

# 2,3-Butanediol



**NON-TOXIC  
ECO-FRIENDLY  
MATERIAL WITH  
VARIOUS  
FUNCTIONS,  
2,3-BUTANEDIOL**



# OUR DISCOVERY AND PRODUCTION

## BIRTH OF 2,3-BUTANEDIOL



## 100% BORN OUT OF NATURAL INGREDIENT

· 2,3-Butanediol, 100% natural substance found anywhere around us including soil, animals and food, is a product **GS** Caltex produces by an eco-friendly method that adheres to the principle of preserving the natural ecosystem.



**FERMENTED AND NATURAL FOOD**

wine, vinegar, kimchi, fermented sauce, honey, raspberry



**ANIMAL**

bee, fish, human body



**PLANT AND SOIL**





## DEDICATED TO TRUE SUSTAINABILITY

### BIO-BASED PRODUCTION

- 2,3-Butanediol is produced by eco-friendly natural fermentation without chemical synthesis.
- **GS** Caltex is the only company that is mass-producing 2,3-Butanediol with a 100% bio-based production process in the world.

### THREE FREES

#### 1 \*GMO-FREE Biomass

2,3-Butanediol uses Non-GMO biomass (cassava, sugar cane) as feedstock.

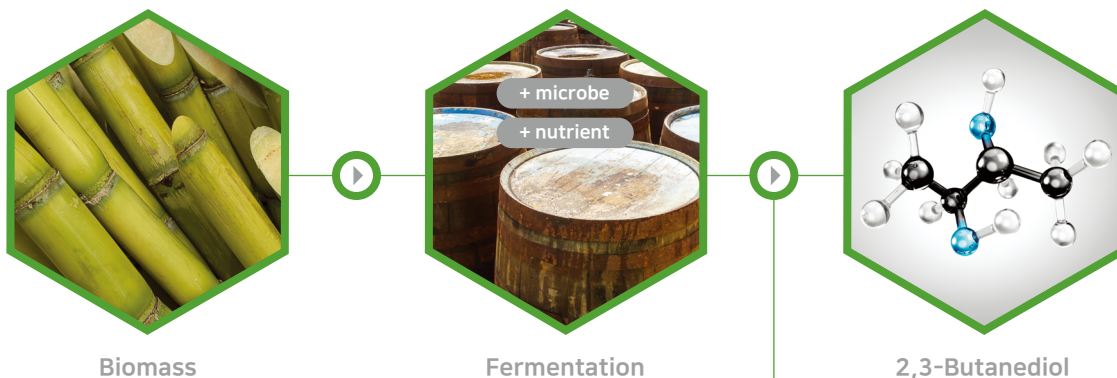
#### 2 \*LMO-FREE Microorganism

**GS** Caltex produces 2,3-Butanediol using microorganisms that have not been genetically modified based on innovative bioengineering technology.

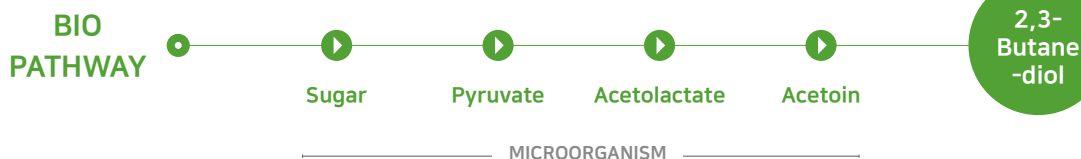
#### 3 TOXIC CHEMICAL -FREE

The production process only uses physical characteristics of 2,3-Butanediol to separate and purify, without applying any harmful chemicals.

### PRODUCTION PROCESS



### 2,3-BUTANEDIOL PRODUCED THROUGH A NON-TOXIC NATURAL PATHWAY

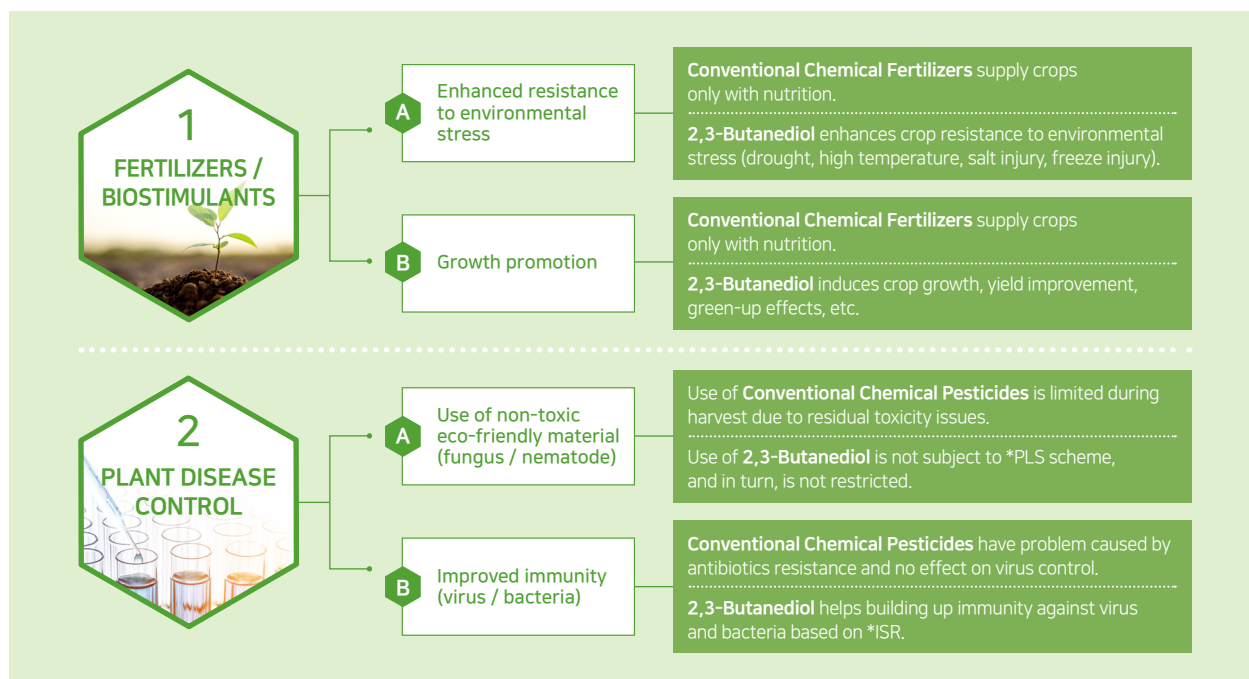


\* GMO : Genetically Modified Organism

\* LMO : Living Modified Organism

# EXCLUSIVE FEATURES OF 2,3-BUTANEDIOL

## DIFFERENTIATION OF 2,3-BUTANEDIOL



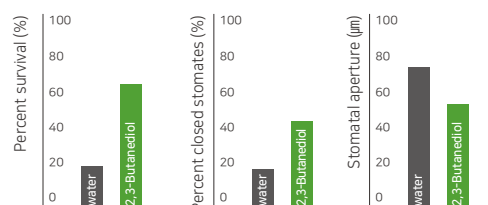
\* PLS (Positive List System) : the system that prohibits use of pesticides above a certain level if they are neither registered for domestic use nor set maximum residue limits (MRLs).

\* ISR (Induced Systemic Resistance) : resistance mechanism in plants that is activated by infection. Its mode of action does not depend on direct killing or inhibition of the invading pathogen, but rather on increasing physical or chemical barrier of the host plant.

## 1 - A FERTILIZERS / BIOSTIMULANTS : ENHANCED RESISTANCE TO ENVIRONMENTAL STRESS

### DROUGHT RESISTANCE MECHANISM ①

- 2,3-Butanediol treatment improved survival rate of Arabidopsis 3 times more than water treatment in drought conditions.
- It has been reported that 2,3-Butanediol induces drought resistance by accelerating Arabidopsis stomatal closure.



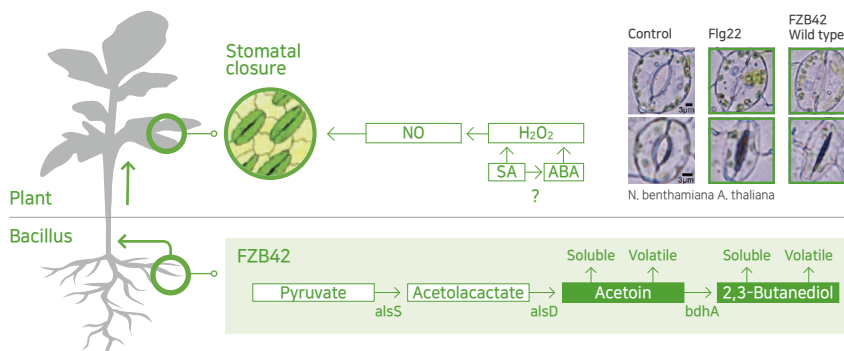
\* 2R,3R-butanediol, a bacterial volatile produced by *Pseudomonas chlororaphis* O6, is involved in induction of systematic tolerance to drought in *Arabidopsis thaliana*, 2008, paper

### DROUGHT RESISTANCE MECHANISM ②

- 2,3-Butanediol produced by *B.amyloliquefaciens* FZB42 induces stomatal closure in *Arabidopsis thaliana* and *Nicotiana benthamiana*.
- It has been reported that 2,3-Butanediol closes pores as plants recognize 2,3-Butanediol, which causes accumulation of  $H_2O_2$  and NO in guard cells by activating the ABA/SA signaling pathway.



## DROUGHT RESISTANCE MECHANISM ②



\* Acetoin and 2,3-butanediol from *Bacillus amyloliquefaciens* induce stomatal closure in *Arabidopsis thaliana* and *Nicotiana benthamiana*, 2018, paper

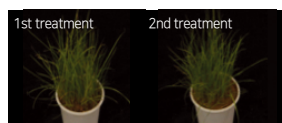
## DROUGHT RESISTANCE : GRASS

- After 3 days of 2,3-Butanediol treatment on grass, drought resistance was improved by 30% compared to the control (control: ASM, water treatment).
- Survival rate after 3 days of drought treatment increased more during the second treatment (7 days before drought, 1 day before drought) than the first treatment (7 days before drought).

2,3-Butanediol



ASM



No Treatment



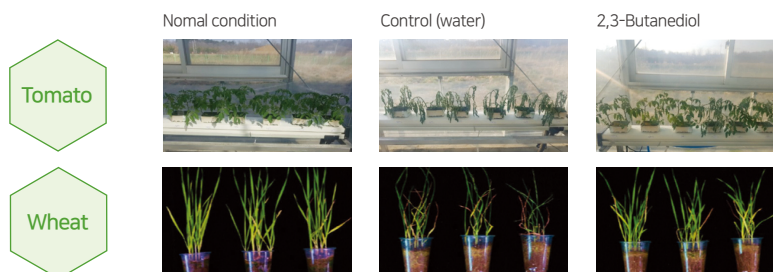
Normal Condition



sample	Dilution	Number of treatment	Drought resistance (%)
2,3-Butanediol 0.9% SL	×1,000	1st treatment	95.0 ± 5.0
		2nd treatment	100.0 ± 0.0
ASM 50% WG	210µg/ml	1st treatment	86.3 ± 4.2
		2nd treatment	85.6 ± 7.3
Control	-	-	72.5 ± 11.8

## DROUGHT RESISTANCE : CROPS (TOMATO/WHEAT)

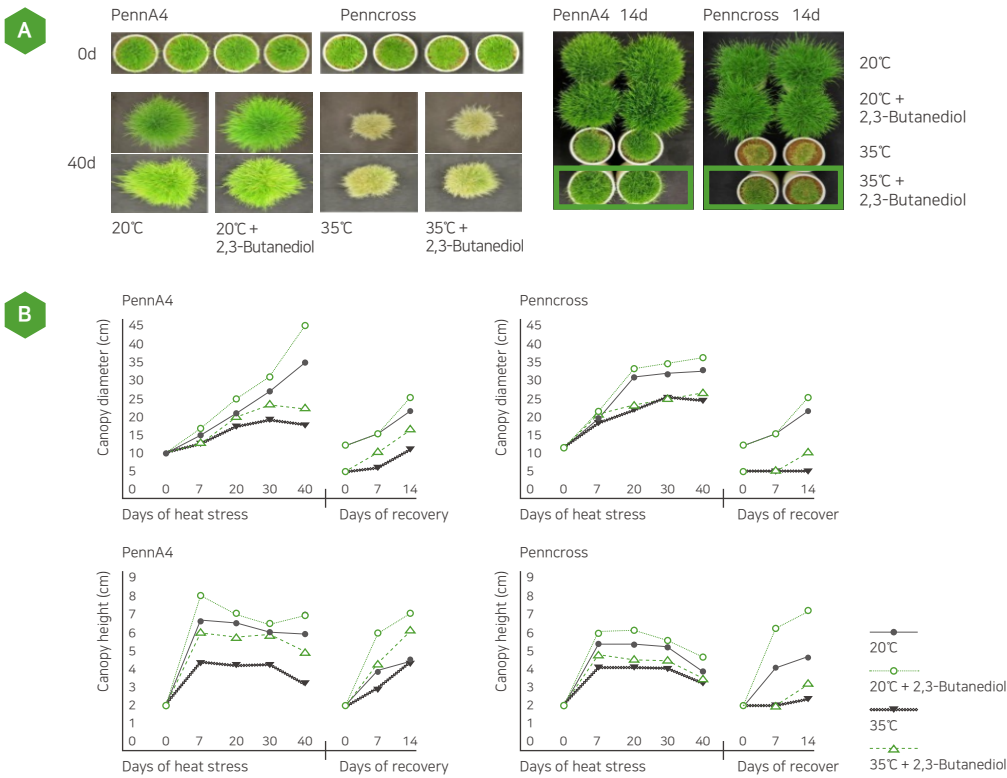
- After 4 days of 2,3-Butanediol treatment in tomato, drought resistance was improved by 40% compared to the control (control: water treatment).
- After 6 days of 2,3-Butanediol treatment in wheat, drought resistance was improved by 60% compared to the control (control: water treatment).





**HIGH TEMPERATURE  
RESISTANCE  
: GRASS**

- The grass treated with 2,3-Butanediol showed faster recovery from high temperature stress than the untreated grass.
- The grass treated with 2,3-Butanediol showed improvements in diameter/height/leaf index compared to the untreated grass.

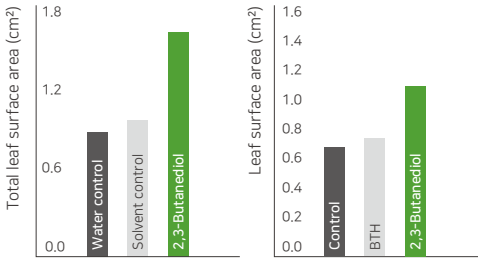


\* Butanediol-enhanced heat tolerance in *Agrostis stolonifera* in association with alteration in stress-related gene expression and metabolic profiles, 2018, paper

**1 - B FERTILIZERS / BIOSTIMULANTS: GROWTH PROMOTION**

**GROWTH  
PROMOTION  
: ARABIDOPSIS  
THALIANA/TOBACCO**

- 2,3-Butanediol treatment improved Arabidopsis growth by more than 50% (control: water treatment).
- 2,3-Butanediol treatment improved tobacco growth by more than 55% (control: water treatment).



\* GacS dependent production of 2R,3R-butanediol by *P. chlororaphis* O6 is a major determinant for eliciting systemic resistance against *E. carotovora* but not against *P. syringae* pv. *Tabaci* in tobacco, 2006



## GROWTH PROMOTION : CHILI PEPPER

- Processing 2,3-Butanediol in the field increased the height and weight of red pepper.
- After 5 days of incubation with 2,3-Butanediol, the weight of germinated seeds was increased compared to the control.

2,3-Butanediol



BTH



WATER



※ Number of fruits per 20 plants

Effect of PGPR strains and their mixtures on the height, fresh weight, and dry weight of peppers under field conditions

Treatment <sup>w</sup>	Height (cm) <sup>x</sup>	Fresh weight (g) <sup>y</sup>	Dry weight (g) <sup>z</sup>
Water	27.08±0.31	30.03±3.55	5.02±0.47
BTH	24.06±0.45 <sup>b</sup>	24.97±1.66 <sup>b</sup>	3.80±0.20 <sup>b</sup>
<b>2,3-Butanediol</b>	<b>28.75±0.23<sup>a</sup></b>	<b>44.52±2.49<sup>a</sup></b>	<b>7.20±0.34<sup>a</sup></b>

In vitro effects of treatment with single PGPR strains, mixtures of PGPR strains, and chemical inducers of systemic resistance on the weight of seeds after 5 days of incubation

Weight of 100 germinated seeds (g)
1.91
1.10
<b>2.20</b>

<sup>\*</sup> Biological Control and Plant Growth Promoting Capacity of Rhizobacteria on Pepper under Greenhouse and Field Conditions, 2012, paper /  
<sup>z</sup> Stereoisomers of the Bacterial Volatile Compound 2,3-Butanediol Differently Elicit Systemic Defense Responses of Pepper against Multiple Viruses in the Field, 2018, paper

## GROWTH PROMOTION : GRASS GREEN-UP

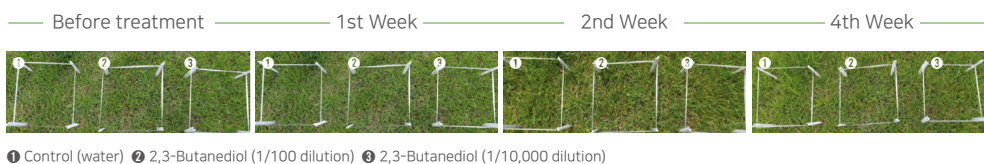
### GREEN-UP PROMOTION EFFECT

- Target crops : Kentucky Bluegrass (G.C.1), Creeping Bentgrass (G.C.2)
- Test method : The product containing 2,3-Butanediol was sprayed on the foliar of the subject every 2 weeks.
- Treatment Material : 2,3-Butanediol
- Test result : The chlorophyll index was increased by 18% (G.C.1) and 8% (G.C.2) compared to the non-treated group, and the leaf index was increased by 11% (G.C.1) and 3.6% (G.C.2).

## 2 - A PLANT DISEASE CONTROL: USE OF NON-TOXIC ECO-FRIENDLY MATERIAL

## PHYTOTOXICITY AND TOXICITY EVALUATION

- No adverse effects were identified when different crops (grass, tomatoes, cucumbers, peppers, etc.) were treated with 2,3-Butanediol (100-fold dilution).



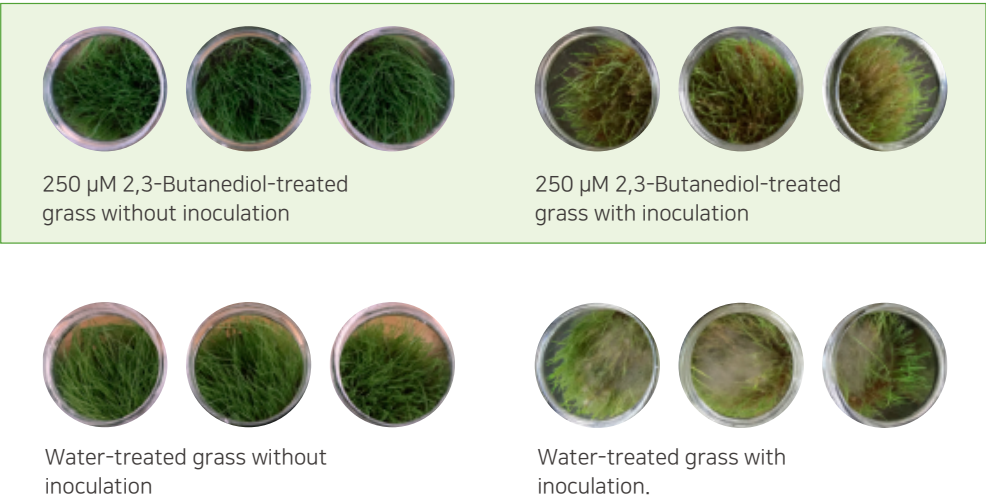
① Control (water) ② 2,3-Butanediol (1/100 dilution) ③ 2,3-Butanediol (1/10,000 dilution)

Types		Safety					
Tests	Single dose toxicity (oral, dermal)	Inhalation toxicity	Skin sensitization	Genetic toxicity	Skin irritation	Eye irritation	Heavy metals, impurities and pesticides (344 species)
<b>2,3-Butanediol</b>	<b>No toxicity</b>				<b>No irritation</b>		<b>No heavy metal</b>



ISR-BASED CONTROL  
EFFECT: FUNGUS ①

· After 7/10 days of inoculation, creeping bentgrass treated with 2,3-Butanediol showed a significant reduction in symptoms compared to the non-inoculated/untreated group.

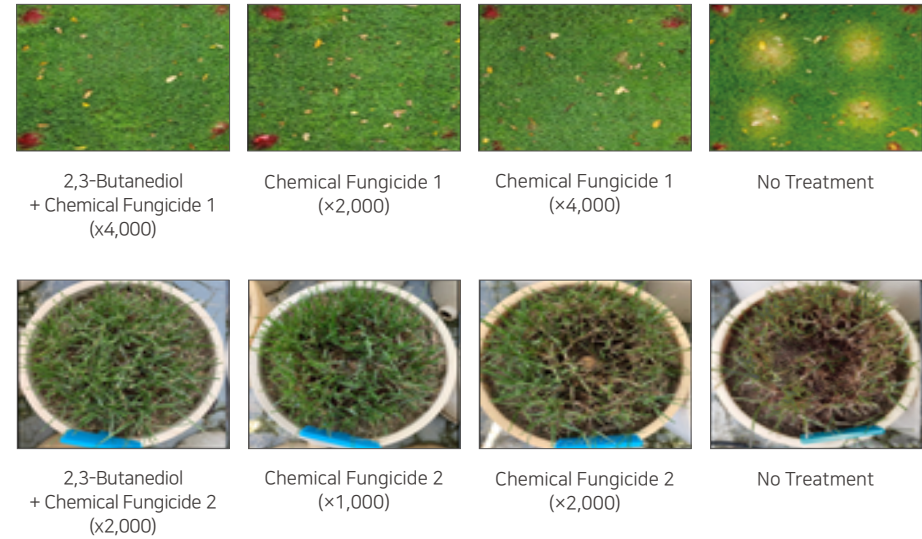


\* Transcriptional Responses of Creeping Bentgrass to 2,3-Butanediol, a Bacterial Volatile Compound (BVC) Analogue, 2017, paper

ISR-BASED CONTROL  
EFFECT: FUNGUS ②

Fungal control effect  
as compound product  
(dollar spot disease,  
summer patch disease)

· Combining 2,3-Butanediol with chemical pesticides showed that half the initial amount of chemical pesticides could still secure the same effect of controlling different fungal diseases (dollar spot and summer patch diseases) as the full amount.

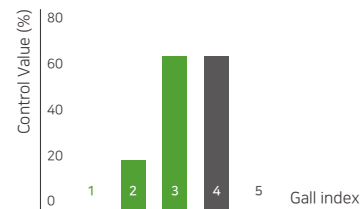




## ISR-BASED CONTROL EFFECT : NEMATODE

- Experiments on the control effect of 2,3-Butanediol against *meloidogyne incognita* in tomatoes showed that 3 times of treatment before and after inoculation caused 66.7% disease control.

- Subject breed : Seokwang Tomato
- Investigation period : 6 weeks after inoculation



Number	Sample	Concentration / dilution factor	Number of Treatment	Control Value (%)
1	2,3-Butanediol	× 10,000	1st time	0.0 ± 11.55
2	2,3-Butanediol	× 10,000	2nd time	26.67 ± 22.11
3	2,3-Butanediol	× 10,000	3rd time	66.67 ± 11.55
4	Chemical Pesticide T	× 5,000	1st time	66.67 ± 22.11
5	No Treatment	-	-	0.0

\* Suspension concentrate of Chemical Pesticide T : Abamectin 1.68% SC



## 2 - B PLANT DISEASE CONTROL : IMPROVED IMMUNITY

## ISR-BASED CONTROL EFFECT : VIRUS

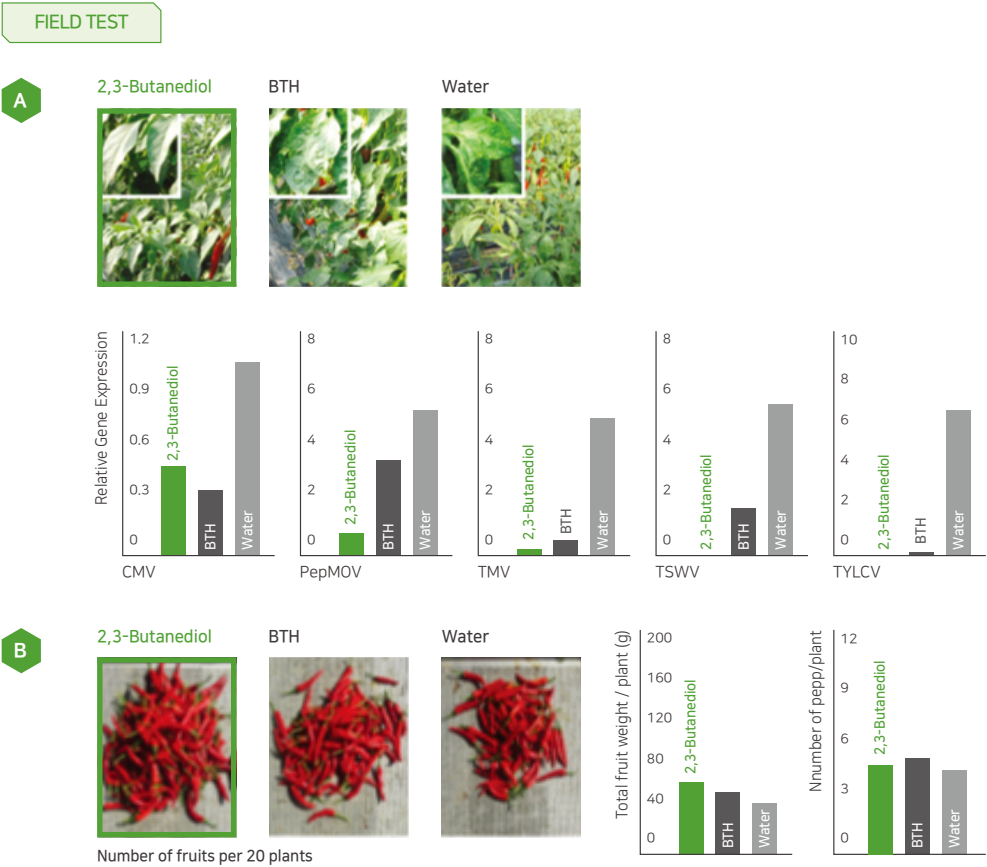
- CMV/TMV virus control evaluation in the greenhouse showed that 2,3-Butanediol treatment reduces virus symptoms.
- CMV/Pepper mottle virus (PepMov)/TMV/Tomato spotted wilt virus (TSWV)/Tomato yellow leaf curl virus (TYLCV) control evaluation on the field showed that 2,3-Butanediol is effective in reducing symptoms and increasing yields.

### GREEN HOUSE TEST





ISR-BASED  
CONTROL EFFECT  
: VIRUS



\* Stereoisomers of the Bacterial Volatile Compound 2,3-Butanediol Differently Elicit Systemic Defense Responses of Pepper against Multiple Viruses in the Field, 2018, paper

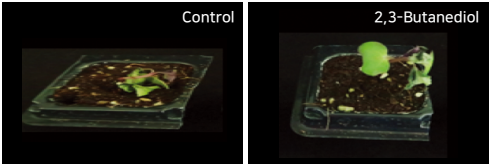
ISR-BASED  
CONTROL EFFECT  
: BACTERIA

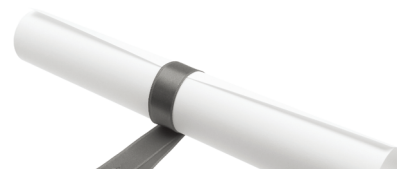
- 2,3-Butanediol treatment showed control up to 80% of tomato bacterial wilt disease caused by *Ralstonia solanaceum*.
- 2,3-Butanediol treatment showed control up to 66% of Cabbage black rot disease caused by *Xanthomonas campestris* pv.

Tomato bacterial wilt disease



Cabbage black rot disease





## PROPERTIES

Divide	2,3-Butanediol
Chemical formula	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>
Molecular weight (g/mol)	90.121g/mol
Boiling point (°C)	approx. 180°C
Vapour pressure (Pa)	24.7~56.6 Pa at 20°C
Water solubility (g/L)	about 500 g/L at 20°C
Density (g/cm <sup>3</sup> )	0.992~1.002g/cm <sup>3</sup>
Flash point (°C)	91~96°C
Viscosity (mPa · s)	44~128mPa · s at 25°C

## PACKAGING

Industrial Standard Pack	Plastic packaging of 20kg and 200kg
Samples	100g, 250g, 500g, 1kg, 2kg

## CERTIFICATES

- EU-REACH ('19)
- USDA BioPreferred® Program
  - 100% Bio-based ('18)
- New Excellence Technology by Korea Ministry of Trade, Industry and Energy ('18)
- New Excellent Product by Korea Ministry of Trade, Industry and Energy ('19)
- COSMOS ('19)
- Vegan ('19)

## PRODUCT SUMMARY

- INCI Name: 2,3-Butanediol
- IECIC name: 2,3-Butanediol
- EC Number: 823-920-1, 208-173-6
- CAS Number: 5341-95-7, 513-85-9
- Functions
  - Environmental stress resistance enhancer
  - Growth promoter
  - ISR-based pest control

## CONTACT INFORMATION

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