (2019) सोयाबीन, एक सुनहरी बीनः उत्पादन एवं उपयोगद्य कृषि चेतना, 2:81—83

शिवानी नागर, महाराज सिंह, सुभाष चन्द्र एवं राकेश कुमार वर्मा (2019)सोयाबीन की फसल पर जल भराव का प्रभाव एवं नुकसान को रोकने के तरीकेद्य कृषक जगत,खरीफ विशेषांक, 13

Raghavendra M, Singh YV, Verma RK, Hanamant MH and Goud BR (2019) System of wheat intensification: An innovative approach. Indian Farming 69(04): 23–26.

सिंह देवव्रत एवं रामटेके राजकुमार. 2019. बदलते मानसून का मुकाबला करने हेतु खेत की सख्त परत को तोड़ेगा सबसॉइलर. कृषक जगत (भोपाल, 13 मई 2019) पृ. 07.

सिंह महाराज, रामटेके राजकुमार एवं सिंह देवव्रत. २०१६. सोयाबीन – मध्य भारत की बहुउपयोगी प्रमुख तिलहनी फसल, किसानो के लिए 'गोल्डन बिन' है सोयाबीन. कृषि गोल्ड लाइन, 16 से 31 जुलाई 2019 (पाक्षिक), वर्ष 11 अंक 24, पृ. 2.

Meena LK (2019) Association of soybean and insects. Agrobios Newsletter, 18(6):80.

Meena LK (2019) Biology and life history of major predators of soybean ecosystem. Agrobios Newsletter, 18(7): 80-81.

Meena LK (2019) Management of insect-pests by genotypic diversity. Popular Kheti 1(6):69-71.

Rajput LS, Kumar, Sanjeev, Meena, LK, Raghavendra M, Verma RK and Natraj V (2019). Chemical management of biotic stress in soybean. Agrobios Newsletter, 18(7): 17-18

Bulletin and Folder

Dupare BU, Billore SD and Sharma AN (2019) Soybean production: package of practices & technical recommendations. bilingual extension bulletin no. 15. Published by ICAR-IISR, Indore. Pp: 55-100

दुपारे, बी.यू., बिल्लौरे, एस.डी. एवं शर्मा, ए.एन. (2019), सोयाबीन उत्पादनः सस्य क्रियाए एवं तकनीकी अनुशंसाए. द्विभाषी विस्तार बुलेटिन क्रमांक 15(2019), भारतीय सोयाबीन अनुसंधान संस्थान, इन्दौर प्रकाशन, पृष्ठः 1–55

दुपारे, बी.यू. एवं बिल्लौरे, एस.डी. (2019). सोयाबीनः उन्नत प्रजातियॉ, गुणधर्म, उत्पादन क्षमता एवं परिपक्वता अवधि (विस्तार फोल्डर क्रमांक 18). भारतीय सोयाबीन अनुसंधान संस्थान प्रकाशन.

दुपारे, बी.यू. एवं बिल्लौरे, एस.डी. (2019). सोयाबीनः समेकित खरपतवार प्रबंधन (विस्तार फोल्डर क्रमांक 19). भारतीय सोयाबीन अनुसंधान संस्थान प्रकाशन.

दुपारे, बी.यू. एवं बिल्लौरे, एस.डी. (2019). सोयाबीनः समेकित कीट प्रबंधन (विस्तार फोल्डर क्रमांक 20). भारतीय सोयाबीन अनुसंधान संस्थान प्रकाशन.

दुपारे, बी.यू. एवं बिल्लौरे, एस.डी. (2019). सोयाबीनः समेकित रोग प्रबंधन (विस्तार फोल्डर क्रमांक 21). भारतीय सोयाबीन अनुसंधान संस्थान प्रकाशन.

दुपारे, बी.यू. एवं बिल्लौरे, एस.डी. (2019). सोयाबीनः प्रसंस्करण तकनीकी एवं खाद्य उपयोग (विस्तार फोल्डर क्रमांक 22). भारतीय सोयाबीन अनुसंधान संस्थान प्रकाशन

Seminar/symposium/conference etc.

Chandra Subhash, Satpute GK, Kumawat G, Singh D, Rajesh V, Ratnaparkhe MB, Nataraj V, Singh M, Shivakumar M, Gupta S and Bhatia VS (2019) standardization of screening technique for identifying water logging tolerant genotype at early vegetative stage in soybean. in: international conference on global research initiatives for sustainable agriculture & allied sciences-2019 held during October 20-22, 2019 at ICAR-NAARM, Hyderabad, India, pp. 16

Chandra Subhash, Talukdar A, Yadav RR, Poonia S, Yashpal, Kumar A, Saini M, Lal SK, Yadav S and Sipani NS (2019) Comparative seed storability study in wild and cultivated soybean. In: 10th national seed congress held during Octo.14-16, 2019 at ICAR-IARI, New Delhi, India, pp.321

Chandra Subhash, Yashpal, Yadav RR, Poonia S and Talukdar A (2019) Quantitative trait loci mapping for seed coat impermeability in inter specific recombinant inbred lines of soybean. In: International conference on global research initiatives for sustainable agriculture & allied sciences-2019 held during October 20-22, 2019 at ICAR-NAARM, Hyderabad, India, pp. 25

Preeti Jha, Aruna Tiwari, Neha Bharill,. Ratnaparkhe MB, Neha Nagendra and Mukkamalla Mounika.(2019) Fuzzy based kernelized clustering algorithms for handling big data using apache spark. International conference: soft computing for problem solving (SocProS), Liverpool, UK, pp12-13

Satpute GK, Gupta S, Bhatia VS, Singh M, Chandra, S, Shivani Nagar, Viraj Kamble, Ratnaparkhe M.B (2019). Improving seed filling under drought stress by stem reserve mobilization in soybean, Glycine max. Oral Presentation at 5th Intl. Conf. plant genetics & genomics: germplasm to genome engineering held during 17th – 18th October 2019 at New Delhi, India

Kumar Sanjeev, Rajput, LS, Nataraj, V, Shivakumar, M, Rajesh V, Chandra Subhash Kumawat, G, Meena LK, and Gupta S (2019). Screening of soybean germplasm for resistance against major foliar diseases. In: International conference on global research initiatives for sustainable agriculture & allied sciences-2019 held during October 20-22, 2019 at ICAR-NAARM, Hyderabad, India, pp. 45

Khandekar N , Aslam Mohd, Verma R K, Vishwakarma P (2019) Biotech-krishi innovation science application network (biotech-kisan): an emerging extension approach. In book of abstracts of international conference extension for strengthening agricultural research and development. December 14-16, 2019, ICAR-KVK, Suttur, Mysuru. Pp 99-100

Kumar S and Chetana Borival (2019) Plagiarism Issues: Type, tools and remedies. presented in national conference on association of agricultural librarians and doumentalists if India (AALDI) at Navsari Agricultural University, Navsari, during 25-27 September, 2019. Pp.479-484.

Kumar S, Sudhir Kumar and Leena Shah (2019) Intellectual Property Roghts (IPR) Issues in Agricultural in India : Acase study with reference to ICAR. Presented In : International conference on digital transformation: A cognitive learning towards artificial intelligence, organised by Rajiv Gandhi National University of Law, Patiala (Punjab), during 06-08 September 2019, pp.737-743.

Singh M, Verma RK and Shivani Nagar (2019) Physiological approach for drought mitigation through nutrient spray. international conference on "sustainable agricultural development in changing global scenario. Held at BHU, Varanasi from Oct., 11-13,

Ratnaparkhe M.B (2019) Bioinformatics tools for DNA and protein sequence analysis . National conference on physical and biological sciences, Council of Surface Science and Catalysis, Indore and Patel group of Institutions, Indore, pp 8-9

Rajput LS, Kumar Sanjeev, Sharma MP, Maheshwari HS, Meena LK, Natraj V and Ratnaparke MK (2019) Screening of fungal and bacterial endophytes: as potential biocontrol agents against major soybean diseases of India. In: International conference on global research initiatives for sustainable agriculture & allied sciences-2019 held during October 20-22, 2019 at ICAR-NAARM, Hyderabad, India, pp. 39.

Jha P, Ratnaparkhe MB and Tiwari A (2019) Pyspark based scalable machine learning algorithm for handling soybean genome sequences. International conference on Python for education and scientific computing. (SciPy), FOSSEE - IIT Bombay. pp 4-5

Rajesh V, Gupta S, Kumawat G, Shivakumar M, Nataraj V, Subhash Chandra, Satpute G K, Rachana Tripathi, Nisha Agrawal and Bhatia VS (2019) Genetic variability studies for yield and yield component traits in soybean germplasm (Glycine max (L.) Merrill). Abstracts of international seminar on modern agriculture approaches in 21st Century during 22-23 November 2019 at University of Lucknow, Lucknow, UP. pp. 147

Sharma MP (2019) Prospects of AM fungi in soil carbon sequestration and sustainable agriculture. Presented during state level seminar on "role of biotechnology in transforming agriculture and rural livelihood" organized by Vivekananda Institute of Biotechnology Sri Ramkrishna Ashram, Nimpith Ashram, Nimpith (South 24-Parganas-West Bengal) from 5th-6th April, 2019.

Sharma MP and Maheshwari H (2019) Plant growth promoting micro-organisms in changed climate scenario: a case of soybean presented during model training course on "climate resilient technologies & practices for soybean production" (4-11 September, 2019) Sponsored by: Directorate of Extension, DAC, MOA, GOI, New Delhi

Subhash Chandra, Satpute GK, Kumawat G, Dipendra Singh, Rajesh V, Ratnaparkhe, MB, Nataraj V, Singh M, Shivkumar M, Gupta S and Bhatia VS (2019) Standardization of screening technique for identifying water logging tolerant genotypes at early vegetative stage in soybean. In Souvenir & Conference Book, Intl. Conf. Global Research Initiatives for Sustainable Agriculture & Allied Sciences, held during 20-22 October, 2019, Hyderabad, Telangana, India, Pp. 16

Talukdar A, Chandra S, Kumar A, Yashpal, Rathod DR, Yadav RR, Saini M, Rathod KK, Gaikwad K, Lal SK, Yadav S and Yadav SK (2019) Enhancing seed viability in soybean: Identifying key factors and genotypes. In: 10th National Seed Congress held during Octo.14-16, 2019 at ICAR-IARI, New Delhi, India, pp.317

Verma RK. Ramesh A, Billore SD, Raghavendra M, Sharma MP, Nita Khandekar and Shivani Nagar (2019) Productivity of soybean-based cropping systems as influenced by different cropping systems, crop establishment method and residue management practices. "Extended Summaries: In Book of abstract of International Conference on Crop Residue Management held at Gyan Bhawan, Patna, (Bihar) from October 14-15, pp 20-22.

Vishwakarma P, Naberia S and Khandekar N(2019) Information Needs of the Dairy Farmers of Jabalpur District of M.P. . In Book of Abstracts of International Conference Extension for Strengthening Agricultural Research and Development. December 14-16, 2019, ICAR-KVK, Suttur, Mysuru. Pp 151-152

Yashpal, Rathod DR, Chandra Subhash, Kumar A, Yadav RR and Talukdar A (2019) QTL mapping for yield and yield attributing traits in Glycine soja Sieb. and Zucc. derived RILs. In: 5th International Conference on Plant Genetics and Genomics: Germplasm to Genome Engineering held during October 17-18, 2019 at NAAS Complex, New Delhi, India, pp.35

Book Chapter

Arya M, Bhartiya, A, Aditya JP, Satpute GK and Ratnaparkhe MB (2019) Unravelling the complex networks involved in plant stress tolerance through metabolomics. In: Recent Approaches in Omics for Plant Resilience to Climate Change, Springer, pp 313-329

Gupta MM, Chourasiya D and Sharma MP (2019) Diversity of Arbuscular Mycorrhizal Fungi in Relation to Sustainable Plant Production Systems. In: Microbial diversity in ecosystem sustainability and biotechnological applications, T. Satyanarayana et al. (eds.), Springer Nature Singapore Pte Ltd. Pages 167-186. https://doi.org/10.1007/978-981-13-8487-5_7

Laad P, Maheshwari HS, and Sharma MP (2019) Utilization of mycorrhizal fungi in the mobilization of macro and micro nutrients to important pulses and oil-seed crops in biofertilizers and biopesticides in sustainable agriculture (1st edition, Eds: B. D. Kaushik, Deepak Kumar & Md. Shamim) 497 pages, Apple Academic Press, USA.

Kumar, Sanjeev, Rajput, L.S., Natraj, V., Maheshwari, H.S. and Shivakumar, M. (2019). Management of major soybean disease diseases with climate resilient practices In: directorate of extension, dac sponsored model training course on climate resilient technologies and practices for soybean production held during Sept. 04 -11, 2019 at ICAR-IISR, Indore

Nataraj V, Kumar Sanjeev , Kumawat G, Shivakumar M. , Rajput Laxman Singh , Ratnaparkhe MB., Ramteke R, Gupta S , Satpute GK, Rajesh V, Kamble V and Subhash Chandra (2019) Charcoal rot resistance in soybean: current understanding and future perspectives. (In): Wani S. (eds) Disease Resistance in Crop Plants. Springer, Cham. doi:https://doi.org/10.1007/978-3-030-20728-1_10.

Raghavendra M, Billore SD and Verma RK (2019) In-situ moisture conservation and residue management for soybean production. In: Directorate of Extension, DAC sponsored model training course on climate resilient technologies and practices for Soybean Production held during Sept. 04 -11, 2019 at ICAR-IISR, Indore

Rajput LS, Kumar S, Natraj, V, Maheshwari, HS and Shivakumar, M. (2019) Management of seedling diseases with climate resilient practices. In: Directorate of Extension, DAC sponsored model training course on climate resilient technologies and practices for soybean production held during Sept. 04 -11, 2019 at ICAR-IISR, Indore

Sharma MP and Maheshwari H (2019) Plant growth promoting micro-organisms in changed climate scenario: a case of soybean. In: Model training course manual on climate resilient technologies & practices for soybean production held during 4-11 September, 2019 at ICAR-IISR Indore

Subhash Chandra, Satpute GK, Verma RK, Kumawat, G, Rajesh V and Singh M (2019) Strategies for management of abiotic stresses in soybean. In: Directorate of extension, dac sponsored model training course on climate resilient technologies and practices for soybean production held during Sept. 04 -11, 2019 at ICAR-IISR, Indore

Verma RK, Raghavendra M. and Billore SD (2019) Climate resilient package of practices for soybean production. In: Directorate of extension, DAC sponsored model training course on climate resilient technologies and practices for soybean production held during Sept. 04 -11, 2019 at ICAR-IISR, Indore

Institute Publication

- Training manual on climate resilient technologies and practices for soybean production (2019) compiled and edited by B. U. Dupare, Purushottam Sharma and Rakesh Kumar Verma In: Model Training Course (4-11, September, 2019), Sponsored By: Directorate of extension ministry of agriculture and farmers welfare, government of India.

- Training Manual on Hybridization in Soybean. (2019) Eds. by Sanjay Gupta, Shivakumar M, Gyanesh K Satpute, Giriraj Kumawat, Nataraj V, Subhash Chandra and Rajesh V. In: ICAR Sponsored "Hands on training on hybridization in soybean" held during Aug. 29-31, 2019 at ICAR-IISR, Indore.

- Soybean Monitor April-September, (2019) (https://iisrindore.icar.gov.in/pdfdoc/soybeanmonitorsept2019.pdf

रेडियो वार्ता

विषय	समनवयक	विषेशज्ञ	दिनांक
मौसम के बदलते परिवेश में सोयाबीन की खेती	डॉ. नीता खाण्डेकर	डॉ. राकेश कुमार वर्मा	04-07-2019
खेत की तैयारी एवं BBF से बुवाई	डॉ. नीता खाण्डेकर	डॉ. राकेश कुमार वर्मा	16-07-2019
सोयाबीन की फसल में कीट तथा रोग प्रबंधन	डॉ. नीता खाण्डेकर	डॉ. राकेश कुमार वर्मा, डॉ. लक्ष्मण सिंह राजपुत	01-08-2019
सोयाबीन की फसल में खरपतवार प्रबंधन तथा पोषक तत्त्व प्रबंधन	डॉ. नीता खाण्डेकर	डॉ. राकेश कुमार वर्मा, डॉ. लक्ष्मण सिंह राजपुत	16-08-2019
कटाई, गहाई एवं बीज प्रबंधन तथा आगामी फसल के लिए सुझाव	डॉ. नीता खाण्डेकर	डॉ. राकेश कुमार वर्मा, डॉ. सौरभ चन्द्र	01-10-2019
गेहूं की फसल के लिए खेत तथा बीज की बुवाई का तरीका	डॉ. नीता खाण्डेकर	डॉ. ए. के सिंह	14-10-2019

14. AWARDS AND RECOGNITIONS

Award to Individuals

- Dr Subhash Chandra received the Young Scientist Award from Society for Scientific development in Agriculture and Technology at International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAS) held during October 20-22, 2019 at ICAR-NAARM, Hyderabad, India

- Dr Laxman Singh Rajput received the Young Scientist Award from Society for Scientific development in Agriculture and Technology at International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences-2019 held during October 20-22, 2019 at ICAR-NAARM, Hyderabad, India

- Sanjeev Kumar received the Young Scientist Award from Society for Scientific development in Agriculture and Technology at International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences-2019 held during October 20-22, 2019 at ICAR-NAARM, Hyderabad, India

- Mis Seema chouhan won second prize (Silver medal) in three events; long jump, Javelin through, 200 meter running in ICAR Zonal tournament held at Nagpur during, 8-10 November 2019

Dr Laxman Singh Rajput receiving Young Scientist Award during GRISAS International Conference

Sanjeev Kumar receiving Young Scientist Award during GRISAS International Conference

Mis. Seema Chouhan, Secured three silver medals in ICAR Zonal tournament held at Nagpur

15. 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

Linkages & collaborations
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, 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
ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra
ICAR-Directorate of Groundnut Research, Junagadh, Gujarat

National Bank for Agriculture and Rural Development
Agharkar Research Institute, Pune
Indian Institute of Technology, Indore
University of Delhi, New Delhi

Regional

Department of Agriculture of Madhya Pradesh, Chhattisgarh, Maharashtra, Himachal Pradesh, Uttar Pradesh, Uttarakhand, Rajasthan, Punjab, Haryana, Jharkhand, Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, North-Eastern States
NGOs like SOPA, OILFED
State Seed Corporation, Department of Seed Certification

16. IMPORTANT COMMITTEES

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

Research Advisory Committee

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, Krishi Bhawan, New Delhi
Member Secretary	Dr S.D. Billore, Principal Scientist (Agronomy), ICAR-IISR, Indore

Institute Management Committee

Chairman	Dr V.S.Bhatia, Director, ICAR- IISR, Indore
Member	Joint Director (Agriculture), Indore, Govt. of Madhya Pradesh,

Member	Director, Soil Conservation & Water Management, Jaipur Govt. of Rajasthan
Member	Director of Research, JNKVV, Jabalpur
Member	Dr Akshay Talukdar, Principal Scientist, ICAR- IA.R.I. New Delhi
Member	Dr P.S. Shukla, Professor GBPUAT, Pantnagar (Uttarakhand)
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

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, Principal 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 Assitt.
	Shri Anil Kumar Carrasco, Sr. Clerk and (CISC Member)
	Shri Sanjeev Mishra, Duplicating Operator.

Other Committees of the Centre (2019)

1.	**Official Language Implementation Committee** Dr V.S. Bhatia, Director (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.	**Printing and Publication Committee (General)** Dr. A.N. Sharma (Chairman) Dr. S.D. Billore Dr. M.P. Sharma **Publication Committee (Annual Report/Newsletter)** Dr M. Shivakumar Dr Rakesh Kumar Verma Dr V. Nataraj Dr Laxman Singh Rajput Dr D.N. Baraskar Dr Surendra Kumar
3.	**Human Resource Development Committee** Dr Sanjay Gupta, (Chairman) Dr Nita Khandekar Dr Savita Kolhe Dr. Rajkumar Ramteke Shri R. N. Singh Administrative Officer	4.	**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
5.	**Consultancy Processing Cell (CPC)** Dr. A. N. Sharma (Chairman) Dr. S.D. Billore Dr. Vineet Kumar Dr. Purushottam Sharma Finance & Accounts Officer Administrative Officer	6.	**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

7.	**Works Committee** Dr. M. P. Sharma (Chairman) Dr. DevVrat Singh Dr. M. Shivakumar Estate Officer Administrative Officer Finance & Account Officer Dr. G.K.Satpute	8.	**Foreign Deputation and Higher Study 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.	**Purchase Advisory Committee** Dr. Vineet Kumar (Chairman) Dr. A. Ramesh Dr. Giriraj Kumawat Dr. Mrinal Kuchlan Finance & Accounts Officer Administrative Officer
11.	**Student Affairs Committee & Higher Study Committee** Dr. Vineet Kumar (Chairman) Dr. A. Ramesh Dr. M.Shivakumar	12.	**Priority Setting Monitoring and Evaluation (PME) Cell** Dr. S.D.Billore (In charge) Dr. B. U. Dupare Dr. Purushottam Sharma Dr. M. Shivakumar
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.	**Hindi Cell** Dr. A. N. Sharma (In charge) Shri S. K. Verma Shri Vikash Keshari Shri Avinash Kalenk
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 Kuma
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** 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.	**Physical Verification Committee** Dr. Vineet Kumar (Chairman) Mr. Hemant Singh Maheswari Dr. Sanjeev Kumar Store Officer	**26.**	**Publicity Committee** Dr. B.U.Dupare (Chairman) Dr. Purushottam Sharma Dr. R.N. Singh Shri S. K. Verma Dr 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.**	**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

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 In Charges** Dr. Sanjeev Kumar - Pathology Dr. Maharaj Singh- Physiology Dr. Sanjay Gupta - Plant Breeding, Seed Technology, and Germplasm Dr. M. K. Kuchalan - DUS Testing, Dr. M.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.**	**Soybean Market Intelligence Cell** Dr. Purushottam Sharma Shri Ram Manohar Patel
		33.	**Estate Officer** Shri S. K. Verma
		34.	**Vehicle In charge** S.K. Pandey
		35.	**Store In charge** Shri S.S. Vasuniaya
		36.	**Tofu Plant In charge** Ms.Neha Pandey Shri S.N. Verma
		37.	**Guest House Incharge** Shri R.N. Shrivastava
		38.	**Record Officer** Shri Ajay Kumar, AAO
39.	**Sport Committee** Dr. A.N. Sharma (Chairman) Shri R.N. Shrivastava Smt. Priyanka Sawan Shri Gorelal Chauhan Shri Balveer Singh		

17. DISTINGUISHED VISITORS

The following are the eminent persons visited this institute during the year 2019

Name and Affiliation	Date of Visit
Dr. S.P. Tiwari, Former DDG (Edn), ICAR & Chairman RAC, ICAR-IISR, Indore	29.05.2019
Dr. D.M. Hegde, Ex Project Director ICAR-IIOR, Hyderabad	29.05.2019
Dr A.K. Sharma, Ex-Director (NBAIM, Mau)	29.05.2019
Dr. Rajiv Sharma, Head of Division (Journalism) Shri Atal Bihari Vajpai Govt. Arts and Commerce College, Indore	18 06.2019
Shri Hare Ram Vajpai, M.P.Hindi Sahitya Samittee, Indore	07.09.2019
Dr Rajeev K Varshney, Research Program Director - Genetic gains, ICRISAT, Hyderabad	26.08.2019
Dr Lee Hickey, University of Queensland, Australia	26.08.2019
Dr. V.K.Dadwal, Director, Indian Institute of Space Science and Technology, Trivendrum and Team	30.11.2019
Dr. (Smt.) Padhama Sharma, Head, Institute of Arts and Huminities, SAIJ University, Indore	16.12.2019

18. PERSONNEL

A.	Research management		
1.	Dr V. S. Bhatia	Director	
B.	Scientific		
2.	Dr. A. N. Sharma	Principal Scientist	Entomology
3.	Dr. Nita Khandekar	Principal Scientist	Agricultural Extension
4.	Dr. S. D. Billore	Principal Scientist	Agronomy
5.	Dr. Sanjay Gupta	Principal Scientist	Plant Breeding
6.	Dr. (Smt.) Anita Rani	Principal Scientist,	Plant Breeding
7.	Dr. Mahaveer P. Sharma	Principal Scientist	Microbiology
8.	Dr. Vineet Kumar	Principal Scientist	Biochemistry
9.	Dr. A. Ramesh	Principal Scientist	Soil Science
10.	Dr. B. U. Dupare	Principal Scientist	Agricultural Extension

11.	Dr. Savita Kolhe	Principal Scientist	Computer Application
12.	Dr. Maharaj Singh	Principal Scientist	Plant Physiology
13.	Er. (Dr.) DevVrat Singh	Principal Scientist	Farm Machinery and Power
14.	Dr. Manoj Kumar Srivastava	Principal Scientist	Biochemistry, w.e.f. 02.12.2019
15.	Dr. Purushottam Sharma	Senior Scientist	Agricultural Economics, up to 03 December 2019
16.	Dr. Milind B. Ratnaparkhe	Senior Scientist	Biotechnology
17.	Dr. Gyanesh Kumar Satpute	Senior Scientist	Genetics
18.	Dr. Rajkumar Ramtake	Senior Scientist	Genetics
19.	Dr. Poonam Kuchlan	Senior Scientist	Seed Technology
20.	Dr. Giriraj Kumawat	Scientist (Senior scale)	Biotechnology
21.	Dr. Mrinal Kumar Kuchlan	Scientist(Senior Scale)	Seed Technology
22.	Dr. M. Shivakumar	Scientist (Senior Scale)	Genetics and Plant Breeding
23.	Shri Ram Manohar Patel	Scientist	Agril. Statistics
24.	Ms. Neha Pandey	Scientist	Food Technology
25.	Dr. Lokesh Kumar Meena	Scientist	Entomology
26.	Shri Hemant Singh Maheshewari	Scientist	Microbiology
27.	Dr. Rakesh Kumar Verma	Scientist	Agronomy
28.	Dr. V. Nataraj	Scientist	Genetics and Plant Breeding
29.	Shri Sanjeev Kumar	Scientist	Plant Pathology
30.	Dr. Subhash Chandra	Scientist	Genetics and Plant Breeding
31.	Dr. Laxman Singh Rajput	Scientist	Plant Pathology
32.	Dr. V. Rajesh	Scientist	Genetics and Plant Breeding
33.	Dr Raghvendra Madar	Scientist	Agronomy
34.	Shri Viraj Gangadhar Kamble	Scientist	Plant Biotechnology

C.	Technical		
35.	Dr. Surendra Kumar	Chief Documentation Officer)	Library & Documentation
36.	Shri R. N. Singh	Chief Technical Officer	Field & Farm
37.	Dr. Nikhlesh Pandya	Chief Technical Officer	Field & Farm
38.	Dr. V. P. S. Bundela (Farm Manager)	Chief Technical Officer	Field & Farm
39.	Dr. Yogendra Mohan	Chief Technical Officer	Field & Farm
40.	Shri S. K. Pandey	Assitt. Chief Technical Officer	Field & Farm
41.	Dr. Sushil Kumar Sharma	Assitt. Chief Technical Officer	Field & Farm up to 30.06.2019
42.	Shri S. S. Vasunia	Assitt. Chief Technical Officer	Field & Farm
43.	Shri R. N. Srivastava	Assitt. Chief Technical Officer	Field & Farm
44.	Dr. D. N. Baraskar	Assitt. Chief Technical Officer	Artist & Photography
45.	Shri S. K. Verma	Senior Technical Officer	Field & Farm
46.	Shri O. P. Vishwakarma	Technical Officer (L/V)	Tractor Driver
47.	Shri I. R. Khan	Technical Officer	Field & Farm
48.	Shri Gorelal Chouhan	Senior Technical Assistant	Field & Farm
49.	Shri R. C. Shakya	Senior Technical Assistant	Field & Farm
50.	Shri Francis Yunis	Senior Technical Assistant (L/V)	Staff Car Driver
51.	Shri Devendra Pratap Yadav	Senior Technical Assistant	Field & Farm
52.	Shri Vikas Kumar Keshari	Hindi Translator	Official Language Cell
53.	Shri Shambhu Nath Verma	Technical Assistant	Field & Farm
54.	Shri Bilbar Singh	Senior Technician (L/V)	Staff Car Driver
55.	Ms. Seema Chouhan	Technician	Field & Farm
D.	Administration and Accounts		
56.	Shri Rakesh Dubey	Administrative Officer	Administration
57.	Shri Ravindra Kumar	Finance and Account Officer	Audit & Account

58.	Shri Ajay Kumar	Assistant Administrative Officer	Administration
59.	Shri S.P.Singh	PS to Director	Administration
60.	Ku. Priyanka Sawan	Assistant	Administration
61.	Shri. Ravishankar Kumar	Assistant	Administration
62.	Shri Avinash Kalanke	Senior Clerk	Administration
63.	Shri Anil Kumar Carrasco	Senior Clerk	Administration
64.	Shri Sanjeev Kumar	Duplicating Operator	Administration
E	**Skilled Supporting Staff**		
65.	Shri Gulab Singh	SSG III	
66.	Shri Dhan Singh	SSG III	
67.	Shri Nirbhay Singh	SSG II	
68.	Shri Janglia	SSG II	
69.	Shri Surla	SSG I	
70.	Shri Sur Singh	SSG I	
71.	Shri Balveer Singh	SSG I	
72.	Shri Prahlad Singh	SSG I	

19. APPOINTMENTS, PROMOTIONS, TRANSFER, etc.

Promotions

Name	Promoted to the post of	w. e. f.
Shri Devendra Pratap Yadav	Senior Technical Assistant	09.06.2014
Dr. Rajkumar Ramteke,	Senior Scientist (Plant Genetics) from PB-3 to PB-4	17.01.2015
Dr. Punam Kuchalan,	Senior Scientist (Seed Technology) from PB-3 to PB-4	16.02. 2018
Shri Shambhu Nath Verma	Technical Assistant	06.10.2019
Shri I.R.Khan	Technical Officer	31.10.2019

Deputations/ Selection

Name	Deputation/ Fellowship	w. e. f.
Dr. Giriraj Kumawat Scientist (Sr. Scale) (Biotechnology)	Japan International Research Centre for Agricultural Science (JIRCAS), Tsukuba, Japan	Tsukuba, 01.10.2019 to 30 Sep. 2020

Transfers

Name	From	To	w. e. f.
Dr. Manoj Kumar Srivastava, Principal Scientist (Plant Biochemistry)	ICAR- IGFRI, Jhansi	ICAR- IISR, Indore	02.12.2019
Dr. Purushottam Sharma Senior Scientist (Agricultural Economics	ICAR-IISR, Indore	ICAR-NIAP, New Delhi	03.12.2019

Retirement

Dr. Sushil Kumar Sharma, Assistant Chief Technical Officer on 30.06.2019

Higher education

Name	Name of Degree	University/ Institution
Shri R.C. Shakya, Senior Technical Assitt. (Field & Farm)	PGDCA (Computer Science)	Makhanlal Chaturvedi National University of Journalism and Communication.

भा.कृ.अनु.प. - भारतीय सोयाबीन अनुसंधान संस्थान, खण्डवा रोड़, इन्दौर (म.प्र.) भारत - 452 001
ICAR-Indian Institute of Soybean Research, Khandwa Road, Indore, M.P., India - 452 001
Ph.: 0091-0731-2476188, 2478414, Fax : 0091-0731-2470520
Emial : Soybean.director@icar.gov.in, dsraddmin@gmail.com, dsrdirector@gmail.com