Risk analysis and yield potential of rice in Bihar, India

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Introduction and background

Erratic Precipitation – Central Bihar Average:
1189 mm, CV (%): 24, Range: 690 - 1807

Implications:
Submergence, Inundation damage, Delayed rice establishment / rice fallows, Delayed rabi establishment, Crop abandonment, seedling mortality, Direct damage from heavy rain, Harvest delays in heavy soils
## Current rice cultivation practices

### Puddled vs Transplanted

<table>
<thead>
<tr>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
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- **Wheat**
  - State productivity ~2 t/ha

- **Rice (PTR)**
  - State productivity ~1 t/ha

### Reasons for low productivity

**Simulation set up**
- Calibrated and validated APSIM-ORYZA was used
- Silt loam soil, Central Bihar 40 years weather data (1970-2009)

**Nursery sowing**- started from 15 May until 15 August, nursery was sown when cumulative rainfall received was => 50 mm in 3 days during this window and there was no rice nursery sown after 15 August if conditions were not met.

**Transplanting**- rice crop was transplanted when seedlings were at least 21 days old and when surface water pond is more than 50mm- No transplanting if seedlings > 60 days

- Long duration rice variety (around 140-145d), rainfed crop, 150kg N/ha
Reasons for low productivity

Nursery sowing and transplanting probability

Vertical shaded bars are 25th-75th percentiles; whisker caps are 10th and 90th percentile and black dots are maximum and minimum values.

Seedling age probabilities

Rice yield probabilities

Grain yield (t ha⁻¹)
Reasons for low productivity

Drought stress

Low temperature stress
Variable monsoon coping up strategies- Direct seeded rice

Why DSR

- Timely rice establishment can be achieved using mechanized dry seeding on unpuddled soil
- lower irrigation requirement for crop establishment, to avoid the need for irrigation,
- Needs less labour

Risk analysis for DSR

Simulation set up

- Silt loam soil, Central Bihar 40 years weather data (1970-2009)
- To find optimum DSR sowing window-15 Sowing windows from 1 May to 7 August (weekly interval), no sowing after end of August
- Sowing rule- based on minimum soil moisture, soil workability and field accessibility (30-90% FC)
- Long duration rice variety (around 145d), rainfed crop, 150kg N/ha
### Risk analysis - sowing date

- Range of sowing dates in 40 years in each tested sowing window, for example in S3 (sowing window started from 15 May) sowing date ranged from (18 May to 10 August) with median of 31 May.
- In most of years earliest sowing opportunity starts from early June.
- Variability decreases in later sowing windows.

- More success in establishing crops in early sowing windows, 38 out of 40 years until June and less than 30 years in later sowings.
- Field accessibility is problem in later years.
- **Cut off date is by end of June.**

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<table>
<thead>
<tr>
<th>Day of year</th>
<th>Sowing window</th>
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<tbody>
<tr>
<td>100</td>
<td>S0</td>
</tr>
<tr>
<td>120</td>
<td>S1</td>
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<tr>
<td>140</td>
<td>S2</td>
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<td>260</td>
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*Note: The diagram shows the distribution of sowing dates across different sowing windows with box plots indicating the median, quartiles, and outliers.*
Risk analysis - grain yield probabilities

- high variability of grain yield, maximum GY during early to mid June sowing Windows
- Low yield during early sowing windows due to crop failure due to drought/water stress, 23 out of 40 years
- Low yield under later sowing is because of crop failure due to water stress, 40 out of 40 years

Optimum sowing window with low risk of crop failure is mid June
Risk management- supplement irrigation

Irrigation application- based on 20kPa threshold

- Higher and more stable yields
- Risk increases after late June sowing windows
- Low yields under later sowing windows- less crop years and low temperature stress risk

Total number of irrigations

- Around 7 irrigation needed for optimum sowing window
- More irrigations required for later sowing windows
Risk management - *Cont’*

**One irrigation application at early stage**

**Two irrigations - early stage + PI**
With 1 supplemental irrig, yield gain by 2 t/ha

I1 = rainfed; I2 = one early irrigation (at 20kPa); I3 = 2 irrigations (as for I2 + 1 at PI); I4 = 3 irrig (as for I3 + 1 at flowering); and I5 = irrigation whenever soil tension exceeded 20kPa.
Risk management - *Cont’*

![Crop failure years](Graph: Rainfed and Irrigation)

![Cumulative probability](Graph: Drought stress factor-grain filling)
Conclusions

- High probability of establishing crop in early June
- Optimum sowing window with low risk of crop failure (due to drought stress) is early-mid June
- Early June sowing with one supplement irrigation can double the rice yield
- Taking message to the farmers through farmers participation trials
- Decision tools to decide the sowing window for DSR in coming monsoon season- climate forecast used in model to find the low risk sowing window
Thank you for your interest!

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