**Supplementary file:**

**TABLE S1** Agro-climatic zones and their corresponding districts selected for insect and disease incidence observations during 2020 and 2022

|  |  |
| --- | --- |
| **Agro-climatic zones of Assam** | **Districts** |
| Central Brahmaputra valley (CBV) | Nagaon |
|  | Morigaon |
| Lower Brahmaputra valley (LBV) | Kamrup,  |
|  | Nalbari, |
|  | Barpeta, |
|  | Bongaigaon, |
|  | Kokrajhar, |
|  | Goalpara, |
|  | Dhubri |
| North bank plain (NBP) | Darrang |
|  | Sonitpur |
|  | Lakhimpur |
|  | Dhemaji |
| Upper Brahmaputra valley (UBV) | Sivasagar |
|  | Jorhat |
|  | Golaghat |

**TABLE S2** Best management practice (BMP) adopted for *Sali* season rice cultivation in Assam during 2020 and 2022

|  |  |
| --- | --- |
| **Component** | **Package** |
| **Recommended varieties** | Swarna-Sub 1, Ranjit-Sub 1, Bahadur-Sub1, Bina Dhan 11 |
| **Seed treatment** | Mancozeb / Captan / Carbendazim @ 2.5g/kg seed in 1L water. Soak 24 hrs, incubate Or *Trichoderma spp.*@ 10g/kg seed (over- night). Dry in shade for 30 mins after treatment |
| **Nursery raising** | Seed rate: 40 kg/ha- Nursery size: 750–1000 m² per ha- Bed size: 10 m × 1.25 m with 30 cm drainage- Irrigation: Maintain saturated soil; 2–3 cm water before uprooting- Plant protection: As per standard practice |
| **Seedling treatment** | Chlorpyriphos 2 ml/L + urea 10g/L; dip roots 3 hrs - Or: Apply carbofuran @3g/m², Diazinon 1g/m², or spray Chlorpyriphos 20 EC @ 2 ml/L 5–7 days before uprooting |
| **Nursery fertilizer** | Urea – 5.6 kg, DAP – 2.2 kg, MOP – 3.2 kg, and 2 t FYM per 1000 m² nursery |
| **Main field preparation** | * Begin ploughing 21 days before transplanting- 4–5 times with deshi plough or
* 1 mouldboard plough + 1–2 puddler passes
* Apply compost uniformly and mix
* Level and repair bunds
 |
| **Transplanting** | * Age: 30–35 days
* Spacing: 20 × 15 cm (8 × 6 inches)
* Density: 2–3 seedlings/hill
* - Depth: 4–5 cm
 |
| **Fertilizer management** | * Basal: Urea – 26 kg, DAP – 45 kg, MOP – 65 kg, Zn – 25 kg/ha
* Tillering: Urea – 45 kg/ha
* Panicle initiation: Urea – 45 kg/ha
* After flood (5–7 days): Urea – 45 kg + MOP – 33 kg/ha
 |
| **Weed management** | * **Hand Weeding**: 3rd week and 6th week after transplanting
* **PE Herbicides** (2–3 DAT): Anilofos 30% EC @ 1330 ml/ha or Pretilachlor 50% EC @ 1500 ml/ha with 150 kg sand or splash in 3–5 cm standing water
* **POE Herbicides**

 (20–25 DAT):  • Bispyribac-sodium 10% EC @ 250 ml/ha (grasses, sedges)  • 2-4 DE 38% EC @ 1500 ml/ha or Ethoxysulfuron 15% WDG @ 125 g/ha (broadleaf, sedges)  • Pyrazosulfuron 10% WP @ 250 g/ha (sedges, broadleaf)  • Combine if mixed flora  • Spray at 2–4 leaf stage with moist soil, no standing water  • Use flat-fan multi-nozzle boom; 500 L/ha spray volume |
| **Irrigation** | Apply 5 cm water 3 days after ponding water disappears |
| **Plant protection** | As per state recommendations |
| **Harvest and post-harvest** | * Harvest at 80–85% grain straw-color (physiological maturity)
* Avoid field drying; keep panicles dry
* Thresh and dry within 2 days
* Clean and store in cool, dry place
 |

**TABLE S3 Total number of sampling plots and points across the four agro-climatic zones of Assam**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Agro-climatic zones of Assam** | **Districts** | **Genotype** | **2020** | **2022** |
| Central Brahmaputra Valley (CBV)        | Nagaon    | Bahadur Sub1 | 2 | 1 |
| Bina dhan 11 | 2 | 2 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 2 | 2 |
| Morigaon    | Bahadur Sub1 | 2 | 1 |
| Bina dhan 11 | 1 | 1 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 2 | 1 |
| Lower Brahmaputra Valley (LBV)                            | Kamrup,     | Bahadur Sub1 | 2 | 2 |
| Bina dhan 11 | 3 | 3 |
| Ranjit Sub1 | 1 | 0 |
| Swarna Sub1 | 1 | 1 |
| Nalbari,    | Bahadur Sub1 | 2 | 2 |
| Bina dhan 11 | 2 | 0 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 1 | 1 |
| Barpeta,    | Bahadur Sub1 | 2 | 1 |
| Bina dhan 11 | 1 | 1 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 1 | 1 |
| Bongaigaon,    | Bahadur Sub1 | 2 | 1 |
| Bina dhan 11 | 2 | 2 |
| Ranjit Sub1 | 1 | 3 |
| Swarna Sub1 | 1 | 1 |
| Kokrajhar,    | Bahadur Sub1 | 2 | 2 |
| Bina dhan 11 | 2 | 2 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 1 | 3 |
| Goalpara,    | Bahadur Sub1 | 1 | 1 |
| Bina dhan 11 | 2 | 2 |
| Ranjit Sub1 | 2 | 2 |
| Swarna Sub1 | 1 | 1 |
| Dhubri    | Bahadur Sub1 | 1 | 1 |
| Bina dhan 11 | 1 | 1 |
| Ranjit Sub1 | 2 | 2 |
| Swarna Sub1 | 1 | 1 |
| North Bank Plain (NBP)                | Darrang    | Bahadur Sub1 | 2 | 2 |
| Bina dhan 11 | 1 | 1 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 2 | 2 |
| Sonitpur    | Bahadur Sub1 | 1 | 1 |
| Bina dhan 11 | 1 | 1 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 1 | 1 |
| Lakhimpur    | Bahadur Sub1 | 1 | 1 |
| Bina dhan 11 | 2 | 1 |
| Ranjit Sub1 | 1 | 2 |
| Swarna Sub1 | 2 | 1 |
| Dhemaji    | Bahadur Sub1 | 2 | 2 |
| Bina dhan 11 | 2 | 1 |
| Ranjit Sub1 | 1 | 3 |
| Swarna Sub1 | 1 | 1 |
| Upper Brahmaputra Valley (UBV)            | Sivasagar    | Bahadur Sub1 | 1 | 2 |
| Bina dhan 11 | 2 | 2 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 2 | 2 |
| Jorhat    | Bahadur Sub1 | 2 | 2 |
| Bina dhan 11 | 2 | 2 |
| Ranjit Sub1 | 1 | 2 |
| Swarna Sub1 | 2 | 2 |
| Golaghat    | Bahadur Sub1 | 1 | 1 |
| Bina dhan 11 | 2 | 1 |
| Ranjit Sub1 | 1 | 1 |
| Swarna Sub1 | 2 | 1 |
| Total sampling plots (each 0.1ha) |  |  | 95 | 91 |
| Each sampling plot has ten spots |  |  | 95\*10 | 91\*10 |
| **Total sampling spots** |  |  | **950** | **910** |

**TABLE S4** Major insect pests and diseases of rice and their damage symptoms and stage of occurrence

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Common name** | **Scientific name** | **Damage symptoms** | **Stage of occurrence** |
| **Insects** | Yellow Stem Borer (YSB) | *Scirpophaga incertulas* | Deadheart (young stage) and whitehead (panicle stage) | Maximum at tillering to panicle  |
|  | Brown Planthopper (BPH) | *Nilaparvata lugens* | Wilting and drying of plants commonly known as hopper burn damage, transmits rice grassy stunt and ragged stunt viruses | All stages |
|  | Green Leafhopper (GLH) | *Nephotettix virescens* | Transmits tungro virus; stunted, yellow plants | Maximum at vegetative stage |
|  | Gall midge | *Orseolia oryzae* | Hollow cavity or tubular gall at the infested base and the gall formed is a slivery white hollow tube like onion leaf | Tillering |
|  | Leaf folder | *Cnaphalocrocis medinalis* | Tubular folded leaves and presence of faecal matter inside the folds | Seedling to tillering |
|  | Rice hispa | *Dicladispa armigera* | Scraped upper leaf surface; white streaks parallel to the midrib | Vegetative stage |
|  | Gundhi bug | *Leptocorisa acuta* | Feeding on developing grains; brown spots and chaffy grains, foul smell | Grain filling stage |
|  | Swarming caterpillar | *Spodoptera mauritia* | Mass defoliation; skeletonized leaves | Seedling to tillering stage |
|  | Caseworm | *Nymphula depunctalis* | Floating leaf cases; whitish leaves with papery upper epidermis | Tillering stage |
|  | Armyworm | *Mythimna separata* | Attacks ear head during panicle initiation stage | Panicle initiation stage |
| **Diseases** | Rice blast | *Magnaporthe oryzae* | Initial symptoms as whtite to gray-green lesions with dark green borders; Older lesions are elliptical or spindle shaped | All stages, severe at panicle initiation |
|  | Bacterial Leaf Blight (BLB) | *Xanthomonas oryzae* pv. *oryzae* | Water-soaked lesions turning yellow and spreading from leaf tip | All stages |
|  | Sheath blight | *Rhizoctonia solani* | Oval or ellipsoidal greenish gray lesions | Tillering to milk stage |
|  | Brown spot | *Bipolaris oryzae* | Small circular yellow brown to brown circular spots on leaves and grains | All stages but crucial during tillering to ripening stage |
|  | Sheath rot | *Sarocladium oryzae* | Reddish-brown lesions on the upper leaf sheath; panicle emergence affected | All stages critical at tillering to panicle emergence |
|  | False smut | *Ustilaginoidea virens* | Greenish to orange color spore balls replacing grains in panicles | Grain filling |
|  | Bakanae disease | *Gibberella fujikuroi* | Elongated, pale, and thin seedlings and they often die early | Seedling stage |

**TABLE S5** Weather variables across agro-climatic zones of Assam during the *Sali* season (specifically for months July-Nov)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Agro-climatic zone** | **Central Brahmaputra Valley** | **North Bank Plain Zone** | **Lower Brahmaputra Valley Zone** | **Upper Brahmaputra Valley Zone** |
| Year | 2020 | 2022 | Average 1991-2020 | 2020 | 2022 | Average 1991-2020 | 2020 | 2022 | Average 1991-2020 | 2020 | 2022 | Average 1991-2020 |
| Mean temperature (℃)  | 26.8 | 26.6 | 26.2 | 26.6 | 25.8 | 26.1 | 24.8 | 25.6 | 25.2 | 24.9 | 24.7 | 23.7 |
| Mean relative humidity (RH) (%) | 83.6 | 82.4 | 80.9 | 84.9 | 82.7 | 82.4 | 86.6 | 83.4 | 83.9 | 84.1 | 83.6 | 81.9 |
| Cumulative precipitation (mm) | 776 | 521 | 852 | 904 | 596 | 938 | 1301 | 713 | 1078 | 1400 | 1072 | 1151 |

The data presented in the table were derived from the NASA POWER (Prediction of Worldwide Energy Resources) database (<https://power.larc.nasa.gov>). The data represent averages extracted for representative coordinates within each agro-climatic zone and were used for comparison only, and not for statistical analysis.

**TABLE** S6 Mean incidence and standard error values of insect and diseases observed across different agro-climatic zones, rice varieties, and year

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Zone** | **Varieties** | **Year** | **Percent *Scirpophaga incertulas* incidence** | **Percent *Cnaphalocrocis medinalis* incidence**  | **Percent *Leptocorisa acuta* incidence**  | **Percent*****Magnaporthe oryzae* incidence** | **Percent*****Bipolaris oryzae* incidence** |
| CBV | Bahadur Sub1 | 2020 | 17.5 ± 4.50 | 0.00 ± 0.00 | 18 ± 1.00 | 1.50 ± 1.50 | 0.00 ± 0.00 |
| LBV | Bahadur Sub1 | 2020 | 3.42 ± 2.04 | 14.88 ± 5.17 | 4.42 ± 1.51 | 3.42 ± 2.73 | 9.00 ± 4.32 |
| NBP | Bahadur Sub1 | 2020 | 2.67 ± 0.33 | 3.50 ± 0.76 | 3.17 ± 0.91 | 1.63 ± 0.33 | 1.83 ± 0.75 |
| UBV | Bahadur Sub1 | 2020 | 4.22 ± 4.22 | 3.20 ± 3.20 | 0.60 ± 0.60 | 0.00 ± 0.00 | 0.40 ± 0.40 |
| LBV | Bahadur Sub1 | 2022 | 2.25 ± 0.39 | 1.97 ± 0.23 | 2.31 ± 0.26 | 0.40 ± 0.18 | 2.53 ± 0.24 |
| NBP | Bahadur Sub1 | 2022 | 0.80 ± 0.23 | 1.20 ± 0.37 | 1.00 ± 0.37 | 0.07 ± 0.07 | 1.13 ± 0.37 |
| UBV | Bahadur Sub1 | 2022 | 0.21 ± 0.10 | 0.00 ± 0.00 | 0.21 ± 0.10 | 3.16 ± 1.44 | 8.16 ± 1.44 |
| CBV | Bina Dhan 11 | 2020 | 6.00 ± 6.00 | 27.50 ± 27.50 | 12.50 ± 2.50 | 4.50 ± 0.50 | 5.00 ± 5.00 |
| LBV | Bina Dhan 11 | 2020 | 5.56 ± 3.67 | 13.94 ± 6.13 | 7.22 ± 2.76 | 0.72 ± 0.56 | 8.89 ± 5.94 |
| NBP | Bina Dhan 11 | 2020 | 1.17 ± 0.65 | 3.17 ± 0.40 | 4.17 ± 0.91 | 1.17 ± 0.40 | 2.25 ± 0.36 |
| UBV | Bina Dhan 11 | 2020 | 3.00 ± 3.00 | 4.75 ± 4.75 | 8.25 ± 1.75 | 0.00 ± 0.00 | 0.75 ± 0.75 |
| CBV | Bina Dhan 11 | 2022 | 9.37 ± 0.39 | 0.00 ± 0.00 | 11.27 ± 0.49 | 11.10 ± 0.80  | 5.17 ± 1.22 |
| LBV | Bina Dhan 11 | 2022 | 3.03 ± 0.36 | 3.00 ±0.20 | 3.24 ± 0.26 | 0.46 ± 0.15 | 3.33 ± 0.25 |
| NBP | Bina Dhan 11 | 2022 | 0.79 ± 0.16 | 0.57 ± 0.14 | 0.30 ± 0.13 | 0.60 ± 0.16 | 1.09 ± 0.20 |
| UBV | Bina Dhan 11 | 2022 | 0.05 ± 0.01 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 2.73 ± 0.54 |
| CBV | Ranjit Sub1 | 2020 | 9.00 ± 4.73 | 23.33 ± 23.33 | 15.00 ± 1.15 | 3.00 ± 1.53 | 5.00 ± 5.00 |
| LBV | Ranjit Sub1 | 2020 | 5.50 ± 2.77 | 17.63 ± 5.98 | 5.67 ± 1.92 | 7.83 ± 3.31 | 13.50 ± 3.54 |
| NBP | Ranjit Sub1 | 2020 | 1.83 ± 0.75 | 4.50 ± 0.67 | 3.50 ± 0.81 | 1.00 ± 0.00 | 2.17 ± 0.40 |
| UBV | Ranjit Sub1 | 2020 | 3.23 ± 3.23 | 2.23 ± 2.23 | 1.33 ± 1.33 | 0.33 ± 0.33 | 2.33 ± 2.33 |
| CBV | Ranjit Sub1 | 2022 | 12.42 ± 0.66 | 2.29 ± 1.13 | 9.83 ± 1.10 | 1.38 ± 0.82 | 10.00 ± 0.89  |
| LBV | Ranjit Sub1 | 2022 | 3.48 ± 0.22 | 3.38 ± 0.10 | 3.58 ± 0.15 | 0.50 ± 0.09 | 3.76 ± 0.17 |
| NBP | Ranjit Sub1 | 2022 | 2.14 ± 0.15 | 1.48 ± 0.13 | 1.65 ± 0.15 | 0.23 ± 0.05 | 1.95 ± 0.14 |
| UBV | Ranjit Sub1 | 2022 | 4.66 ± 0.44 | 0.00 ± 0.00 | 0.19 ± 0.04 | 2.93 ± 0.20 | 2.25 ± 0.20 |
| CBV | Swarna Sub1 | 2020 | 20.00 ± 4.00 | 0.00 ± 0.00 | 23.50 ± 2.50 | 2.50 ± 2.50 | 0.00 ± 0.00 |
| LBV | Swarna Sub1 | 2020 | 4.20 ± 2.37 | 11.30 ± 3.92 | 4.30 ± 1.41 | 3.95 ± 2.98 | 6.82 ± 3.41 |
| NBP | Swarna Sub1 | 2020 | 2.67 ± 0.80 | 3.83 ± 0.17 | 3.17 ± 0.54 | 0.87 ± 0.18 | 1.50 ± 0.50  |
| UBV | Swarna Sub1 | 2020 | 4.75 ± 4.75 | 3.50 ± 3.50 | 1.25 ± 1.25 | 0.00 ± 0.00 | 4.00 ± 4.00 |
| CBV | Swarna Sub1 | 2022 | 9.44 ± 1.67 | 5.56 ± 2.82 | 6.56 ± 1.67 | 5.78 ± 1.19 | 12.44 ± 1.34 |
| LBV | Swarna Sub1 | 2022 | 3.36 ± 0.37 | 2.99 ± 0.18 | 3.49 ± 0.31 | 0.87 ± 0.19 | 3.26 ± 0.29 |
| NBP | Swarna Sub1 | 2022 | 2.09 ± 0.28 | 2.07 ± 0.35 | 1.89 ± 0.37 | 0.58 ± 0.17 | 2.71 ± 0.34 |
| UBV | Swarna Sub1 | 2022 | 1.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 |

CBV- Central Brahmaputra Valley; LBV- Lower Brahmaputra Valley; NBP- North Bank Plain; UBV- Upper Brahmaputra Valley



**FIGURE S1** Percentage of insects and disease incidence that were observed across the four Sub1 rice varieties (Bahadur-Sub1, Bina dhan11, Ranjit-Sub1, Swarna-Sub1) grown across agro-climatic zones of Assam

FS- False smut *(Ustilaginoidea virens*), BLB- bacterial leaf blight (*Xanthomonas oryzae*), SR- sheath rot (Sarocladium oryzae), SB- sheath blight *(Rhizoctonia solani)*, BPH- brown plant hopper *(Nilaparvata lugens)* , SC- swarming caterpillar (*Spodoptera Mauritia)*, LF- leaf folder (*Cnaphalocrocis medinalis*), BS- brown spot (*Bipolaris oryzae*), blast- Magnaporthe oryzae, GB- gundhi bug (*Leptocorisa acuta),* DH- dead heart (stem borer- *Scirpophaga incertulas).*



**FIGURE S2** Cumulative precipitation (mm) across agro climatic zones of Assam during *Sali* season (July-Nov)