Algorithm Logic Document

For Brazil

Product	Product Description	Type of crop applicable
Stress Buster	Aboitic stress , allows the plants to tolerate and quickly overcome the stress, preserving yield under Cold, Heat, drought, wounding	Soybean, Corn, Cotton
Nutrient Booster	Increases the efficiency of plants nutrient use.	Soybean, Corn
Yield Booster	guarantees maximum productivity	Soybean, corn, cotton

For India

Product	Product Description	Type of crop applicable
Stress Buster	Abiotic stress , allows the plants to tolerate and quickly overcome the stress, preserving yield under Cold, Heat, drought, wounding	Rice, Wheat & Cotton
Yield Booster	guarantees maximum productivity	Rice, Wheat & Cotton

Algorithms logic

Stress Buster

1.Day time heat stress risk (algorithm based on maximum temperatures)

Each crop has specific cardinal temperatures that define limits of growth and development.

The scale will be from 0 to 9, zero means no stress, and 9 is the maximum diurnal heat stress

Equation

Diurnal heat stress = 0 for (TMAX =< TMaxOptimum)

Diurnal heat stress = 9 * [(TMAX - TMaxOptimum) / (TMaxLimit - TMaxOptimum)] for (TMaxOptimum < TMAX < TMaxLimit)

Diurnal heat stress = 9 for (TMAX => TmaxLimit)

Where,

TMAX = daily maximum air temperature (ºC)

TMaxOptimum is defined as the maximum temperature for optimum growth

TmaxLimit is defined as the temperature when the crop does not grow anymore (zero growth)

Crop	TMaxOptimum	TmaxLimit
Soybean	32	45
Corn	33	44
Cotton	32	38
Rice	32	38
Wheat	25	32

Diurnal heat stress for soyabean = 9*[(TMAX - 32) / (45- 32)]

2.Nighttime heat stress risk (algorithm based on minimum temperatures)

Warm night temperatures during the flowering and other growth stages lead to yield reductions due to a high rate of cellular respiration and accelerated phenological development.

The scale will be from 0 to 9, zero means no stress, and 9 is the maximum diurnal Night stress

Nighttime heat stress = 0 for (TMIN < TMinOptimum).

Nighttime heat stress = 9*[(TMIN - TMinOptimum) / (TMinLimit - TMinOptimum)] for (TMinOptimum ≤ TMIN < TMi

Nighttime heat stress = 9 for (TMIN ≥ TMinLimit).

Where,

TMIN = daily minimum air temperature (°C) (Variable obtained from the WTH file).

TMinOptimum is defined as the maximum daily minimum temperature for optimum growth.

TMinLimit is the minimum temperature at which the crop is significantly affected by night heat stress.

Crop	TMinOptimum	TminLimit
Soybean	22	28
Corn	22	28
Cotton	20	25
Rice	22	28

Wheat	15	20

Diurnal Night stress for soyabean = 9*[(TMAX - 32) / (45- 32)]

- If the “Nighttime heat stress” is >9, then use 9.

3.Frost stress (algorithm based on minimum temperatures)

Freezing temperatures prior to maturity can result in yield losses. A killing freeze occurs when temperatures dip to zero degrees Celsius for four hours or 2.2 degrees Celsius for minutes. A killing freeze can still happen with temperatures above zero degrees Celcius, especially in low and unprotected areas when there’s no wind.

Calculate frost stress when TMIN is < = 4 ^{o}C. If TMIN is more than 4 ^{o}C, then there is no frost, frost is zero.

Frost stress = 0 for (TMIN >= TMinNoFrost)

Frost stress = 9*[ABS(TMIN - TMinNoFrost) / ABS(TminFrost - TMinNoFrost)] for (TMIN < TMinNoFrost)

Frost stress = 9 for (TMIN =< TMinFrost)

Crop	TMinNoFrost	TminFrost
Soyabean	4	-3
Corn	4	-3
Cotton	4	-3
Rice	NA	NA
Wheat	NA	NA

Where,

TMIN= daily minimum air temperature (^{o}C)

TMinNoFrost = is the minimum temperature at which the crop is not affected by Frost stress.

TminFrost = is the minimum temperature at which the crop is significantly affected by Frost stress.

The final equation with the temperatures listed above is,

Frost stress = 9*[ABS(TMIN - 4) / ABS(-3 - 4)]

4.Drought risk

A simplified drought index (DI) can be expressed as:

DI = (P - E) + SM / T

Where:

- (P) = Cumulative rainfall (mm) over a specific period (e.g., growing season).

- (E) = Cumulative evaporation (mm) over the same period. (e.g., growing season).

- (SM) = Soil moisture content (mm or %). (average over the growing season)

- (T) = Average temperature (°C) over the period.

- Rainfall (P):
    - Rainfall is the primary source of water for crops. Insufficient rainfall leads to drought conditions.
- Evaporation (E):
    - Evaporation represents water loss from the soil and crop surface. High evaporation rates increase water stress.
    - Use evapotranspiration (ET) data.

- Soil Moisture (SM):
    - Soil moisture indicates the available water in the root zone. Low soil moisture levels indicate drought stress.
    - Measure soil moisture as volumetric water content (VWC) or as a percentage.

- Temperature (T):
    - High temperatures increase evaporation and transpiration rates, exacerbating drought conditions.
    - Use average daily
- Interpretation of the Drought Index (DI)
    - *DI > 1: No risk

- *DI = 1: Medum risk
- DI < 1: Medum risk

Yield Booster

5. Yield risk

For Yield risk, you can have two approaches

1. Gather the yield from the grower for past years and identify if the field is at risk and recommend the biosimulate to increase the yield.

2. Compute the yield risk using the formulae below and recommend the biosimulate.

Yield risk can be calculated based on nitrogen, temperature, rainfall, and the soil's pH. The duration of the growing seasons will be different for different crops.

The simple formula is

YR=w1·(GDD− GDD_opt)2+w2·(P−Popt)2+w3·(pH−pHopt)2+w4·(N−Nopt)2

Where:

- (GDD) = Actual Growing Degree Days

- (GDD_opt) = Optimal Growing Degree Days

- (P) = Actual rainfall (mm)

- (P_opt) = Optimal rainfall for growth (mm)

- (pH) = Actual soil pH

- (pH_opt) = Optimal soil pH- (N) = Actual available nitrogen in the soil (kg/ha)

- (N_opt) = Optimal nitrogen availability for soybean (kg/ha)

- (w_1, w_2, w_3, w_4 \) = Weighting factors for each variable, reflecting their relative importance.

Example weighting factors: Here's an example of how weighting factors might be distributed:

- w1 (GDD): 0.3 w2 (Precipitation): 0.3 w3 (pH): 0.2 w4 (Nitrogen): 0.2
- This distribution suggests that GDD and precipitation have a slightly higher impact on yield risk than pH and nitrogen levels

The optimal values for the crop are given below

Crop Name	GDD optimal	Precipitation Optimal	pH optimal	N Optimal
Soyabean	2400-3000	450-700 mm	6.0-6.8	0-0.026 g/kg
Corn	2700-3100	500-800 mm	6.0-6.8	0.077-0.154 g/kg
Cotton	2200-2600	700-1300 mm	6.0-6.5	0.051-0.092 g/kg
Rice	2000-2500	1000-1500 mm	5.5-6.5	0.051-0.103 g/kg
Wheat	2000-2500	1000-1500 mm	5.5-6.5	0.051-0.103 g/kg

Growing Degree Days (GDD) is:

GDD = [(Tmax + Tmin) / 2] - Tbase

Where:

Tmax = Maximum daily temperature

Tmin = Minimum daily temperature

Tbase = Base temperature (threshold for plant growth)

Nutrient Booster

6. Nitrogen stress

The biosimulants are recommended for improving nutrient uptake and efficiency and based on the NUE (Nitrogen Use Efficiency (NUE).

Based on the projected yield and taking the nitrogen inputs and rainfall and soil moisture, we can predict whether we need biosimulants.

Generally, NUE ranges can be categorized as follows:

High NUE: > 40 kg yield / kg N applied

Moderate NUE: 20-40 kg yield / kg N applied

Low NUE: < 20 kg yield / kg N applied

For moderate and Low NUE, we recommend Biosimilars..

To compute NUE, this is a formula.

NUE = (Crop yield / Nitrogen applied) * (Rainfall factor) * (Soil moisture factor)

Crop Yield – Projected crop yield kg/ha

Nitrogen applied – Nitrogen applied kg/ha

1. Rainfall factor (RF): RF = 1 if rainfall is optimal RF < 1 if rainfall is below optimal (drought conditions) RF > 1 if rainfall is above optimal (potential leaching)

Example calculation: If optimal rainfall is 600 mm and actual rainfall is 500 mm: RF = 500 / 600 = 0.83

2. Soil moisture factor (SMF): SMF = 1 if soil moisture is optimal SMF < 1 if soil is too dry SMF > 1 if soil is too wet (potential denitrification)

Example calculation: If optimal soil moisture is 25% and actual soil moisture is 20%: SMF = 20 / 25 = 0.8

The Optimal values for soil moisture and precipitation are given below

Crop Name	Soil moisture optimal	Precipitation Optimal
Soyabean	50-70%	450-700 mm
Corn	50-70%	500-800 mm
Cotton	50-70%	700-1300 mm
Rice	80%	1000-1500 mm
Wheat	80%	1000-1500 mm

7. Phosphorus stress

The biosimulants are recommended for improving nutrient uptake and efficiency and based on the PUE (Phosphorus Use Efficiency (PUE).

PUE = (Yield / Papplied) * SF

Where:

PUE = Phosphorus Use Efficiency (tonnes of crop per kg P applied, adjusted for soil factors)

Yield = Crop yield (tonnes/ha)

Papplied = Phosphorus applied as fertilizer (kg P/ha)

SF = Soil Factor (a value between 0 and 1)

Based on the projected yield and taking the phosphrous inputs and rainfall and soil moisture,pH and organic matter we can predict whether we need biosimulants.

Generally, PUE ranges can be categorized as follows:

Low PUE < 0.05

Moderate PUE < 0.05-0.10

Good PUE < 0.10-0.15

Excellent PUE > 0.15

For moderate and Low PUE, we recommend Biosimilars.

The Soil Factor (SF) is calculated as follows:

SF = (pHf + SMf + RFf) / 4

Where: pHf = pH factor (0-1)

SMf = Soil Moisture factor (0-1)

RFf = Rainfall factor (0-1)

Each factor is scored on a scale of 0 to 1, where 1 represents optimal conditions for phosphorus availability and uptake

1. pH factor (pHf) : RF =1 if pH is optimal

   Exanple calculation : If optimal pH is 5 and actual Ph is 6 then RF = 5/6 = 0.8

2. Rainfall factor (RF): RF = 1 if rainfall is optimal RF < 1 if rainfall is below optimal (drought conditions) RF > 1 if rainfall is above optimal (potential leaching)

Example calculation: If optimal rainfall is 600 mm and actual rainfall is 500 mm: RF = 500 / 600 = 0.83

3. Soil moisture factor (SMF): SMF = 1 if soil moisture is optimal SMF < 1 if soil is too dry SMF > 1 if soil is too wet (potential denitrification)

Example calculation: If optimal soil moisture is 25% and actual soil moisture is 20%: SMF = 20 / 25 = 0.8

The Optimal values for soil moisture and precipitation and pH are given below

Crop Name	Soil moisture optimal	Precipitation Optimal	pH optimal
Soyabean	50-70%	450-700 mm	6.0-7.0
Corn	50-70%	500-800 mm	6.0-7.0
Cotton	50-70%	700-1300 mm	6.0-6.5
Rice	80%	1000-1500 mm	5.5-6.5
Wheat	80%	1000-1500 mm	6.0-7.0