# TECHNICAL WHITE PAPER: PRINCIPLE™ WP

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## PRINCIPLE WP: What it is and how it works

PRINCIPLE WP is a new mycoinsecticide containing the live fungus *Beauveria bassiana* strain BW149. PRINCIPLE WP is labeled for management of thrips, whiteflies, aphids, mealybugs, diamondback moths, cabbage loopers, and other damaging insects. *Beauveria bassiana* products have a more than twenty-five year record of safe and effective use for a variety of indoor and outdoor agricultural and non-agricultural applications. It is therefore labeled for use on food crops and non-food crops including ornamental plants, hemp, shrubs, forestry, orchard, and turf. See the label for a full list of pests and crops.


## ACTIVE INGREDIENT:

*Beauveria bassiana* strain BW149 – ..... 21%

Contains a minimum of $1 \times 10^{10}$ colony forming units per gram of product

*Beauveria bassiana* is an entomopathogenic fungus found naturally in soils worldwide that causes white muscardine disease in infected hosts. The fungus has been widely utilized as a bioinsecticide, with products containing spores (conidia). When the spores contact a susceptible host insect, they germinate; the hyphae penetrate the insect cuticle via a combination of physical force and enzymatic degradation of the insect's body wall. Once inside the host, the fungus feeds on nutrients within the insect, while releasing metabolites that will cause insect blood poisoning and death.

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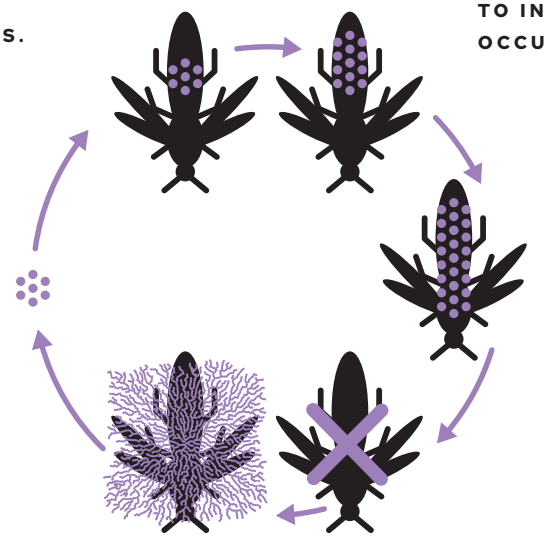
## *BEAUVERIA BASSIANA* LIFE CYCLE

1. APPLICATION OF SPORES.

2. 0-6 HOURS: ADHESION TO INSECT CUTICLE OCCURS.



3. 6-12 HOURS: UNDER WARM, HUMID CONDITIONS, GERMINATION BEGINS.

4. 12-72 HOURS: CUTICLE PENETRATION AND HEMOLYMPH COLONIZATION OCCURS.

5. 24-48 HOURS: INSECTS STOP FEEDING/ FLYING. SMALLER INSECTS AND INSECTS WITH THINNER CUTICLES DIE IN LESS TIME THAN LARGER INSECTS WITH THICKER CUTICLES.

6. 72-96 HOURS: SPORULATION MAY OCCUR WHEN THE INSECT BECOMES ENCASED IN MYCELIUM AND SPORES AFTER INFECTION AND DEATH.*

*NOTE: SPORULATION ONLY OCCURS WHEN AMBIENT HUMIDITY IS HIGH AND SHOULD NOT BE CONSIDERED A MEASURE OF CONTROL .

## ENVIRONMENTAL PARAMETERS

- **Air/soil temperature:** The fungus is active over a broad temperature range between 50-86 °F, with optimal growth occurring between 73-82 °F. Temperatures outside this range will typically not kill the fungus but can slow germination and infection. Once optimal temperatures resume, so will germination and growth of the fungus.
- **Suspension temperature:** Once in suspension, spore survival in suspension is a function of temperature and time.
  - 100 °F okay but for no longer than 6 hours
  - 110 °F will decrease spore viability and increase germination time
  - 120 °F for 4 hours will result in a significant decline in spore viability
  - 140 °F will kill spores
- **Relative humidity (RH):** Dependence of infection on humidity depends upon the insect, and its ecology, especially in relation to the phylloplane and its microclimate i.e. the leaf boundary layer (1-10 mm thick) that surrounds the leaf. The boundary layer is affected by leaf size and shape, presence of other leaves and wind velocity. Ambient conditions of 50-70+ % RH are ideal as the leaf boundary layer increases humidity at the leaf surface by around 20-30%. Additionally, the inter segmental membranes on insects have higher humidity than exposed surfaces and are ideal germination/penetration locations, as the insect cuticle is much thinner at these sites. RH > 50%+ will increase efficacy if maintained for 24-48 hours after application.

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## ENVIRONMENTAL PARAMETERS (CONTINUED)

- **Persistence:** dependent on many factors but mainly temperature, moisture and UV exposure.
    - **Soil:** High soil temperatures and poorly drained soils will be detrimental to spore longevity. Spores have been documented to live in soil for a few days up to a year.
    - **Foliar:** UV (-A & -B) is very detrimental to spores. The persistence of spores depends on their location on the plant. Spores protected on the underside of leaves or in the plant canopy will survive longer (days to months) than spores directly exposed to UV (hours). Application coverage to the underside of leaves is vital to efficacy especially when applied outdoors. It is important to remember that many pest insects are also found on the underside of leaves, so proper targeting of sprays is also vital for insect control. Over time, spores will be washed off and/or die so regular reapplication is important to maintain high spore density.
- **Media:** Soil/soilless media plays a significant role in spore retention. Coarse particles will cause spores to be lost quickly vs a peat-based mixture that can capture and hold spores in place. Once applied, spores will get caught up in the media with more spores at the soil surface. Subsequent irrigation can push spores deeper in the soil. Good soil coverage is important.
- **Endophytism:** Entomopathogenic fungi of several genera (*Beauveria, Metarhizium, Cordyceps*) can colonize plant tissue (leaves, stems, roots) and subsequently cause insects feeding on colonized plants to become less fit (shorter life span, reduced fecundity), make the plant less desirable for feeding or oviposition, and in some cases may lead to premature death of arthropods. This has been documented in many plants such as strawberries, tomato, corn, coffee, banana, grapevine, fruit trees, potato, cotton, wheat, cabbage, etc. Sometimes endophytic colonization can last weeks or years, other times it may never colonize the plant or colonize only for a brief period. There is also great variation among *B. bassiana* strains in their capacity to become endophytes. After application you may get a secondary endophytic effect, but it is impossible to know or count on it as a management strategy. Consequently, this mycoinsecticide should be re-applied at regular intervals to directly target and infect pests.

## BENEFITS OF PRINCIPLE WP

- Easy-to-use, minimal leaf residue WP formulation built on more than 25 years of experience
- Complex mode of action provides control without the risk of resistance
- Provides insect control comparable to conventional insecticide programs
- Excellent compatibility with conventional pesticides and other biological products
- OMRI-approved
- Exempt from residue tolerance
- 4-hour REI, 0 day PHI

## APPLICATION PARAMETERS

- Best applied early morning or late afternoon/evening to reduce exposure to UV and high temperatures
- For greenhouse, nursery, etc., the product can be applied by high-, low- and ultra-low-volume sprayers, as well as by dipping
- For food and non-food crops grown outdoors, applications can be made by ground or aerial sprays to the foliage, or heavy sprays to the soil
- Do not apply through drip chemigation (poor coverage) or thermal foggers
- PRINCPLE WP is a contact biopesticide; good coverage on the top and bottom of leaves and to the soil profile is essential

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## APPLICATION RATE

- Foliar: All pests ½–2 lb/100 gallons, depending on pest population and foliage density (see label for recommendations on specific pests)
- Drench: Up to a maximum of 3 lb/acre for high pest pressure and/or dense foliage
- Dip: ¼–½ oz/gallon of water (see Dip Guide for more information at **bioworksinc.com/wp-content/uploads/Dips_CleanUp_US-10.25.23.pdf**)
- Refer to BioWorks application methods guide and rate calculator tools at **https://bioworksinc.com/ask-us/**

## APPLICATION FREQUENCY

- Apply at first sign or symptom of pest; repeat applications for as long as pest pressure persists
- Apply preventative applications at 5-10-day intervals
- For high pest pressure, increase rate and/or frequency of sprays
- There is no limit on the number of applications or total amount of product that can be applied in one season

## FORMULATION EASE-OF-USE

- Stable at room temperature for 12 months
- Mixes easily in water with low dust
- No phytotoxicity has been observed when applied to the foliage or media (see Phytoxicity Comparison Trial outcome below)
- Leaf residue was significantly reduced when compared to competitive wettable powder formulations of *Beauveria bassiana* (see Leaf Residue Comparison Trial outcome on next page)
- Compatibility:
    - Visit **bioworksinc.com/ask-us/product-compatibility/** for a full list of compatible tank mixes and rotational options
    - Synergistic/additive effects are often observed when combined with products like Molt-X® (azadirachtin) and EpiShield™ (peppermint & clove essential oils).

## PHYTOTOXICITY COMPARISON TRIAL: CUCUMBERS

**CONTROL**

**PRINCIPLE WP**

**COMPETITOR ES**
***B. bassiana***

**Results:** Plants treated with PRINCIPLE WP carry no signs of damage or injury, making them visibly healthier than those using other formulations.

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## LEAF RESIDUE COMPARISON TRIAL: CUCUMBERS

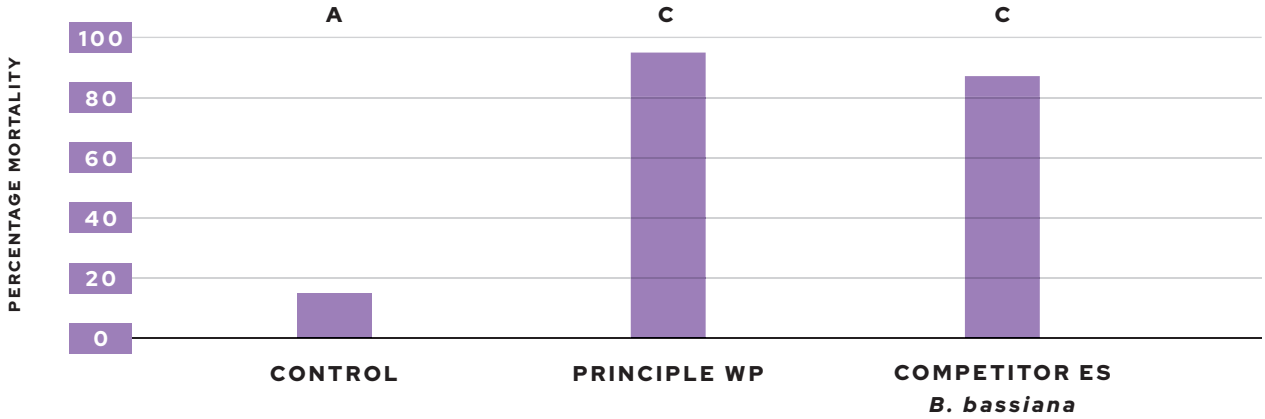
**CONTROL** | **PRINCIPLE WP** | **COMPETITOR WP** *B. bassiana*

**Results:** Leaf residue was significantly reduced when compared to competitive formulations of *Beauveria bassiana*.

## PRINCIPLE WP: PROVEN PERFORMANCE

Extensive trialing of PRINCIPLE WP has demonstrated its effectiveness and plant safety in a diverse range of crop settings as shown in the following examples from internal R&D trials as well as third-party independent trials. Additional trial data can be found on the BioWorks website at **bioworksinc.com/ask-us.**

### WESTERN FLOWER THRIPS MORTALITY




Mean percent mortality after a dip application against adult western flower thrips. Data recorded 6 days after treatment. Means followed by the same letters are not significantly different.

Western Flower Thrips research conducted in 2020 at Vineland Research & Innovation Center, ON Canada.

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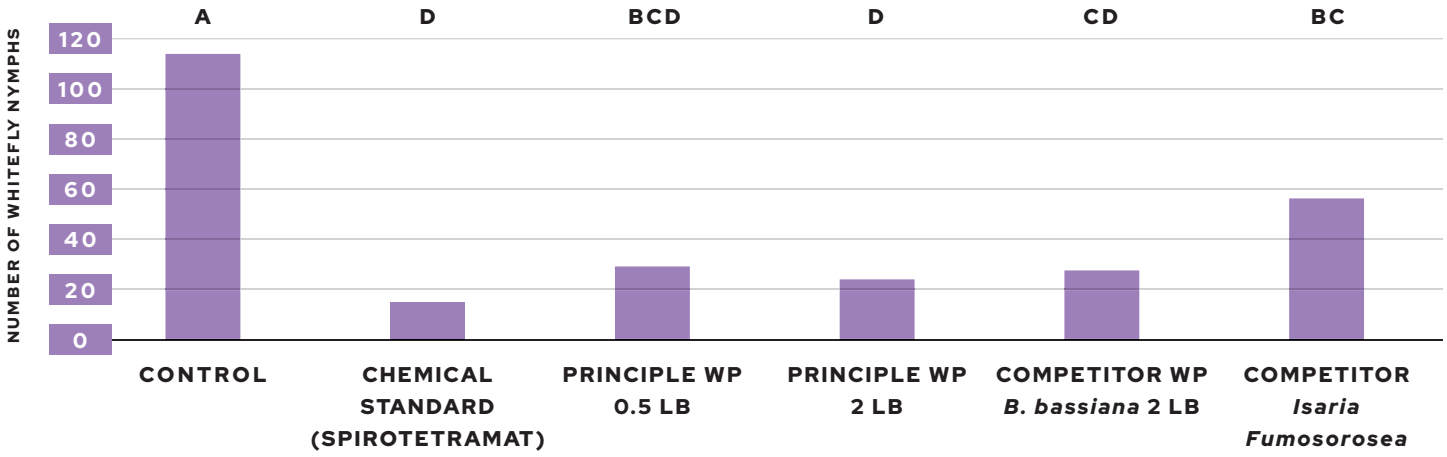
## PRINCIPLE WP: PROVEN PERFORMANCE (CONTINUED)

**ADULT WESTERN FLOWER THRIPS COVERED IN WHITE MYCELIA AND SPORES CHARACTERISTIC OF BEAUVERIA INFECTIONS.**

### Key takeaways

- PRINCIPLE WP delivered 4% greater control of thrips than competitor *Beauvera bassiana* ES product
- After a dip application, the 2 lb/100-gallon rate of PRINCIPLE WP provided 98% mortality of western flower thrips compared to the untreated control
- The 2 lb/100-gallon rate of PRINCIPLE WP provided control similar to the competitive *Beauveria bassiana* ES standard
- No plant phytotoxicity was observed during the study

## WHITEFLY NYMPHS 14 DAYS AFTER TREATMENT




Mean nymphs per 2.5-inch leaf disk 14 days after treatment. Three applications were made seven days apart. Means followed by the same letters are not significantly different (P<0.05).

Greenhouse whitefly research conducted in 2019 by Steve Frank, IPM Research & Consulting, LLC

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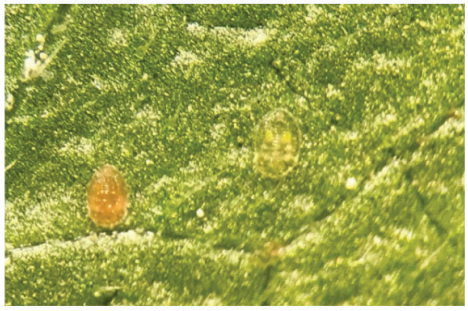
## PRINCIPLE WP: PROVEN PERFORMANCE (CONTINUED)

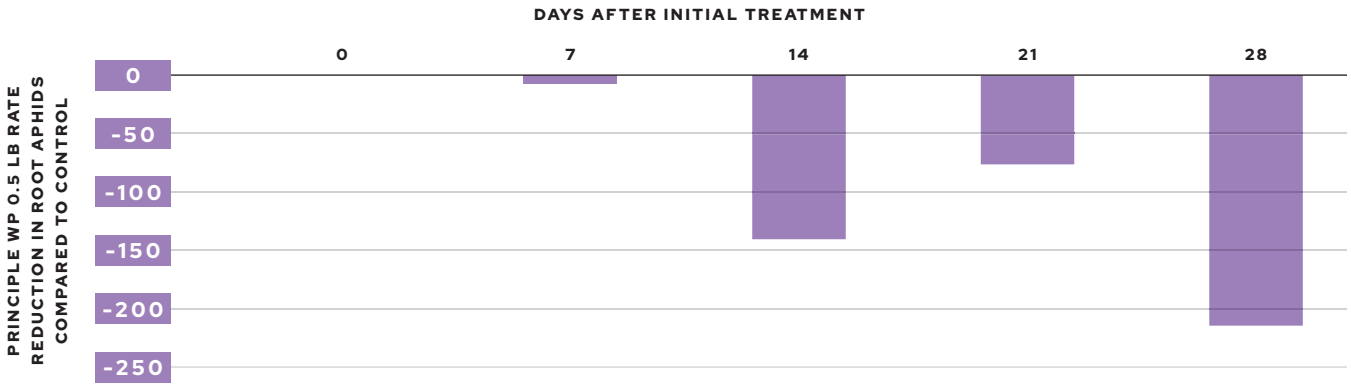


**WHITEFLY NYMPH KILLED BY PRINCIPLE WP (LEFT). NOTICE COLOR DIFFERENCE FROM HEALTHY WHITEFLY NYMPH (RIGHT).**

### Key takeaways

+ PRINCIPLE WP delivered 9% greater control of whitefly nymphs than a Competitor *B. bassiana* product and 56% greater than a competitor *Isaria fumosorosea* product.
+ After three applications, the low and high rates of PRINCIPLE WP significantly reduced whitefly nymphs compared to the untreated control
+ The low and high rates of PRINCIPLE WP provided efficacy statically similar to the chemical standard spirotetramat
+ No plant phytotoxicity was observed during the study

## PRINCIPLE WP VS ROOT APHIDS




### Control of Root Aphid in Hemp

Reduction in root aphids present in the PRINCIPLE WP 0.5 lb/100 gal treatment compared to the untreated control treatment. Drench applications were made weekly with the days after initial treatment indicated on the horizontal axis of the chart.

Root aphid research conducted in 2024 at The Ohio State University

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## PRINCIPLE WP: PROVEN PERFORMANCE (CONTINUED)

**Key takeaways**

+ PRINCIPLE WP at 0.5 lb per 100 gallons reduced the root aphid population over time compared to the untreated control
+ PRINCIPLE WP at a weekly application interval showed control of root aphid populations even with the high root aphid pressure seen in this trial
+ No plant phytotoxicity was observed during the study

## PROGRAM IMPLEMENTATION

BioWorks goal is to help growers successfully implement PRINCIPLE WP into their IPM programs. Our Technical Services Team specializes in turning more than 25 years of experience with *Beauveria bassiana* into effective programs that work within unique grower systems. Here are the services available from BioWorks to optimally implement PRINCIPLE WP into a program.

## SERVICES

**Virtual Meeting**

+ Plant health and protection challenges
+ Plant health solutions

**Webinars**

+ Types of spray equipment and spray calibration
+ Best application methods for BioWorks products
+ IPM strategies for specific crops
+ Monitoring/scouting techniques for insects, diseases, and plant nutrients

**On-Site Training/Presentations**

+ Insect, disease, and nutrient deficiency identification, scouting/monitoring, and management
+ Implementation of integrated pest and plant health management and strategies
+ Application of BioWorks products and plant health management strategies
+ Dipping demonstrations

**Holistic Operation Assessment**

+ Personalized crop solutions and spray rotation programs
+ Operational and process-specific assessment

Refer to product label for complete application directions. Always read and follow label directions.

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