DIVISION OF CROP PRODUCTION

Introduction

This Division comprises of major disciplines of Crop Production with a scientific strength of six scientists. Division of Crop Production is engaged in research and extension activities related to the cropping system, integrated nutrient, water and weed management and Resource Conservation.

Thrust Areas

1. Resource use efficiency
2. Integrated crop management module for pulses in different cropping systems
3. Long-term effect of pulses in cropping systems on soil health and crop productivity
4. Resource Conservation Technology on Pulses in Rice Fallows
5. Farm mechanization suitable for pulses
6. Post-harvest technology and value addition in pulses

On-going Research projects

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<td>Dr. S.S. Singh</td>
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<td>2.</td>
<td>Efficient water management in pulses for higher productivity (2012-17)</td>
<td>Dr. Chandra Sekhar Praharaj</td>
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<td>3.</td>
<td>Development of RCT and weed management strategies in pulse based cropping system (2009-16)</td>
<td>Dr. Narendra Kumar</td>
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<td>4.</td>
<td>Enhancing Resource Use Efficiency of pulse based cropping systems in Indo-Gangetic plains (2012-17)</td>
<td>Dr. Ummed Singh</td>
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<td>5.</td>
<td>Enhancing resource use efficiency in Pulse based cropping system in central India (2014-17)</td>
<td>Dr. Chandra Sekhar Praharaj</td>
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<td>6.</td>
<td>Mitigating abiotic stresses and enhancing resource-use efficiency in pulses in rice fallows through innovative resource conservation practices (2011-16) <strong>NASF</strong></td>
<td>Dr. S.S. Singh</td>
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Research achievements

- Intensification of efficient pulses based cropping systems (rice/bajra/maize/pigeonpea-wheat/chickpea-mungbean)
- Developed efficient pulse based intercropping systems.

- Standardized agro-technologies for early pigeonpea-wheat cropping system.
- Developed agro-technology for late chickpea, rabi rajmash, dwarf pea and late sown kharif mungbean
- Established the need of sulphur, zinc & boron for balanced nutrition of pulse crops.
- Identified Critical stage of irrigation for long duration pigeonpea, Rabi and Summer pulses.
- Developed Integrated weed management technology for pulse based cropping system.
- Developed planting techniques for efficient water management
- Standardized foliar spray of urea in pulses
- Identified short duration pulse crops in Rice-wheat system
- Quantified nutrient contribution through leaf litter fall in pulses
- Residue management practices standardized in pulse based cropping system
- Enhanced phosphorus use efficiency in maize-chickpea system through integrated phosphorus management
- Enhanced productivity and water use efficiency in pulses through raised bed/ridge planting technique
- Enhanced productivity and water use efficiency in pulses through micro-irrigation especially drip-fertigation in pigeonpea, sprinkler irrigation in Rabi pulses and precision tillage & sprinkler irrigation in summer pulses

- In long duration pigeonpea, paired row planting (60 x 20 -120 cm at 55,500 plants/ha) at 0.4 IW/CPE is optimum for irrigation scheduling.

- On a contingency planning mode, 3 Weeks old seedlings (WAS) raised in polythene bags transplanted on ridge was optimum (with 30% higher yield) over normally planted pigeonpea grown in situ (and 4-5 weeks of transplanting).
Normal harvesting                          Combine harvesting
Summer mungbean under rice-wheat-mungbean system

Drip Irrigation in Pigeonpea

CONTROL            BALANCED NUTRITION

Transplanting in pigeonpea

Direct seeded
BRIEF ACHIEVEMENTS (Project wise)

1. **Long term effect of pulses in cropping systems on soil health and crop productivity in Indo-Gangetic plains (2014-15 onwards)**

- Upland system (Maize/bajra based)
- Lowland system (Rice based)

Two permanent experiments aiming at enhancing productivity of pulses based cropping systems and soil quality build up were initiated during 2014-15 which comprised of four maize/bajra based cropping systems (viz., maize/bajra-wheat, maize/bajra-wheat-maize/bajra-chickpea, pigeonpea-wheat and maize/bajra-wheat-mungbean) and four rice based cropping systems (viz., rice-wheat, rice-chickpea, rice-wheat-rice-chickpea, and rice –wheat-mungbean) with 3 nutrient management treatments viz., control, inorganic and integrated nutrient management practices. The system productivity in terms of Pigeonpea Equivalent Yield (PEY) was highest with maize/bajra-wheat-mungbean. Similarly in rice based long-term trial, based on chickpea equivalent yield (CEY), highest system productivity was recorded in rice-wheat-mungbean. Therefore, inclusion of pulses in the cereal based system augmented the system productivity as well as yield of component crops. Inclusion of summer mungbean in cereal based rotation (rice-wheat and maize-wheat) also improved soil organic C and soil available nutrients.

![Performance of crops under different nutrient management](image)

In addition, mungbean performed best under INM plot as its seed yield was 18.6 and 32.5% higher over inorganic (758 kg/ha) and control (678 kg/ha) plot, respectively. Overall performance of rice was also higher in INM than inorganic fertilizer and control. Maximum paddy yield was observed under INM in rice-chickpea system (5568 kg/ha). The average yield data also showed maximum paddy yield under rice-chickpea (4263 kg/ha) which was at par with both rice-wheat-mungbean (4231 kg/ha) and rice-wheat-rice-chickpea (4215 kg/ha); and was however, lowest in rice-wheat (3536 kg/ha). Moreover, significantly higher paddy yield was observed in INM.
(5286 kg/ha) plots than that in inorganic (4513 kg/ha) and no fertilizer i.e., control (2285 kg/ha) plots.

✓ Comparision made among different cropping systems in upland long-term fertility experiment, the study revealed that maize-wheat-mungbean (PEY, 2801 kg/ha) and bajra-wheat-mungbean (PEY, 2688 kg/ha) were efficient systems recording highest pigeonpea equivalent yield. Among various nutrient management practices application of inorganic (NPKSZnB) recommended fertilization recorded highest PEY of 1925 kg/ha and 1908 kg/ha under maize and bajra based system, respectively.

2. **Efficient management of water for higher productivity in pulses (2012-17)**
   ✓ Influence of precision tillage and sprinkler irrigation in summer pulses
   ✓ Demonstration of Agro-technology in mungbean involving sprinkler irrigation
   ✓ Water management in Rabi pulses (Chickpea/Lentil)

✓ A significant improvement in seed yield (31%) and water saving (11% less water use and 43.2 % enhanced WUE) were recorded in mungbean with a precision tillage carried out by a laser leveler experimented under a micro-irrigation management in pulses. Sprinkler irrigation was advantageous for enhancing the irrigation efficiency even for two months duration of mungbean crop (with 19.9% less water use and 23.8 % higher WUE) over flood irrigation at podding & seed setting.
On an on-station demonstration to confirm the effect of overhead sprinkler irrigation + improved agro-techniques (paired row, narrow row spacing with sprinkler irrigation), it convincingly showed the beneficial role of sprinkler irrigation in summer mungbean. There was a significant difference in seed yield under improved irrigation scheduling (through sprinkler irrigation at two critical stages of crop viz., at branch and pod development) over conventional farmers’ practice (flood irrigation at above stages). Besides this, micro-irrigation maintained a substantial water economy over that in flood irrigation (up to 35%). In addition, farmers’ practice of planting at 30 cm row spacing reduced seed yield to the extent of 22.0% over the best practice of 22.5 cm row spacing.

Moreover, significantly higher yield (9.4%) was realized under ‘SAMRAT’ (1230 kg/ha) over ‘IPM 205-7’ (1120 kg/ha) when mungbean is sown during last week of March (25th march, 2015 in this case).

In case of mungbean, when it is planted during last week of March (after potato harvest in NE plains), it requires 2 irrigations in comparison to 3 irrigations for late (April) planted crop (after wheat harvest in NE plains).

In late planted (2nd week of April) mungbean crop, significantly higher seed yield was obtained at 15 x 10 cm (1563 kg/ha) over both 22.5 x 10 and 30 x 10 cm. IPM 410-3 performed the best both at 15 x 10 cm and 22.5 x 10 cm (economical with low seed rate) when comparison was made amongst the summer grown varieties.

Normal irrigation in chickpea at both branch & pod development could reduce seed yield (17.7%) due to excess soil moisture condition (with 23% higher CU and 44% less WUE) which was further affected by rainfall events (and was also less evident with sprinkler). Tillage options despite their inherent differences in frequency and time of tillage could not influence chickpea crop performance on short term basis (2-3 years). Keeping in view the risk involved with unanticipated rainfall during Rabi, sprinkler irrigation could play a safe proposition for precision/regulated irrigation scheduling (in respect of frequency/time/quantum).
3. **Development of RCT and Weed management strategies in pulse based cropping system (2009 onwards)**

- Effect of tillage and residue incorporation in rice (transplanted) - pulse based cropping system
- Performance of summer mungbean under conservation agriculture in rice-wheat cropping system in IGP
- Weed management in both *Kharif* (mungbean) and *Rabi* (chickpea)

- On a 5th crop cycle on RCT and its embedded practices, there was an improvement in rice yield to the tune of 5.6 recorded due to residue incorporation. Improvement in rice yield (11.6%) was also observed in rice-chickpea-mungbean over rice-wheat. Similar trend was also observed in case of *Rabi* crops (wheat and chickpea).

- Summer mungbean performed better under residue incorporation as its yield was higher in case of residue incorporation (9.94%) in comparison to no-residue (1399 kg/ha). In contrast to previous year, system productivity in terms of chickpea equivalent yield was 9.9% higher in case of conventional tillage than that in zero-tillage (3905 kg/ha). Improvement in system productivity (7.06%) was also recorded due to residue incorporation. Conservation agriculture also improved soil fertility.

![Effect of CA on soil fertility](image)

- In four years of permanent raised bed study, the performance of maize, spinach and chickpea were influenced by nutrient management practices. Maximum yield of these crops were recorded in the plot with dhaincha + FYM followed by FYM and the lowest yield in control. The improvement in yield of maize, spinach and chickpea due to dhaincha + FYM over control was 70, 94 and 26 percent, respectively. Similar trend was also observed in system productivity.

- **Weed management in Kharif mungbean:** Application of post-emergence herbicides resulted in maximum grain yield of *Kharif* mungbean in comparison to weed free (1009 kg/ha) followed by pendimethalin *fb* imazethapyr (932 kg/ha), pendimethalin *fb* clodinafop-propargyl @ 150 g/ha (869 kg/ha). The observation showed that fenoxaprop-p-ethyl and propaquizafop were effective in controlling grassy weeds.
However, clodinafop-propargyl control *Digera arvensis* (a major broad leaved weed in *kharif* mungbean) that further enhanced the weed control efficiency and grain yield of mungbean (42%) under the treatment.

**Weed management in chickpea:** A study on post-emergence herbicides revealed maximum grain yield of chickpea under weed free (801 kg/ha) followed by Pendimathalin fb quizalofop-ethyl @ 100 g/ha (632 kg/ha), Pendimathalin fb clodinafop-propargyl @ 150 g/ha (608 kg/ha). The observation showed that all three POE herbicides are effective in controlling grassy weeds.

4. **Enhancing Resource use efficiency of pulse based cropping systems in Indo-Gangetic plains (2012-17)**
   - Evaluation of Next generation fertilizers in maize-chickpea
   - Enhancing Resource use efficiency in pigeonpea-wheat
   - Agronomic Evaluation of hybrid pigeonpea-wheat
   - Assessment of Soil-Plant Nutrient Dynamics for strategic nutrient management

   Higher pearl millet equivalent yield (4784 kg/ha) was recorded with pearl millet + mung bean followed by pearl millet + cowpea (4373 kg/ha) (and the least in pearl millet sole (3224 kg/ha). In early pigeonpea, sowing on 5th June out yielded (1642 kg/ha) following 25th June and 15th June. The crop geometry of 50×15 cm was more appropriate in terms of grain yield (1721 kg/ha). Early sowing of hybrid pigeonpea (IPH 09-05) on 1st June at 70×20 cm fetched higher grain yield of wheat (3720 kg/ha) following application of 125% RDF to wheat in succession.

   Higher chickpea equivalent yield was realized when pearl millet + mung bean (3630 kg/ha) followed by Bajra + Cowpea (3486 kg/ha) (with the least in bajra sole, 2794 kg/ha). In addition, higher net return (INR 63238/ha), B:C ratio (2.22) and production efficiency (13.59 kg/ha/day) was recorded in pearl millet + mung bean following chickpea with 100% RDF and one supplemental irrigation.
Application of P to maize at 60 kg P\textsubscript{2}O\textsubscript{5}/ha improved grain yield of chickpea by 98 kg/ha over 30 kg P\textsubscript{2}O\textsubscript{5}/ha. Further, application of 30 kg S/ha to chickpea recorded highest grain yield (1435 kg/ha) followed by that of 15 kg S/ha to each maize and chickpea (1419 kg/ha) in maize-chickpea.

Approaches of micronutrient addition (Ferti-fortification) viz., seed treatments (seed coating and seed priming), soil and foliar applications were analyzed for enriching in respect of Zn & Fe content in both Rabi and Kharif pulses. Foliar spray of zinc enhanced its concentration in leaves, stem and grain from 7 to 11% both in Rabi and Kharif pulses. Seed coating beyond 4.0 g Zn/kg seed showed toxicity symptom in lentil, field pea and mungbean at germination stage. Although toxicity symptoms in chickpea, rajmash and urdbean were noticed when seed coatings employed beyond 6.0 g Zn/kg seed.

Application of Carfentrazone ethyl @ 20 g/ha neither controlled weeds nor had toxicity symptoms. However, application of Carfentrazone ethyl @ 30 g/ha and Imazathapyr @ 75 g/ha killed the weeds but had toxicity symptoms.

Chickpea ‘HC 5’ out yielded (1824 kg/ha) under planting geometry 22.5×10cm. Highest point of podding from soil surface was recorded (28.03-34.71cm) in chickpea ‘HC 5’ and is amenable to mechanical harvesting.

5. Enhancing resource use efficiency in pulse based cropping system in central India (2014-17)

- Enhancing crop productivity and sustainability in soybean based intercropping system(from 2014-15)
- Enhancing system productivity of soybean-lentil system in rainfed areas(from 2015-16). With the above objectives, the study revealed as under:

- Raised bed had the distinct advantage for Kharif and Rabi crops as significant productivity enhancement to the tune of 16.4-20.8% in soybean, lentil, and soybean based intercrops were observed in Central rainfed India (Bhopal). On total system productivity, significantly higher total productivities/BCR and net incomes were recorded with Soybean + Urdbean/ Maize – Lentil.
Therefore, there is a need for short duration pigeonpea variety for fitting in soybean + pigeonpea-lentil system. If both pigeonpea/sorghum were harvested late (mid-December) then it delayed lentil sowing that affected both Rabi crop (lentil) and total productivity adversely.

Supplementary irrigation once to the delayed planted lentil also could not enhance its productivity over the timely planted crop due to well distributed rainfall event during Rabi.

On an evaluation study to show the effect of nutrients and tillage management practices in legume based cropping systems on soil health and sustainability in Vertisol of central India, it revealed that although both the tillage and fertility levels could not influence chickpea/wheat grain yield during Rabi season, yet comparing the productivities during Rabi, chickpea (soybean-chickpea) out-performed over wheat (soybean-wheat) in terms of chickpea equivalent yield.
6. Mitigating abiotic stresses and enhancing resource-use efficiency in pulses in rice fallows through innovative resource conservation practices (2011-16)

- Enhancing Resource use efficiency through rice establishment methods and nutrient management in rice-chickpea system.
- Monitoring Abiotic stresses, soil micro-climate and its mitigation strategies through conservation agriculture in rice-chickpea.
- Mitigating Soil impediments and improving soil health and chickpea

- Significantly higher soil moisture was retained under chickpea sown after unpuddled transplanted rice (UPR) i.e., 19.7% at 10 cm, 15.3% at 20 cm, 10.7% at 30 cm, 12.1% at 40 cm, 8.4% at 60 cm and 7.7% at 100 cm soil depth over puddled transplanted rice (PTR). Similarly, chickpea sown after direct seeded rice (DSR) conserved significantly higher soil moisture over PTR by 15.9, 15.0, 11.9, 8.0 and 6.0 percent at 10, 20, 30, 40, 60 and 100 cm soil depth, respectively. Less amount of soil moisture was conserved in chickpea sown after PTR. The maximum weed density and weed dry biomass (166 m² & 58.48 g m²) was observed in DSR followed by UPR (150 m² & 41.6 gm²) and PTR (106 m² & 13.1 gm²) transplanting technique. The chickpea sown after UPR gave significantly higher yield (23.9%) over PTR. However, chickpea yield sown after DSR was 16.9 % higher in comparison to chickpea sown after PTR.

- In another study, results revealed that application of recommended NPK + FYM to rice crop conserved higher soil moisture (17.9, 11.6, 7.3, 8.1, 5.9 and 6.5% at 10, 20, 30, 40, 60 and 100 cm, respectively) over farmer’s practice. Maximum shoot and root dry weight were observed in NPK+FYM followed by NPK over farmer’s practice at vegetative, flowering and pod development stages. Similarly, significant increase in nodule per plant and nodule dry weight at different chickpea growth stages was observed under NPK+FYM. The improvement in chickpea grain yield was also recorded under NPK+FYM (57.4%) followed by NPK (27.4%) over farmer’s practice. However, foliar nutrition could not influence chickpea yield.
The rice fallow experiment has the following recommendations.

- Paired rows planting (22.5 cm x 45 cm) of chickpea.
- Foliar application of 2% urea / DAP (in T.N.) at flowering and 10 days thereafter in pulses for alleviating N stress and enhancing seed yield under rice fallow.
- Application of quizalofop-p-ethyl @ 100 g/ha post-emergence to control rice ratoons at 2-3 leaves stage.
- Two prototypes of manual operated single row ZT Drill for sowing of pulses under rice fallows of heavy and medium textured soils.
A PhD. Research programme entitled “Assessment of soil-plant phosphorus dynamics in aerobic rice-lentil production system” was undertaken by Mr. K.K. Hazra, Scientist (Agronomy) at IIT, Kharagpur (course program) in collaboration with IIPR, Kanpur (Field study). The study showed that system of Rice Intensification (SRI) method of rice cultivation produced significantly higher yield over puddled transplanted (PTR) and direct seeded rice (DSR). The relative response of inorganic phosphors was found higher on aerobic rice production system compared to flooded anaerobic production system. All the yield attributing parameters were largely influenced by without phosphorus application thereby indicating the importance of P nutrition in aerobic rice production system. Incorporation of rice residue and suboptimal application of inorganic phosphorus along with PSB inoculation improved the lentil crop growth. Performance of lentil crop was better under DSR than that of SRI and PTR.

**Infrastructure**

The division of Crop Production has following well-equipped laboratories for analysis of soil, plant and water samples.

- Soil chemistry lab is having pH and conductivity meter, spectrophotometer, flame photometer, automatic N analyzer, Auto-analyzer, Atomic Absorption Spectrophotometer, Millipore ultra pure water purification system and willey mills.
- Agronomy lab has muffle furnace, Quartz double Distillation apparatus and BOD incubators
- Water management lab has pressure plate apparatus, soil moisture meter, infiltrometers, lux meter and pshycrometer, penetrologger, pressure chamber, water quality kit
- Meteorological Observatory for recording weather parameters
Agricultural Engineering

This section was created primarily to carryout research and development activities in the area of post production handling, storage and processing of pulses. But now it has diversified its activities into farm mechanization as well. The section has initiated work on development of efficient farm machineries for judicious use inputs, and reducing drudgery in various farm operations along with reduction in post harvest losses, from production till consumption and utilization of milling by-products.

This section, over a period of time, has developed modest facilities for grain testing, milling and storage, workshop and prototype fabrication. A pulse milling laboratory has also been established for standardization of pre-milling treatments, testing of mini dal mills and identification of pulse cultivars for higher dal recovery. IIPR Dal Chakki, IIPR Mini Dal Mill and IIPR Multipurpose Grinder are some of the technologies developed by the section which got commercialized. Recently the section has designed and developed vertical thresher, rubbing thresher, pigeonpea stripper and suction winnower.

Salient Achievements

A. Pulse Processing Machineries Developed

1. IIPR Dal Chakki
   ✓ Useful for domestic and cottage scale pulse milling.
   ✓ Milling mechanism in the chakki, comprises of stationary rubber and rotating steel disks to dehusk and split pretreated pulse grains. Cyclone separator removes husk and powder from the milled fractions.
   ✓ Powered by 1.5 hp single phase motor, the chakki has capacity to mill 75-125 kg/h.

2. IIPR Mini Dal Mill
   ✓ Useful for grading of raw grains and milled fractions and emery roller for ease of dehusking and pitting.
   ✓ The mill operates on 2 hp single phase motor and has capacity of 75-125 kg/h.
   ✓ The quality of dal is comparable with that obtained at cottage level pulse milling.
   ✓ Suitable for rural entrepreneurs, unemployed youth and progressive farmers.
3. Multi-purpose Grinding Mill

- Useful to make besan from broken cotyledons obtained from milling of chickpea.
- It comprises of swinging beater type rotor to crush the fed material inside the chamber.
- Also suitable for grinding of spices like turmeric, coriander, red chili, black pepper etc.
- This 1 hp single phase grinder can grind 40-45 kg for besan and rice flour, 3-4 kg of coriander and black pepper, 2-3 kg of red chili and 9-10 kg of turmeric per hour.

4. Rubber and Steel Disk Type Hand Operated Dal Chakki

- Useful in rural areas where still dal is made from stone chakkies.
- It utilizes IIPR pulse milling technology of vertical rubber and steel disks.
- Thoroughly pre-treated grains are fed from the hopper.
- Auger feeding mechanism helps uniform input of grains to the dehusking unit.

5. Emery Disk Type Hand Operated Dal Chakki

- Hand operated chakki along with horizontal emery disks uses bearings at central pivot and handle base to reduce drudgery.
6. Value Added Products from Pigeonpea Milling By-products

- Several homemade recipes (*barfi, ladoo, sev, kachri, sweet puries, kachauri masala*) are made from pigeonpea milling by-product.
- Biscuit is developed incorporating husk and cotyledon powder mixture in different proportions.
- Value added products from pigeonpea milling by-product are rich in protein, fiber and phenols, thus, have higher food value.
- Fractional separation of pigeonpea milling by-product yields 25% cotyledon powder for making *dal* analogue by unheated extrusion. Powder fraction can directly be poured into boiling water to make *dal*.
- Colour of *dal* is little brownish (due to husk in the mixture) while protein content is similar to *dal*.
- Alternatively useful for soup, gravy thickener and protein enhancer.
B. Farm Machineries Developed

1. Manually Operated No-Till Drill
   ✓ Useful for small farmers at a reduced cost for direct line sowing under residues.
   ✓ Moisture is retained on the soil surface in rice fallow due to least soil disturbance.
   ✓ Field capacity is 0.05 ha/h with two manpower against four needed for hand plough.
   ✓ The cost of operating manual zero-till drill is Rs.845/ha as against Rs.1690/ha incurred in hand plough.

2. Vertical Thresher
   ✓ Useful for threshing pulse crops with least adjustment.
   ✓ The thresher gave capacity of 450 kg/h for stripped pigeonpea and 300 kg/h for chickpea.

3. Pigeonpea Stripper
   ✓ A pigeonpea stripper envisages removal of pods and leaves from plants, with least damage to plant structure.
   ✓ This stripped material can be threshed in a vertical thresher/other commercially available thresher.
   ✓ The stripper has a capacity of 150 kg/h.
   ✓ Stripped pigeonpea plants are used in various traditional usages such as mud thatched walls, roof covering, basket making, fuel etc.
4. Suction Winnower

- The hopper is fed with the materials allowing free fall of these in a closed chamber.
- Light impurities, dust and dirt are sucked and blown away in direction opposite to operator.
- Winnowing capacity is 150 kg/h.

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<td>✓ Installation of mini dal mill</td>
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<tr>
<td>✓ Workshop</td>
<td>✓ Resource generation through pulse processing</td>
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<td></td>
<td>✓ Operation and maintenance of seed processing plant</td>
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<tr>
<td></td>
<td>✓ Operation, repair and maintenance of farm machineries and implements</td>
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## Scientists and their area of specialization

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<tr>
<td>Dr. S.S. Singh Head</td>
<td>Conservation Agriculture, Water Management, Farmers’ Participatory Research</td>
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<td>Dr. Chandra Sekhar Praharaj</td>
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