New Developments in Soybean Cultivation in India

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Global Production of Soybean (av. 2016-17 to 2018-19)

Source: AMIS-FAO
Soybean yield in major producing countries
(av. 2016-17 to 2018-19)

Source: AMIS-FAO

Comparative Global Area and Production 2018 Vs 2019 (Est)

Dr Sanjay Gupta

October 2019
Soybean: Area Confined to Central India

Concentration of soybean area in India

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Soybean in Central India

Area under soybean in India

Production of soybean in India

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Area, Production and Productivity of Soybean in India

Average Soybean Productivity in States
### Sowing position of Soybean in India as on 27.09.2019
(Area in Lakh Ha)

<table>
<thead>
<tr>
<th>States</th>
<th>2019</th>
<th>Same period 2018</th>
<th>Same period 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bihar</td>
<td>0.420</td>
<td>0.368</td>
<td>0.000</td>
</tr>
<tr>
<td>Chhattisgarh</td>
<td>0.742*</td>
<td>1.290</td>
<td>1.320</td>
</tr>
<tr>
<td>Gujarat</td>
<td>1.003*</td>
<td>1.365</td>
<td>1.290</td>
</tr>
<tr>
<td>Karnataka</td>
<td>3.302*</td>
<td>3.394</td>
<td>2.710</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>55.160**</td>
<td>53.180</td>
<td>50.100</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>40.113*</td>
<td>40.444</td>
<td>38.397</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>10.608**</td>
<td>10.461</td>
<td>9.690</td>
</tr>
<tr>
<td>Telangana</td>
<td>1.770*</td>
<td>1.789</td>
<td>1.650</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>0.208**</td>
<td>0.199</td>
<td>0.195</td>
</tr>
<tr>
<td>Uttarakhand</td>
<td>0.260**</td>
<td>0.240</td>
<td>0.250</td>
</tr>
<tr>
<td>Others</td>
<td>0.402**</td>
<td>0.367</td>
<td>0.319</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>113.988**</td>
<td>113.097</td>
<td>105.921</td>
</tr>
</tbody>
</table>

### Comparative Indian Area and Production 2018 Vs 2019 (Estimated)

<table>
<thead>
<tr>
<th>Year</th>
<th>Area ('000 Ha)</th>
<th>Production ('000 Tons)</th>
<th>Yield (Kg/Ha)</th>
<th>Change in Area (%)</th>
<th>%Change in Production</th>
<th>%Change in Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-17</td>
<td>11.1834</td>
<td>13158.7</td>
<td>1177</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-18</td>
<td>10.3288</td>
<td>10933.0</td>
<td>1058</td>
<td>-7.6</td>
<td>-16.9</td>
<td>-10.1</td>
</tr>
<tr>
<td>2018-19*</td>
<td>10.9600</td>
<td>13786.0</td>
<td>1258</td>
<td>6.1</td>
<td>26.1</td>
<td>15.2</td>
</tr>
<tr>
<td>2019-20**</td>
<td>11.3990*</td>
<td>13505.0</td>
<td>1185</td>
<td>4.0</td>
<td>-2.0</td>
<td>-2.8</td>
</tr>
</tbody>
</table>

*Fourth advance estimates, ** First advance estimates,
*All India weather summary and forecast bulletin 27.09.2019 (http://agricoop.nic.in/sites/default/files/Cwwg-Data-as-on-27.09.2019.pdf)
Yield Potential and Yield Gap in Soybean

Yield potential (as per Simulation study):
- Average water non-limiting potential: 3.0 t/ha
- Average water limiting potential: 2.2 t/ha

Yield Gap:
- FLD average yield with full package: 1.8 t/ha
- National average: 1.1 t/ha
- Average yield gap: 0.7 t/ha

Low Yield of Soybean: Issues

- The majority of the crop is rainfed (95%) - weather variability
- Only two early maturing varieties (< 90 days) in Central India.
- Lack of abiotic stress (drought, heat, waterlogging) tolerant varieties of suitable maturity duration.
- Limited varieties with biotic stress (YMV, charcoal rot and anthracnose) resistance with desirable maturity group.
- Low adoption of improved crop production technology
  - Seed treatment - low adoption
  - Continuous mono-varietal culture
  - Increasing insect-pest infestation
  - Poor soil fertility and imbalanced nutrient application
- Poor availability of quality inputs at affordable prices
- Farm Implements
New Varieties for Different Zones

Six Agroclimatic Zones

- Northern Hill Zone
- Northern Plain Zone
- Eastern Zone
- North Eastern Hill Zone
- Central Zone
- Southern Zone

- 120 soybean varieties released
- 47 under seed chain
### Northern Hill Zone (NHZ)

<table>
<thead>
<tr>
<th>States</th>
<th>Uttarakhand and Himachal Pradesh; J &amp; K included in 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Diseases</strong></td>
<td>Frog Eye Leaf Spot (Hot spots).</td>
</tr>
<tr>
<td><strong>Abiotic Stress</strong></td>
<td>Heavy rains in few years</td>
</tr>
<tr>
<td><strong>Desirable features in varieties</strong></td>
<td>Earliness</td>
</tr>
<tr>
<td><strong>Additional Requirement</strong></td>
<td>Black seeded, null-KTI, null-lox</td>
</tr>
</tbody>
</table>

![Frog Eye Leaf Spot](image)

### Recent Soybean Varieties of NHZ

<table>
<thead>
<tr>
<th>Variety</th>
<th>VLS 89</th>
<th>PS 1556</th>
<th>VL Bhat 202 (Dal) (UK)</th>
<th>Shalimar Soybean (J &amp; K)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Notified / Identified</strong></td>
<td>Notified 2019</td>
<td>Under notification 2019</td>
<td>2018 (State Release)</td>
<td>2017 (under notification)</td>
</tr>
<tr>
<td><strong>Days to Maturity</strong></td>
<td>116</td>
<td>120</td>
<td>112</td>
<td>142</td>
</tr>
<tr>
<td><strong>100 Seed Weight</strong></td>
<td>14.4</td>
<td>12.5</td>
<td>16.4</td>
<td>18.5</td>
</tr>
<tr>
<td><strong>Grain Yield (Q/ha)</strong></td>
<td>23-25</td>
<td>23-25</td>
<td>15-17</td>
<td>22-25</td>
</tr>
<tr>
<td><strong>Oil%</strong></td>
<td>19.1</td>
<td>18.8</td>
<td>39.1% Protein 16.5%</td>
<td>Oil</td>
</tr>
<tr>
<td><strong>Seed Colour</strong></td>
<td>Yellow</td>
<td>Yellow</td>
<td>Black</td>
<td>Yellow</td>
</tr>
<tr>
<td><strong>Resistance</strong></td>
<td>MR to FLS</td>
<td>MR to FLS, R to YMV and SMV</td>
<td>MR to FLS, Pod Blight and Bacterial Pustules</td>
<td>-</td>
</tr>
</tbody>
</table>
Northern Plain Zone (NPZ)

- **States**: Punjab, Haryana, Delhi, UP (except Bundelkhand), Bihar
- **Main Diseases**: Yellow Mosaic Virus, Soybean Mosaic Virus, Rhizoctonia Aerial Blight
- **Abiotic Stress**: Photosensitivity
- **Desirable features in varieties**: Earliness
- **Additional Requirements**: Food Usages (null-KTI, null-lox)

### Recent Soybean Varieties of NPZ

<table>
<thead>
<tr>
<th>Variety</th>
<th>SL 958</th>
<th>SL 979</th>
<th>SL 955</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Notified / Identified</strong></td>
<td>Notified 2016</td>
<td>Under notification (2019)</td>
<td></td>
</tr>
<tr>
<td><strong>Days to Maturity</strong></td>
<td>122-124</td>
<td>125-128</td>
<td>124-128</td>
</tr>
<tr>
<td><strong>100 Seed Weight</strong></td>
<td>12.3</td>
<td>11.3</td>
<td>8.77</td>
</tr>
<tr>
<td><strong>Grain Yield (Q/ha)</strong></td>
<td>22-25</td>
<td>22-24</td>
<td>21-23</td>
</tr>
<tr>
<td><strong>Oil%</strong></td>
<td>19.7</td>
<td>20.6</td>
<td>18.9</td>
</tr>
<tr>
<td><strong>Seed Colour</strong></td>
<td>Yellow</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td><strong>Resistance</strong></td>
<td>Resistant to YMV, MR to RAB and SMV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Eastern (EZ) and North Eastern Hill Zone (NEHZ)

**States**  
- EZ: Chhatisgarh, West Bengal, Orissa,  
- NEHZ: Assam, Meghalaya, Tripura, Nagaland, Manipur, Mizoram, Sikkim, Arunachal Pradesh

**Main Diseases**  
- Bud Blight in EZ,  
- Rust and collar rots in parts of NEHZ

**Abiotic Stress**  
- Drought in EZ and  
- Excess moisture in NEHZ

<table>
<thead>
<tr>
<th>Rust</th>
<th>Collar Rot</th>
<th>Bud Blight</th>
</tr>
</thead>
</table>

**Recent Soybean Varieties of EZ and NEHZ**

<table>
<thead>
<tr>
<th>Variety</th>
<th>RSC 10-46 (EZ)</th>
<th>KDS 753 (EZ &amp; NEHZ, SZ)</th>
<th>MACS 1460 (EZ &amp; NEHZ, SZ)</th>
<th>JS 97-52 (EZ &amp; NEHZ, CZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notified / Identified</td>
<td>Identified 2016</td>
<td>Identified 2016</td>
<td>Identified 2016</td>
<td>Notified 2008</td>
</tr>
<tr>
<td>Days to Maturity</td>
<td>100-104</td>
<td>95-97 days (EZ)</td>
<td>92-98 (EZ)</td>
<td>100-103 (NEHZ)</td>
</tr>
<tr>
<td>100 Seed Weight</td>
<td>10</td>
<td>8.4</td>
<td>10.1</td>
<td>7.8</td>
</tr>
<tr>
<td>Grain Yield (Q/ha)</td>
<td>20-22</td>
<td>18-20 (EZ)</td>
<td>21-23 (EZ)</td>
<td>15-17 (NEHZ)</td>
</tr>
<tr>
<td>Oil%</td>
<td>16.2</td>
<td>16.1</td>
<td>17.6</td>
<td>-</td>
</tr>
<tr>
<td>Resistance</td>
<td>HR to Bud Blight</td>
<td>HR to Bud Blight</td>
<td>HR to Bud Blight</td>
<td>YMV, BB</td>
</tr>
<tr>
<td>Abiotic Stress</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Tolerance to drought, heat and excess moisture</td>
</tr>
</tbody>
</table>
## Central Zone

<table>
<thead>
<tr>
<th>States</th>
<th>Madhya Pradesh, Maharashtra (except western Maharashtra), Rajasthan, Gujarat</th>
</tr>
</thead>
</table>
| **Main Diseases**       | • Charcoal Rot  
                          • Anthracnose stem and pod blight  
                          • YMV |
| **Abiotic Stress**      | • Drought, Excess moisture  
                           |
| **Desirable Features in Vr** | • Early to Very Early (< 90 days) |

### Charcoal Rot

- ![Charcoal Rot Image](image1.jpg)

### Anthracnose

- ![Anthracnose Image](image2.jpg)

### Drought and Heat

- ![Drought Image](image3.jpg)
- ![Heat Image](image4.jpg)

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<table>
<thead>
<tr>
<th>Irrigated</th>
<th>Not irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>JS 97-52</td>
<td>JS 90-41</td>
</tr>
</tbody>
</table>
**Recent Soybean Varieties of Central Zone**

<table>
<thead>
<tr>
<th>Variety</th>
<th>JS 97-52</th>
<th>JS 20-34</th>
<th>JS 20-69</th>
<th>JS 20-98</th>
<th>JS 20-116</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to Maturity</td>
<td>102-105</td>
<td>85-88</td>
<td>98-103</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil%</td>
<td>-</td>
<td>20.3</td>
<td>20-22</td>
<td>19.3</td>
<td>18.5</td>
</tr>
<tr>
<td>Resistance</td>
<td>HR to CR, MR to YMV</td>
<td>HR to CR, MR to YMV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tolerance to drought and heat, Waterlogging</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Southern Zone**

<table>
<thead>
<tr>
<th>States</th>
<th>Karnataka, Andhra Pradesh, Telengana, Kerala, Tamil Nadu and Western Maharashtra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Diseases</td>
<td>Rust in areas surrounding Krishna river</td>
</tr>
<tr>
<td>Abiotic Stress</td>
<td>Drought</td>
</tr>
</tbody>
</table>

Soybean Rust
### Recent Soybean Varieties of Southern Zone

<table>
<thead>
<tr>
<th>Variety</th>
<th>MACS 1460</th>
<th>KDS 726</th>
<th>DSb 21</th>
<th>DSb 23</th>
<th>DSb 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to Maturity</td>
<td>86-88</td>
<td>88-89</td>
<td>92-95</td>
<td>93-95</td>
<td>93-95</td>
</tr>
<tr>
<td>Grain Yield (Q/ha)</td>
<td>18-20</td>
<td>23-25</td>
<td>25-30</td>
<td>20-22</td>
<td>21-23</td>
</tr>
<tr>
<td>Oil%</td>
<td>18.9</td>
<td>18.4</td>
<td>18.2</td>
<td>18.6</td>
<td>20.1</td>
</tr>
<tr>
<td>Resistance</td>
<td>MR to Rust</td>
<td>HR to Rust</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Breeder Seed Production

Breeder Seed Production: 17000 Q

- **JS 20-34**: 18%
- **JS-335**: 14%
- **JS 95-60**: 7%
- **JS 93-05**: 8%
- **JS 20-98**: 8%
- **JS 20-69**: 9%
- **JS 20-29**: 11%
- **Others**: 25%
Soybean for Food Usage

- 40% Protein and 20% Oil.
- Three limiting factors for soybean food usage
  – Presence of Trypsin Inhibitor
  – Presence of beany flavour in soy milk
  – Poor shelf life of soybean oil

Varieties with null-Kunitz Trypsin Inhibitor (KTI)

- KTI Binds with trypsin in intestine and results in poor protein digestion.
- Long term use may cause liver damage.
- Wet boiling inactivates it. Requires additional inputs.
- KTI-free lines NRC 101 and NRC 102 developed commercialized. (Ruchi and ITC)
- **Varietal conversion**: JS 97-52 (NRC 127), NRC 7, MACS 450, JS 93-05
- NRC 127, the first null-KTI variety released in 2018.
Varieties with Reduced Beany Flavor

- During processing Lipoxgenase Enzyme (Lox) reacts with PUFA and produce grassy and beany flavor.
- Wet heat inactivation: Cost and Protein insolublity.
- Varietal conversion: JS 97-52 (NRC 127), NRC 7, MACS 450, JS 93-05
- **Null lox varieties would be released in 2020.**
- Varieties combining null KTI and reduced beany flavour would be released in 2021

Varieties with High Oil Shelf Life

- Oxidation of poly unsaturated fatty acids (PUFA)

<table>
<thead>
<tr>
<th>Fatty Acid</th>
<th>Mono-unsaturated</th>
<th>PUFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oleic Acid</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>Linoleic Acid</td>
<td>55%</td>
<td>7%</td>
</tr>
<tr>
<td>Linolenic Acid</td>
<td>7%</td>
<td></td>
</tr>
</tbody>
</table>

- Requirement for high oleic soybean
- Varieties with 80% oleic acid developed in world
- **Mid Oleic variety developed in IISR would be released in 2020.**
- Breeding lines up to 60% oleic acid developed in IISR Indore
- High Oleic variety would be developed 2022.
**Vegetable Soybean**

- Immature Seed shelled from the pods picked at R6 stage of reproductive phase when 80-90% of the pod cavity is filled and the seeds and pods still green.
- Nutritious (vitamins, minerals) like green pea, chick pea, french bean.

**Vegetable Soybean Characters**

- Sweet in taste (about 8% sucrose at R6 stage)
- Large seed size (about 50g) at picking
- Mild beany flavour
- No flatulence factors (raffinose & stachyose)
- Quick-to-cook
- Protein 10%; Fat 3% on fresh weight basis
NRC 105 and Karune: Vegetable Soybean

- Trials initiated in AICRP in 2018
- NRC 105 and Karune promising entries
- Days to R6: 65-70 days
- 100 green seed weight: 60 (NRC 105) & 75 (Karune)
- Sucrose: 6.5 (Karune) amd 8.0 (NRC 105)
- Green Pod Yield: 8-10 t/ha
- Green seed yield: 4-5 t/ha

Enhancing soybean yield - Sowing and Seed rate

- Suitable production technologies developed and continuously fine tuned:
  - Optimum plating time (15th June to 5th July); Increase seed rate in delayed sowing.
  - Optimum seed rate (60-65; 65-70; 70-75 kg/ha)
  - Optimum soil moisture (at least 100 to 120 mm rains)
  - Optimum sowing depth (2-3 cm)
Seed Quality Management

- **Seed polymer coating for better emergence, growth and protection**
  - Micronutrients (Mo, B),
  - biocontrol agents (Trichoderma),
  - fungicides (carboxin, thiram)
  - insecticides (Thiomethoxam)

- **Foliar salicylic acid application**
  - Increased seed yield, resistance to foliar diseases and better shelf life.

- **High seed coat lignin lines identified**
  - Lee, MACS 450, MAUS 47, VL Soya 1, PS 1042, JS 97-52

Soybean for Mechanical Harvesting

- **X-radiography**
  - gap between seed coat and cotyledons, and the position of radicle over the cotyledons varies among varieties

- **Compact seed coat over the cotyledons reduces the risk of cracking**

- **Position of radicle is raised more over the cotyledons, the chances of damage to radicle is more**
Varietal Cafeteria Approach at IISR-Indore

Varietal Cafeteria at Farmer’s Field (2019)
### Enhancing Soybean Yield - Water Management

- Planting on Broad-bed furrows (BBF) and Ridge-Furrow system: 20% yield enhancement
- BBF seed drill (i) creates broad beds and (2) plants the soybean developed
- Provides effective drainage under high rainfall

### Micro irrigation: Technology for Future in Soybean

- 16 m ha under micro-irrigation in USA. Mainly Sprinkler and Drip.
  - 17% of micro-irrigation area by Sub-surface.
  - Shift towards sub-surface: 0.2 m, 0.4 m, 0.6 m depth.
  - Last Up to 20 years.

- Researchable issues:
  - Row distance
  - Weed management: drip lines etc
Enhancing Soybean Yield - System Approach

Soybean fits well in all traditional cropping systems.

Irrigated conditions:
(i) Soybean-wheat
(ii) Soybean-potato/Garlic/Onion-wheat

Unirrigated/Limited irrigation:
(i) Soybean-Chickpea

Soybean-based intercropping:
Soybean + Pigeonpea, Soybean + sorghum (unirrigated),
Soybean + Maize/Cotton/Sugarcane etc. (Irrigated)

Intercrop seed drill for planting of soybean with intercrops has been developed, demonstrated and validated.

Crop Residue Management: Technology Under Development

- Mulching with crop residues contribute to the conservation of soil and rainwater
- This method reduces evaporative losses, runoff from cropped fields
- Crop residues modify soil biological activity resulting in improved soil fertility and better soil physical conditions.
Site Specific Nutrient Management: Technology under Development

- We are developing Decision Support System for working out site specific nutrient requirement for soybean in collaboration with IPNI

- Addressing nutrient deficiencies which exist within field and making adjustment in nutrient application to match these locations or soil differences

Enhancing soybean yield- pest and disease management

- Insects like Stem fly, Girdle beetle, tobacco caterpillar (*Spodoptera litura*) and Bihar hairy caterpillar are causing substantial yield losses.

- Diseases like Yellow mosaic, Charcoal rot, Anthracnose, Pod Blight, Collar rot, Rust etc. too are affecting the productivity potential of the soybean crop

- For them regular scouting is required so that immediate action can be taken

- Integrated insects and disease management which include use of variety, bio-control and chemicals has been recommended
Enhancing the soybean production - mechanisation

- Soybean is a short season crop
- It provides a limited window for most of the agronomic practices that include planting time, management of weeds, control of insects and pests and harvesting
- The mechanization of agricultural operations can help in timely interventions and operations for harnessing potential productivity of the crop

- Subsoiler
- Seed cum fertilizer drills
- BBF/FIRBS seed drill
- Sweep seed drill
- Ridge fertilizer drill cum seed planter
- Intercrop seed drill

Thank you very much