## Innovation in integrated control of greenhouse pests:

# An urgent need!

In greenhouse crops, biological control as a component of Integrated Pest Management (IPM) went through a considerable growth in the first years of this millennium, after a virtual standstill in the nineties. Already common practice in the production of fruiting vegetables, biocontrol is now on the increase in floriculture, mainly in cut flowers, and to a lesser extent in potted plants. Moreover, we witness regional expansion from the moderate climate zone towards subtropical areas. The driving force behind the trend is the increasing social and political call for sustainable production. With respect to acceptable pesticide residues on vegetables, supermarkets impose stricter standards than health authorities. In ornamental production, presence of pesticide residues is not so much of an issue. These growers appear to have other motivations: pesticide resistance prevention, labour, environmental concerns, product reputation and sometimes even yield increase. Curiously, while IPM is increasing, little innovation can be observed in the field of biocontrol itself. Why is that so and what needs to be done to change the situation were the two main questions addressed by P.M.J. Ramakers, Wageningen UR Greenhouse Horticulture in the Netherlands, during his excellent keynote lecture at the opening session of the Miami conference.

P.M.J. Ramakers

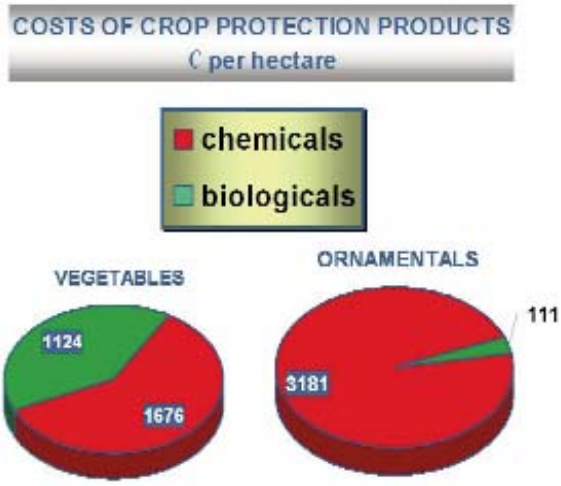
Courtesy of NAI

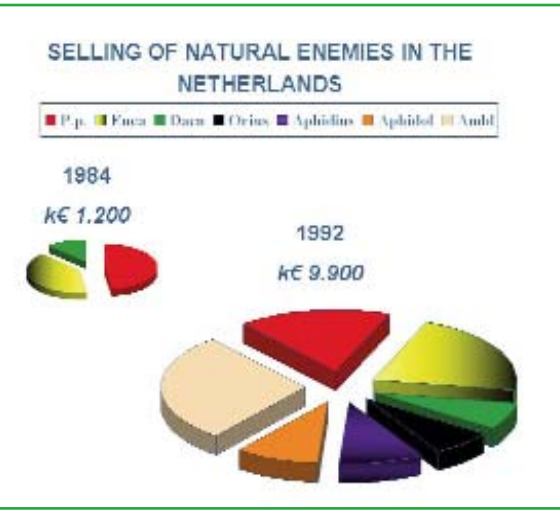
### PROGRESS IN IPM BASED ON THE DEVELOPMENT OF NEW (SYNTHETIC AND MICROBIAL) CHEMICAL PESTICIDES

According to Ramakers, most of the antagonists used in biocontrol have been available for decades, with the phytoseiid mite Typhlodromips swirskii (predator of thrips and whiteflies simultaneously) as a rare exception. New pesticides, however, appear regularly, often representing completely new chemical groups with novel modes of action. Traditional broad-spectrum insecticides like organophosphates, carbamates and pyrethroids have been replaced by selective products like nicotinoids, spinosyns and hydrazines. So it is actually the progress in the chemical field that has allowed a wider application of biologicals, most of which were known before!

### LACK OF INNOVATION IN BIOCONTROL

Why is there a lack of innovation

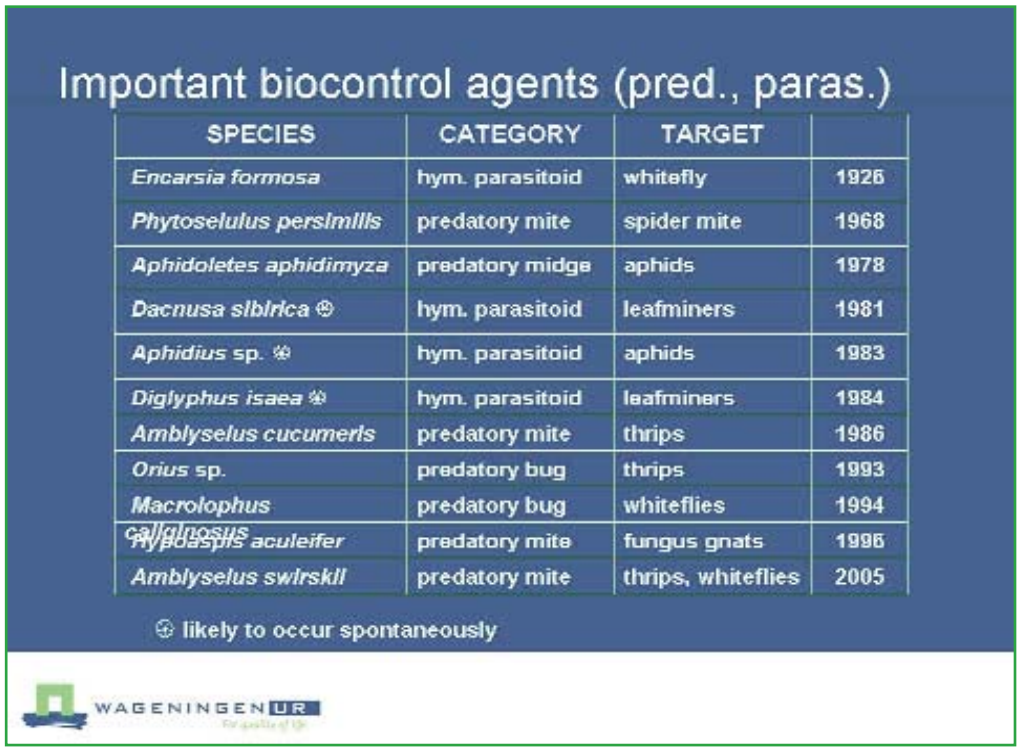


in biocontrol? Ramakers sees a series of reasons to this situation. First reason is that biocontrol products are products of nature, not patentable. This is actually the main reason why there is such a discrepancy between chemical versus biological innovation.
The second reason is that biocontrol products have a specific mode of action and therefore there is only a small market niche for each of them, with a few exceptions of course. Biocontrol manufacturers are not able to make in-depth investments, knowing that fast-following competitors will soon come alongside, often within a year. Hence, innovative efforts are directed at mass-production, storing, formulation (of microbials) and application techniques, rather than at developing different antagonists.
The last but not least reasons listed by Ramakers to explain the lack of innovation in the biocontrol industry are the privatization of independent research & extension services with public and cooperative funds shrinking as well.
Biocontrol is thus widely adopted, but based on relatively few products. Considering the huge assortment of botanical species and cultivars in floriculture, grown under a wide variety of climatic conditions, it is highly unlikely that biocontrol can conquer this field with the few antagonists currently available. This gap between growers' demands and availability in the marketplace has created a vacuum, which seems to suck in new suppliers offering products of sometimes doubtful quality. These doubts relate to the biological effectiveness in the first place, to the targets recommended and to the sheer quality (viability) of the finished product. The most common error is the translation of petri dish observations into conclusions about field efficacy without too much of evidence.
It may be tenable to leave field evaluation to the growers and their advisors in cases where the effect of the antagonist is obvious. However, with some of the antagonists recently commercialized, field evaluation is difficult if not impossible since the biological interaction with the target is concealed. Alertness is particularly recommendable if products are claimed to be effective only when used preventively or in combination with other (chemical or biological) pesticides.

## WHAT DO WE NEED?

For Ramakers, there are four pillars to build on in order to change the situation.
First and most urgent, search for new pest antagonists everywhere in nature, in agricultural ecosystems and in the area of pest origin. Next is to develop microbial pesticides such as bacterial insecticides, soilborne fungi, NP viruses and EP nematodes. Then there is a compulsory need to confirm efficacy in field experiments with an adequate monitoring of both the pest and the antagonist. Last but not least, there is a need for continuous quality control: those products are living organisms and there is a risk of contamination and genetic drift.
Ramakers concluded his lecture by raising the question of whether investing in biocontrol agents pays? He balanced ther positive and negative arguments. The positive ones: an urgent and increasing demand, a simple registration procedure (except for microbials), a market targeting well-educated growers who can handle complicated strategies and used to relatively high product prices.
On the "negative side", products are not patentable, they are niche products, the growers are in demand for extremely high quality and …..the growers are well educated, which prevents snake oil products to stay long in the market. Is this really negative? In any case, reliable suppliers to this market will not complain. The biocontrol industry needs to mature. ■



# Role of Mineral Nutrition in IPM

Mineral nutrients are involved in many physiological and biochemical processes as enzyme activators, structural components, metabolic regulators, substrates, and osmotica. The nutritional status of a plant affects inherent disease resistance which affects disease escapes, alters pathogenesis, and modifies the virulence of the pathogen and its ability to survive. Proper nutrition is first line of defense. Any nutrient that is deficient or in excess will increase a plant's susceptibility to disease. Because nutrients influence the relationship between the plant and the pathogen, growers have a valuable IPM method already in place to effectively reduce damage from plant diseases. In his keynote address at the opening session of the New Ag International conference in Miami, Prof Lawrence E. Datnoff, Department of Plant Pathology & Crop Physiology, Louisiana State University, and a world expert on the topic, presented the interactions and effects, and prescribed nutritional regimes that will minimize crop loss to disease and improve overall plant health and development.

Prof Lawrence E. Datnoff

Courtesy of NAI

Nutrients that are known to influence diseases in some plants are N-form, K, Ca, Cl, S, Mn, Ni, and Si.

## NITROGEN

Nitrogen can be absorbed as a reduced (NH4) or oxidized form (NO3). The form of nitrogen affects disease as diseases can react differently to each N-form. NH4-N is associated with reductions in pH while NO3-N increases pH. N03-N suppresses Fusarium diseases. NH4-N suppresses most other soilborne diseases. Datnoff developed on several examples such as Fusarium wilt being suppressed by NO3 on tomatoes as well as Rhizoctonia root rot on beets, Verticillium wilt being suppressed by NH4 on potato as well as Black root rot on strawberries.

## CALCIUM

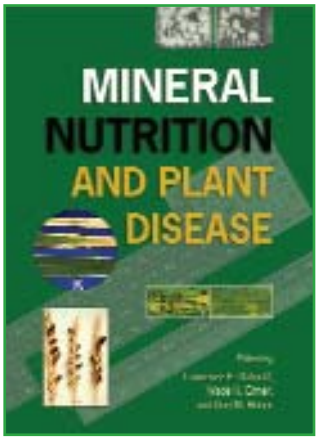
Ca reinforces cell wall components to resist infection. It suppresses a number of diseases such as Club root of cabbage, Southern blight and cavity spot of carrot, Fusarium wilt of tomato, Erwinia soft rot of potato or Botrytis blight of many vegetables.

## POTASSIUM

Potassium is absorbed solely as K. Effects on disease are numerous and variable. Results often depends on the form of K - KCl, K2SO4, KNO3. K provides proper ion balance and turgor maintenance. Datnoff underlines that the form of K may be more important than the amount applied.

## SULPHUR

Sulphur (S) deficiency impairs crop productivity and quality. Suphur Induced Resistance (SIR) denotes the reinforcement of the natural resistance of plants against fungal pathogens by sulphate-based, soil-applied fertilization and is one constituent of the complex phenomenon of induced resistance. The potential efficacy of SIR expressed as a reduction of the disease index ranged from 5-50% to 17-35% in greenhouse and field experiments, respectively.




**The book of Prof Datnoff is the world reference book on the subject. It can be ordered from www.shopapspress.org**

## CHLORINE

Long before the role of Cl in crop production was recognized, Cl was routinely applied as chloride in NH4-N, K, and Ca

# for Suppressing Plant Diseases

fertilizers. However, even in the last decade, the disease-suppressing benefits of chloride salts are still mistakenly being ascribed to NH4, K, or Ca, says Datnoff. Soil applications of Cl influence nitrification, manganese availability, and beneficial soil microorganisms. Chlorine affects osmoregulation, organic and amino acid synthesis, nutrient cycling and root exudation that, in turn, directly influences the plant's susceptibility to infection. Datnoff's presentation explored the uses and mechanisms of suppressing diseases on asparagus, beets, celery and corn with Cl. Suppressed diseases were: Asparagus (Fusarium crown rot), beets (Rhizoctonia crown rot), celery (Fusarium yellows) and corn (Stalk rot, Smut).
Those treatments that suppressed disease were associated with an increase in Manganese (Mn) content in the plant. Many disease-suppressing activities, such as mulching, no-till, cover cropping, green manuring, will increase Mn availability. Mn containing fungicides (Mancozeb (Maneb® and Dithane®) are generally more effective than Zineb or Ferbam. Mn increases host defense mechanisms.

## NICKEL

Accumulating evidence implicates the essential nutrient, nickel (Ni), as potentially influencing crop diseases, says Datnoff. Effects can be direct control of certain pathogens upon contact, increased/decreased host-plant resistance, increased susceptibility at high concentration, or a variety of Ni-linked physiological and growth disorders. There is evidence that excessive usage of transition metal fertilizers (N, P, or divalent metals e.g. Ca, Mg, Mn, Fe, Cu, Zn), or certain agrichemicals such as glyphosate, might be adversely impacting the endogenous biological availability of Ni for key disease-associated metabolic processes.

## SILICON

Although silicon is the second most abundant element in the earth's crust, many soils still may be low or limiting in this element. Although not considered an essential nutrient, when silicon is amended to silicon-deficient soils, plants may show improved growth and enhanced plant disease resistance. Many components of host plant resistance (i.e., lesion number and size) are reduced; consequently, the resistance of susceptible cultivars is dramatically improved. Silicon also has been shown to suppress plant diseases as effectively as fungicides; thus reducing the number and rate of fungicide applications. Based on these findings, silicon may play an important role in the IPM of plant diseases. For more information, readers may refer to the article written by Prof Datnoff in the March 2009 issue of New Ag International. ■

**Potential efficacy of *SIR***

**Reduction of disease index (%)**

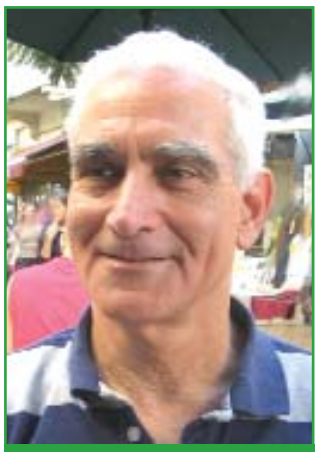
| Greenhouse experiments | Field experiments |
|---|---|
| 5-50% | 17-35% |

Haneklaus et al., 2009

## Plant Nutrients & Diseases resistance: Highlights

- N-form is important and will effect certain plant diseases differently. NH4-N is associated with reductions in pH while NO3-N increases pH. For example, Nitrate suppresses Fusarium, while Ammonium suppresses Verticillium.
- K provides proper ion balance and tugor maintenance. Form of K may be more important than amount.
- Ca reinforces cell wall components to resist infection.
- Cl suppressed diseases on crop that are tolerant of Cl such as asparagus, beets, celery, and corn perhaps by enhancing Mn uptake.
- S is involved in metabolic and disease defensive pathways in the plant.
- Ni is an important 'cofactor' and/or 'enzyme activator' of metabolic and disease defensive pathways in the plant.
- Si reinforces cell walls and acts as a signal to elicit plant mediated disease resistance.

# Can potassium nitrate be used as a pest-control agent?



Courtesy of M. Loison

**Dr Oded Achilea**

The answer is definitely yes, according to Dr Oded Achilea, from Haifa Chemicals Ltd. Much empiric evidence has accumulated over the years among Haifa's agronomists, regarding the pesticidal effects of potassium nitrate- based products, on different types of crop pests. These types encompassed mainly spider-mites and insects. A literature survey has identified recorded evidence of the effects of potassium nitrate (PN) also on nematodes and fungi. In his Miami lecture, Achilea highlighted such effects.

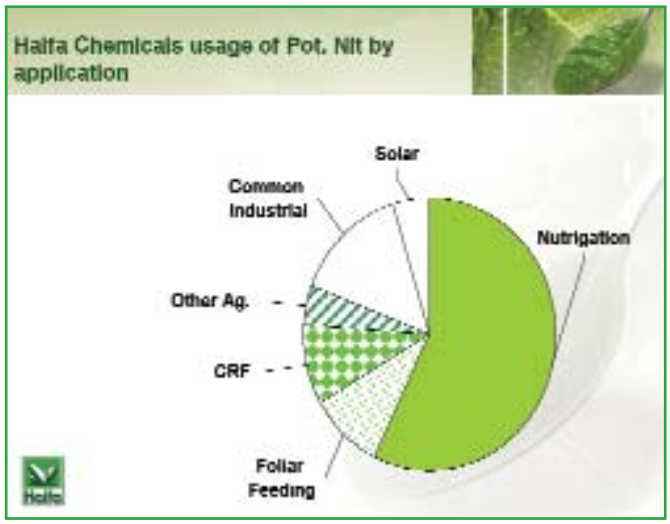
## SOLID EVIDENCE DOCUMENTED SINCE MORE THAN 25 YEARS

Potassium Nitrate (PN) was found to produce a negative chemotaxis for 2nd-stage juveniles of the very common and aggressive nematode Meloidogyne incognita. Castro et al, have found in California, USA. 1991, that PN presence at concentration above 30 mg/L creats a chemical protective shield around the root system of tomato plants, that prevents the nematodes from approaching the root system.

PN sprayed at 1% on pecan trees in Georgia USA, has reduced Yellow Pecan Aphid (Monelliopsis pecansis Bissell) population by factors of 3–9 during different parts of the growth season, when sprayed at a fortnightly schedule, 10 times between April and August. These results were very consistent during 4 consecutive years, showing highest effectiveness against the pest larvae.

Florida Wax Scale (FWS) (Ceroplastes floridensis Comstock) was found highly susceptible to PN sprays over 25 years ago in Israel (Yardeni & Shapira). PN at 4%, tank-mixed with 2% summer oil, sprayed on various citrus species has controlled 80% of the FWS larvae, which was a better result than spraying them separately. Due to the importance of this pest in Israel, these experiments were practiced several more times with excellent results that exceeded the results obtained with highly-toxic and non-selective organo-phosphates, e.g. chlorpyrifos, carbaryl, methoate, ethione. A thinning procedure aimed at the weak larvae stage in the build-up of the FWS population, by spraying PN, leaves the natural enemies undisturbed to build up their populations, and allows them a long activity time. This procedure has kept a certain experiment citrus grove free of FWS during 7 successive years.

Recently, PN has been found as a potent anti-fungal agent too. Phytophthora (P. sojae) stem-rot disease was efficiently controlled in soybeans in experiments carried out in Japan (Sugimoto, 2009). Two mechanisms have been identified. PN concentrations as low as 0.4-10 mM decreased the release of the fungus zoospores, while the application of 30mM has suppressed the disease mainly by accumulation of potassium in the penetration-stopping sites in the cortex layer of the soybean plants.




## A NEW TOOL IN IPM STRATEGIES

According to Achilea there are two main advantages of using PN and its specially-developed derivatives for pest management. First, PN is already in wide nutritional use for great many crop species, as a foliar spray and a soil- or a nutrigation-applied product, so best application techniques are already well known, and can be easily adapted to the new pest-control application. Second advantage is that PN is considered as an environment-safe substance that has expressed so far high specificity against the targeted pests. There is therefore, such as for other fertilizers like MKP, an opening for an increased usage of Potassium Nitrate in the design of integrated pest management programmes on a number of crops. ■

# Managing grapevine diseases with Ecoswing®

**In Miami, Nicolas Cock, President of the Colombian company EcoFlora S.A., presented Ecoswing, a natural fungicide for agricultural use made from plant extracts.**

Potassium EcoSwing® is a wide acting natural preventive and curative fungicide, which has been successfully used to control powdery mildew (Sphaerotheca pannosa) in roses, acid rot, oidium (Uncinola necator) and Botryitis sp. in grapevines, crown rot in bananas, and other diseases. In order to widen the scope of field tests performed in Colombia (Isabela grapevine variety cultivated in Valle del Cauca), field tests were made in several zones of Peru to verify the control of acid rot, oidium, and botrytis in other commercial grapevine crops. When compared with other products (21,7% control), EcoSwing® (99% control) achieved significantly better control of acid rot, within the phenological stage of ripening and harvesting of the fruit. In adition, the product achieved a comparable level of control of oidium at a dose of 2ml/L as Iprodione based chemical product (both treatments achieved 100% control of infected leaves and a stable infection degree in leaves previously infected). Finally, for the control of Botrytis all of the EcoSwing® dose levels tested achieved favourable results when compared to the chemical products traditionally used (100% control of the infected clusters and decreased infection levels in clusters previously infected).

Courtesy of M. Loison

**Nicolas Cock**

Cock concluded that the results obtained using EcoSwing® show that it is an ideal product to be used in vineyard integrated disease management plans. Further, the use of EcoSwing® has several advantages over the use of synthetic products. Firtsly it does not leave toxic residues and hence it has been shown that it presents no risk to the health of agricultural workers and consumers of the treated fruits and for this reason it has no pre-harvest restrictions / period. Secondly, being a natural product that combines a mixture of synergistic ingredients, it is a product of great complexity in its composition, thus reducing the risk of pest resistance. ■

## Timorex Gold™:

# A novel approach for controlling Black Sigatoka disease in Banana

Courtesy of Reuveni

**Moshe Reuveni**

Introduced in Miami by Moshe Reuveni, the Scientific Director of the Swiss-Israeli company Stockton Agrimor AG, a product based on Tea tree oils shows great potential in the control of the most damaging disease that affects banana in the world.

A novel product controls the most harmful disease that affects banana: Mycosphaerella fijiensis (Morelet), a fungus widely known as Black Sigatoka Disease (BLS). Black Sigatoka, BLS, is considered the most damaging and costly disease of banana and plantain. The control of the disease accounts for about 30% of the total production costs and about 40% yield loss on plantain. Greater losses may occur on export banana as a result of premature ripening, during transportation and storage, when control measures fail. Chemical control of BLS is achieved with the alternation or tank mixing of protectants and systemic fungicides in order to provide a sufficient control and to reduce resistance risk.

Many chemical products have been used against BLS. In fact some of them such as Dithiocarbamates have been in use for more than 50 years. Others have been sprayed in the farms for more than 20 years such as Benzimidazole, and Ftalonitrilo, Morpholine, and Triazoles. Among the "new" products used are Strobirulines, Anilinopyrimidine, Spriroketalamina and some "soft" options such as Bacilus Subtilis and M. Alternifolia. The problem is that the fungus has developed resistance to most of them: Dithiocarbamates, Ftalonitrilo, Morpholine, Anilinopyrimidine and Spriroketalamina.

### THE SOLUTION COMES FROM THE TEA TREE

Timorex Gold™ 24 EC is a natural fungicide based on an extract of Melaleuca alternifolia, a plant commonly know as Narrow-leaved Paperbark or Narrow-leaved Tea-tree. This species is native to Australia and it is used for distillation of essential oil. It is the primary species for commercial production of Tea tree oil (melaleuca oil), a topical antibacterial and antifungal used in a range of products including antiseptics, deodorants, shampoos, soaps and lotions. The product was developed by Biomor, an israeli subsidiary of the Swiss Stockton Agrimor. Timorex Gold™ is a non residual product, safe to beneficial insects, environment and humans. It is a tool for Resistance Management, due to it being a multi-component substance and it has been approved by leading organic associations.

Moshe Reuveni showed several data obtained in the lab and in the field. The in vitro studies show that Timorex Gold™ is highly effective against Mycosphaerella fijiensis spore germination. At concentrations of 0.01% and 0.1% Timorex Gold™ provides 39% and 100% inhibition, respectively. The results also demonstrate that Timorex Gold™ is effective on both conidia and ascospores. Timorex Gold™ also inhibits mycelial growth of the fungus. Reuveni also showed very promising results on field trials done comparing young banana plants in conventional

management, organic management and a commercial comparison of Timorex Gold™ vs. a standard conventional products protocol (Triazole, Strobilurine). According to Reuveni, Timorex Gold™ exhibits high prophylactic and curative efficacy against BLS. Timorex Gold™ actually demonstrates an efficacy comparable to leading systemic fungicides (such as Strobilurines and Triazoles groups). It is widely adopted for large scale use in the key banana growing countries in conventional farms. The product is already registered in most banana-growing countries - Colombia, Costa Rica, Guatemala, Honduras, Nicaragua, Mexico, Republic Dominican and Philippines. ■

# Managing plant parasitic nematodes with bio-fumigants and bio-stimulants

Courtesy of NAI

**S.J Turner**

This was the topic covered by S.J Turner, Agri-Food & Biosciences Institute & The Queens University of Belfast in Northern Ireland, during her Miami lecture. Her conclusion? Potential is there but do not expect any miracle. At the moment, biofumigants and biostimulants formulas are not as efficient as existing synthetic nematicides but their role may increase in the future, at least for certain crops.

In recent years the control of many plant parasitic nematodes has been heavily reliant on synthetic nematicides, resulting in good quality products, but not necessarily reducing nematode levels. Following the withdrawal of many nematicides a number of plant-based products are becoming available for agricultural use with claims to either kill a range of plant pests or to act as a plant bio-stimulant, enabling crops to better tolerate pest attacks. Cyst (Globodera/Heterodera spp.) and root-knot (Meloidogyne spp.) nematodes are, economically, the most important groups of nematode pests of many agricultural and amenity sectors. Potato cyst nematodes [PCN] (Globodera spp.) continue to be the most important pest of potato in many regions of the world, with their management by nematicides and resistant varieties limited. Root-knot nematodes have become more widely recognised as causing crop damage in recent years, due to climate change and other environmental and management practices. Both pests have the potential to be controlled by integrated application of bio-fumigant and bio-stimulant plant products.

## FARMERS MUST REMAIN REALISTIC!

A series of field trials evaluated the effect of plant-based bio-fumigants/stimulants on PCN G. pallida population levels and resulting potato yields and quality. Bio-fumigant formulations derived from sugar, mustard, garlic and bio-stimulant products derived from seaweed were compared with a granular nematicide and untreated controls. The effect of G. pallida on growing potato crops was assessed by tuber yield and leaf tissue analysis of essential minerals. The resulting increase or decline of PCN was also recorded. Results showed that all bio-fumigant products increased both total tuber and marketable yield, but to varying extents, and that yield was further enhanced by supplementary foliar application of seaweed-based bio-stimulants. In addition some products reduced PCN multiplication (Pf/Pi), compared with untreated controls.

Preliminary trials suggest that these plant-based products have the potential to accelerate PCN decline within an integrated management system once optimum treatment regimes are further clarified, but that farmers must be realistic in evaluating their effectiveness, compared with chemical nematicides.

Laboratory tests were performed assessing the effects of seaweed extracts and other organic materials on the growth of creeping bentgrass and perennial ryegrass infested with Meloidogyne minor. Both bulk seaweed extracts and specific purified fractions significantly enhanced root growth. Root knot nematode attack reduced root growth of both ryegrass and bentgrass but this reduction was ameliorated by biostimulant application. Most biostimulants did not affect nematode gall numbers, however application of harpin protein significantly reduced galling in creeping bentgrass roots. With the regulatory removal of a number of effective nematicidal products, the control of plant parasitic nematodes in amenity turfgrass has become increasingly difficult. Biostimulants may have a key role in the management of nematodes in this sector. ■

*Plant products used for nematode control*

| | | Sources |
|---|---|---|
| 1. | Bio-fumigants | - *Graminae* [Saccharum spp.] (Sugarcane)<br>- *Meliaceae* [*Azadirachta indica*] (Neem)<br>- *Brassicaceae* (mustard, rocket etc.)<br>- *Solanaceae* [Capsicum spp.] (Chilli etc.)<br>- *Liliaceae* [Allium spp.] (Garlic) |
| 2. | Bio-stimulants | - *Ascophyllum nodosum* (seaweed)<br>- *Laminaria hyperborea* (seaweed)<br>Humic Acid |

## Marrone Bio Innovations:

# Regalia® for Control of Fungal and Bacterial Diseases

Marrone Bio Innovations was founded in 2006 by Pam Marrone in Davis, California, USA. The company discovers, develops, and markets effective and environmentally responsible natural products (biopesticides) that fill unmet needs for weed, pest & plant disease management, said Julie Versman, VP of Marketing of Marrone Bio in her Miami lecture.

The company focuses on products that improve yields and quality in conventional ag compared to chemical-only systems, products that lower the cost and increase yields in organic farming and products for water treatment and water bodies.

Julie Versman

Courtesy of M. Loison

### A BIOFUNGICIDE FROM GIANT KNOTWEED

Regalia® is a novel biofungicide extracted from a plant: giant knotweed Reynoutria sachalinensis. It`s main active ingredients are Emodin and Physcion. It has proven efficacy in the control of powdery & downy mildews, gray mold, bacterial leaf spots and bacterial blights. The product is currently sold in the US, Ecuador and in the UK.

Giant Knotweed`s antibacterial activity was discovered in 1980 and it´s antifungal effects in 1984. Some companies have developed products based on this plant, such as Compo and KHH BioSci, Inc.

Regalia® , that was launched in 2008, induces systemic resistance. The product induces plant immune system to produce phytoalexins, PR proteins, phenolics and antioxidants. It also has a strengthening effect inducing papillae formation and a contact effect inhibiting spore germination.

Versman showed a massive amount of data based on many trials. Regalia® works in berries, citrus, cucurbits, grapes, leafy greens, ornamentals, turf, peppers, pome fruits, stone fruits, strawberries, tomatoes, walnuts. And it controls the following diseases: Powdery Mildew (Sphaerotheca spp, Erysiphe cichoracearum), Gray Mold (Botrytis cinerea), Downy Mildew (Bremia lactucae, Peronospora spp.), Bacterial Blight (Xanthomonas spp.), Citrus Canker (Xanthomonas spp.), Greasy Spot (Mycosphaerella citri), Bacterial Leaf Spot (Xanthomonas spp.), Target Spot (Corynespora casslicola), Bacterial Speck (Pseudomonas syringae), Tomato Late Blight (Phytophthora infestans), Early Blight of Tomato (Alternaria solani) and Bunch rot/gray mold (Borytis cinera).

Julie Versman also showed very interesting data in tomatoes, citrus, grapefruit, blueberries, cucurbits, melons and lettuce. Beyond the specific crop results some interesting features of the product are that it is very resistant to rainfall, it has a very good combination with copper products and especially with many other chemical products such as Azoxystrobin, Chlorothalonil, CU2O, Thiophanate Methyl, Bacillus Subtilis, Famoxadone + Cymoxanil, Manganese Ethylene, Mefenoxam and Pyraclostrobin. ■