

## **II. Production Information**

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**II.2.1 Microbial Functions**

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NutriSmart (NS) and NutriWiz (NW) series of products consist of unique microbial formulations. The microbes are specially formulated and produced by the company's proprietary technologies. The active ingredients of the product series comprise two major components:

1. Beneficial microbes
2. Microbial activators

## **II.1 Product Composition**

### **II.1.1 Beneficial Microbes**

In contrast to other bio-fertilizer products, the microbial blending in NS & NW series of product possesses the following advantages:

- (a) contains bacteria, fungi, and yeasts to provide microbial diversity and balance,
- (b) isolates from soil, so they are able to survive soil conditions,
- (c) scientifically proven to be useful for:
  - Phosphate solubilization
  - Potassium decomposition
  - Nitrogen fixation
  - Organic degradation
  - Soil bioactivity enhancing
  - Plant growth promotion
- (d) in more stable forms and thus having better storage and processing properties
- (e) acceptable for biofertilizer registration in many countries

NS & NW product series are composed of specific groups of microbes depending on the application, final product forms, specific market needs, and etc. In general, the “microbial cocktail” can contain the following microbes:



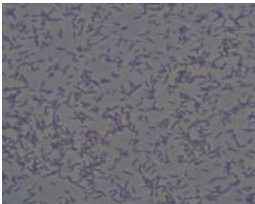
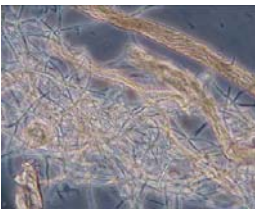
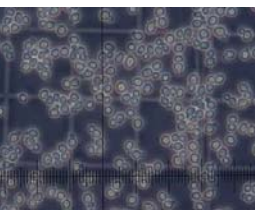
Table II.1.1a: Basic microbial composition in NS & NW product series

<b>Microbial Species*</b>	<b>Microbial Type</b>	<b>Major functions</b>
<i>Bacillus polymyxa</i>	Bacteria	Nutrient release and nitrogen fixation
<i>Bacillus subtilis</i>	Bacteria	Organic nitrogen release, phosphate and potassium decomposing and pest resistant

<i>Azotobacter chroococcum</i>	Bacteria	Nitrogen fixation and growth enhancement
<i>Trichoderma harzianum</i>	Fungi	Enhance organic degradation, nutrient update and pest control
<i>Saccharomyces cerevisiae</i>	Yeast	Promote the growth of soil microbes

\* Final microbial formulations may vary depending on applications and market needs

Table II.1.1b: Micrograph of basic microbes in NS & NW product series

Microbial Species*	Micrograph
<i>Bacillus polymyxa</i>	
<i>Bacillus subtilis</i>	
<i>Azotobacter chroococcum</i>	
<i>Trichoderma harzianum</i>	
<i>Saccharomyces cerevisiae</i>	

### **II.1.2 Microbial Activators**

The proprietary activators are naturally occurring materials and fermentation products. These compounds are not major nutrients of the microbes. Instead, they are able to improve metabolism of microorganisms, stimulate their growth, and increase the production of biochemicals. The stimulating mechanisms of these activators vary with their types. Scientific understanding of the activators is the key to their selection for the optimum efficacy. A series of microbial activators has been developed for selected microbes to enhance their specific functions. The microbial activators have the following advantages:

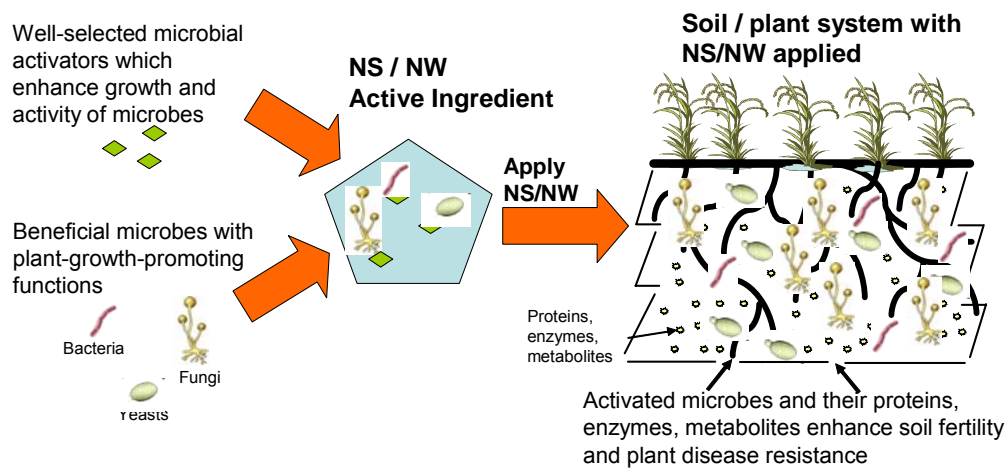
- (a) multiple stimulating agents chosen for specific microbes,
- (b) technically proven to have effects on promoting plant growth

In summary, the use of the microbial activators can significantly increase the activity of the microbes contained in the products and boost up soil microbial population, thus making the best use of the beneficial microbes.

## II.2 Microbial Functions and Mechanism

The two components, beneficial microbes and microbial activators contribute the major functions of the NS and NW product series. Once the fertilizer products have been applied into soil, the well-selected microbial activators enhance the growth and activity of the plant-growth-promoting beneficial microbes in the product. The activated microbes and their proteins, enzymes, metabolites enhance soil fertility, bioactivity and subsequent nutrient use efficiency (Diagram II.2a).

Diagram II.2a: Outline of the mechanism of NS/NW components



## II.2.1 Microbial Functions

NS and NW microbes have many functions that are beneficial to enhance fertilizer efficiency and plant growth.

### *Bacillus polymyxa*

Some *Bacillus* strains., such as *B. polymyxa*, are nitrogen fixers (Grau and Wilson 1962; Seldin *et al.* 1983) and there is evidence for the secretion of plant growth-enhancing substances by root-associated *B. polymyxa* (Holl *et al.* 1988).

### *Bacillus subtilis*

*B. subtilis* is able to enhance organic nitrogen cycle in field soil - by producing & regulating the protease in soil. This mechanism is critical to improve the soil fertility and hence improve the use efficiency of organic nutrients (Watanabe K. *et al.* 2003).

Beside, *B. subtilis* is a common phosphate solubilizing bacterium which improves the availability of phosphate in soil, especially when associated with arbuscular mycorrhiza. *B. subtilis* is also known as a "mycorrhiza helper bacterium" (Toro M. *et al.* 1997; Almas Z. & Khan S. 2006).

### *Azotobacter chroococcum*

*Azotobacter* spp. plays a vital role in every ecosystem, working to make nitrogen available. *Azotobacter* spp. and similar bacteria turn nitrogen into ammonia through the process of nitrogen fixation. In an experiment, *Azotobacter* cells are known to excrete small amounts of nitrogenous compounds into the medium, indicating their nitrogen fixation capability (Francisco *et al.* 1986).

### *Trichoderma harzianum*

*Trichoderma* strains are able to promote root development, increase efficiency of fertilizer utilization, improve rhizosphere environment, and enhance plant resistance to disease and augment of minor nutrient uptake by plants.

The application of *Trichoderma* spp. has not only an antagonistic effect on plant pathogens but also a positive effect on plant growth and yield in some vegetable crops by promoting efficiency of basal organic fertilizer application. The increased growth response is mainly due to mineral solubilization and uptake of minor and other minerals as well as improvement in the root morphology enabling the roots to exploit a large volume of soil (Altomare *et al.* 1999; Elad and Kapat, 1999). Uptake of some nutrients (e.g. copper, phosphorus, iron, manganese and sodium) in roots in hydroponic culture could also be

increased after introduction of *Trichoderma spp.* (Yedidia *et al.* 1999; Howell *et al.* 2000).

*Saccharomyces cerevisiae*

*Saccharomyces* strains promote the growth of soil bacteria. Yeast cells and the culture contain growth factors (e.g. organic acids and B vitamins) which are necessary for the development and multiplication of other bacteria (Johannes Z. *et al* 2003a & b).

Table II.2.1a: Summary of Microbial Function

Microbes	Major functions
<i>Bacillus polymyxa</i>	Nutrient release and nitrogen fixation
<i>Bacillus subtilis</i>	Organic nitrogen release, phosphate and potassium decomposing and pest resistant
<i>Azotobacter chroococcum</i>	Nitrogen fixation and growth enhancement
<i>Trichoderma harzianum</i>	Enhance organic degradation, nutrient update and pest control
<i>Saccharomyces cerevisiae</i>	Promote the growth of soil bacteria

## II.2.2 Performance conditions

### Temperature

The optimal temperature of the microbes and microbial activators should be in a range from 20 to 40 degree Celsius.

### pH

The working pH for the microbes and microbial activators is from pH 4 to pH 9, with an optimum at pH 5 to 7.5.

### Salinity

Salinity is one of the important factors that may affect the microbial activity. The optimal salinity for the microbes and microbial activators is less than 0.8 % and the working salinity is less than 1.0 %.

### Field Capacity (Moisture in Soil)

The working field capacity of soil is 50 to 100 %. The optimal field capacity of soil is 80 to 100 %.

### Compatibility with Organic and Chemical Fertilizer

In general, the active ingredients should be compatible with various organic and chemical fertilizers. However, special attentions should be paid to keep the products from higher than 45 °C, strong chemicals and other conditions harmful to microbes.

When a microbial fertilizer is mixed with liquid chemical fertilizer, the mixture needs to be used as soon as possible to avoid the possible damage to the microbes. If the concentration of total chemical fertilizers in the liquid mixture is less than 10%, the liquid mixture of microbe and chemical fertilizer might be used within 2 hrs.

The allowable retention time of microbes in a chemical fertilizer solution varies with types of chemical fertilizers. For a specific chemical fertilizer solution, the detailed information should be provided so that we can perform some tests to determine the best conditions.

Table II.2.2a Summary of Performance Conditions

<b>Conditions</b>	<b>Optimal Range</b>	<b>Working Range</b>
Temperature	20 - 40 °C	4 - 45 °C
pH	5 - 7.5	4 - 9
Salinity	0 - 0.8 %	0 – 1.0 %
Field Capacity	80 – 100 %	50 – 100 %