# Introduction

Diseases naturally occur as a part of any plant ecosystem. In human managed cropping systems, the environment that is created by the farmer influences disease development as well as the natural environment. Some diseases are favoured by cool, wet weather while others are more favoured by warm and wet weather. In Indian rice there are many diseases that affect rice causing yield losses. We focused on three major diseases in most tropical and sub-tropical rice growing areas are bacterial blight, caused by *Xanthomonas oryzae* pv. *oryzae*; brown spot, caused by *Cochliobolus miyabeanus*; and leaf blast, caused by *Magnaporthe oryzae*.

# Methods

To estimate the relative risk of three major rice diseases in India, the EPIRICE model (Savary et al. 2012; Hijmans et al. 2015) was used with interpolated Global Summary of the Day (GSOD) data at 15 arc-minutes (Sparks unpublished) for the years of 2001 to 2008. The statistical software, R (R Core Team 2015) package raster (Hijmans 2015) was used to extract the resulting area under the disease progress curves by state using FAO’s Global Administrative Unit Layers (GAUL) and were classified according to relative risk. Results were compared with district level maps that had been vetted by expert Indian scientists and found to be suitable.

# Results

Bacterial leaf blight risk is most severe in the southwest and north east. The disease most commonly occurs in areas of high humidity and high temperatures. High rates of fertilization will favor disease development. Bacterial blight can be controlled using resistant varieties, proper fertilisation rates and keep the fields clean of weeds and after the season, stubble, to reduce sources of the bacteria capable of causing infection.

Brown spot risk follows a similar pattern as bacterial blight. The disease is also favoured by high temperatures but rather rice stressed by drought or low fertility rates favour disease development. Thus rainfed rice is often afflicted with this disease. For control, use varieties that are known to be resistant, apply proper fertiliser rates and use certified or good seeds along with seed treatments as the disease is seedbourne.

Leaf blast risk is less severe than the other two diseases examined here. This disease tends to be most severe in rainfed rice areas and upland areas where there are cooler temperatures and greater day-night time temperature differences that cause dew formation on the leaf. The risk of this diease is the highest in far northeast India but risk is also elevated in the mountainous regions of the southwest and far north. Leaf blast can be devsatating, to control it, plant after the start of the rainy season, if possible and use proper fertiliser rates. Do not overfertilise with nitrogen, split applications can help reduce the risk.

# References

R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.

Robert Hijmans, Jorrel Aunario, Adam Sparks (2015) cropsim: Functions for use in the dynamic & mechanistic simulation of crop (plant) growth and development, and of plant diseases; and to implement these functions in a number of models. R package version 0.2.0-5. <https://r-forge.r-project.org/projects/cropsim/>

Robert J. Hijmans (2015). raster: Geographic Data Analysis and Modeling. R package version 2.4-20. <http://CRAN.R-project.org/package=raster>

Table 1: Relative risk rank of bacterial blight, brown spot and leaf blast diseases in Indian states

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| --- | --- | --- | --- |
| **ADM1 NAME** | **Bacterial Blight** | **Brown Spot** | **Leaf Blast** |
| Andaman and Nicobar | NA | NA | NA |
| Andhra Pradesh | Moderately Severe | Moderate | Low |
| Assam | Severe | Moderately Severe | Low |
| Delhi | Low | Low | Low |
| Goa | Severe | Moderate | Low |
| Gujarat | Low | Low | Low |
| Haryana | Moderately Low | Low | Low |
| Himachal Pradesh | Low | Low | Moderately Low |
| Karnataka | Moderately Severe | Moderate | Moderately Low |
| Kerala | Severe | Severe | Moderately Low |
| Lakshadweep | NA | NA | NA |
| Maharashtra | Moderately Severe | Low | Moderately Low |
| Manipur | Moderately Severe | Moderately Severe | Moderately Severe |
| Meghalaya | Severe | Moderately Severe | Moderate |
| Mizoram | Severe | Severe | Moderate |
| Nagaland | Moderately Severe | Moderate | Moderately Severe |
| Orissa | Severe | Severe | Low |
| Punjab | Moderate | Low | Low |
| Rajasthan | Moderately Low | Low | Low |
| Sikkim | NA | Low | Severe |
| Tamil Nadu | Moderate | Moderately Low | Low |
| Tripura | Severe | Severe | Low |
| West Bengal | Severe | Moderate | Low |
| Arunachal Pradesh | Moderate | Low | Severe |
| Bihar | Moderately Severe | Moderately Low | Low |
| Chandigarh | Moderately Severe | Low | Low |
| Chhattisgarh | Moderately Severe | Moderately Low | Low |
| Dadra and Nagar Haveli | NA | NA | NA |
| Daman and Diu | Moderate | Low | Low |
| Jharkhand | Severe | Moderately Low | Low |
| Madhya Pradesh | Moderately Severe | Low | Low |
| Puducherry | Severe | NA | Low |
| Uttar Pradesh | Moderately Severe | Low | Low |
| Uttarakhand | Low | Low | Moderately Severe |