"SURROUND® (KAOLIN 95% W/W) WP CROP PROTECTANT: A NEW BROAD SPECTRUM CROP PROTECTANT AGAINST INSECTS, SUNBURN AND HEAT STRESS ON MANY CROPS"

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Summary

Particle film technology is an exciting recent development with tremendous potential in both organic and integrated pest management (IPM) of horticultural crops. Surround WP is a product of Engelhard Corporation manufactured from kaolin, a naturally occurring mineral that is safe enough to be used as human food additive and in toothpaste. Surround WP forms a white barrier coating on crops which allows the passage of photosynthetically active radiation (PAR) while reducing the amount of harmful infrared and ultraviolet radiation that reaches the plant. Surround WP reduces canopy temperature, alleviating heat stress and sunburn. Photosynthesis is not impeded and can actually increase in many cases. Surround WP also protects plants against certain insects. Many insect species are repelled from the plants thus reducing oviposition and feeding. Insects that come in contact with Surround WP-treated plant surfaces often become agitated by the microscopic mineral particles. These unique product characteristics have been exploited worldwide, in controlling or reducing damage from pear psylla, leafhopper, thrips, and olive fruit fly. Surround WP is also used with promising results against many other pests on many crops. Surround WP is soft on ladybeetles. In Greece in particular Surround WP has been tested by the Trial Unit of Hellafarm SA against pear psylla and thrips on grapes. A field trial against olive fruit fly is in progress in Chania, Crete by the Institute for Olive Tree and Subtropical Plants.

Introduction

Organic production of high quality fruits and fruit products still remains difficult while the demand for high quality organically grown plant products continues to increase with encouraging prospects. Conventional plant cultivation occasionally requires a large number of pesticide applications annually, without ensuring adequate pest control (Andrew, 2002). Many of these pesticides are classified as toxic or irritating, posing thus a threat to the workers, neighbours, beneficial organisms, animals, environment and finally to the consumers. Nonetheless, it must be pointed out that many efforts are being made by the plant protection product industries to commercialise products more friendly to the farmer, the consumer and the environment, with low or even no toxicity.

Consumer interest in organically grown products has evolved as a major force, driving farmers from conventional to organic cultivation. Farmers interested in transitioning some or all of their land to organic production requires information on management practices for such systems. Both farmers and agronomists rightfully consider the first years of transition, from the conventional way to the organic one, the most challenging and difficult period. The need for ensuring the income of the farmers during these first difficult years and onwards sets a challenge to the production of plant protection products to be labelled as "suitable for organic cultivation."

Particle film technology has emerged as a new method for controlling pests and diseases of horticultural crops in both organic, integrated and conventional pest management (Andrew,

2002). Organic growers need better methods of controlling devastating pests in their crops, while conventional growers would gladly embrace pest-control products that are effective, yet safer to use in pest management programs. Particle film technology offers such opportunities and advantages, as fine film coatings of microscopic mineral particles are sprayed onto plant surfaces to form a protective barrier that either controls or suppresses pests, while at the same time many beneficial pests that do not feed on the plant surfaces generally remain unharmed (Glenn and Puterka, 2005).

What is Surround WP crop protectant?

Particle film technology is a combined synthesis of knowledge on mineral technology, pest behaviour and light physics as they apply to both pest control and plant physiology. One of the most promising particle films is manufactured from kaolin, a naturally occurring clay mineral that is approved as human food additive. Kaolin is a white non-porous, non swelling, low abrasive, fine grained, plate-shaped alumino-silicate mineral that easily disperses in water and is chemically inert over a wide range of pH (Glenn and Puterka, 2005). Scientists with the U.S. Department of Agriculture have developed and researched these coatings under a Cooperative Research and Development Agreement with Engelhard Corporation, Iselin NJ. Engelhard has modified the kaolin mineral to make it uniform, sprayable, and of optimum size for pest control or suppression while allowing the passage of photosynthetically active radiation (PAR) and reflection of ultraviolet and infrared radiation without blocking stomatal function (Figure 1). The product is commercialised under the trademark Surround WP crop protectant (from now on referred as Surround WP) (Glenn and Puterka, 2005).

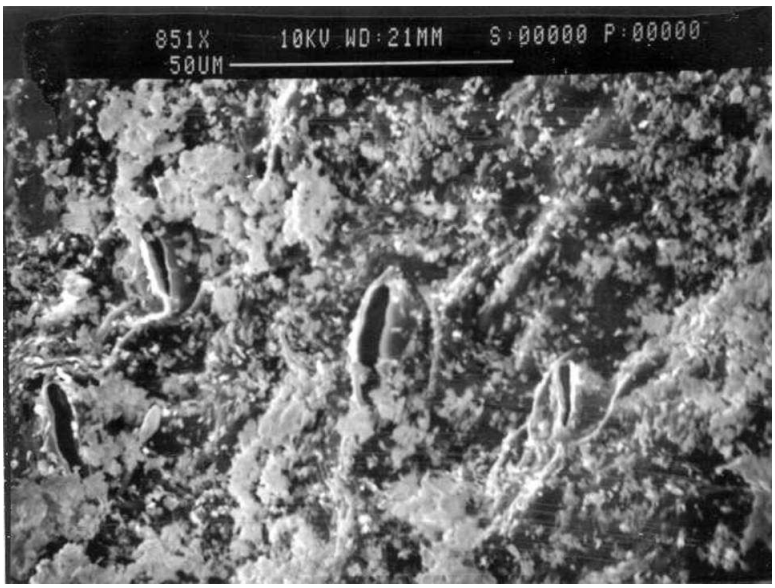

Figure 1. *Scanning Electron Micrograph (SEM) of a particle film, Surround WP, on the lower apple leaf surface (Glenn and Puterka, 2005)*

Surround WP offers growers a potent new tool against pests and harmful solar effects (sunburn and heat stress). After Surround WP is sprayed on the plant surfaces it leaves a powdery white film that safeguards foliage and fruit against harmful pests, sunburn damage and heat stress. Surround WP forms a barrier coating on crops that acts as a physical barrier between pest and its host plant, providing thus protection to the plant (Engelhard Surround WP crop protectant product label; Kerns and Wright, 2001; Glenn and Puterka, 2005).

General Application Guidelines

(Engelhard Surround WP crop protectant product label).

The rate of the product to be used is dependent on the amount of plant surface to be covered. Surround WP is generally recommended to be used at concentrations of 2.5 to 5 kg/hl. Sufficient spray volume should be used in order to obtain good coverage. That usually means a thorough near-drip application. As coverage of all portions of the plant that are to be protected is deemed essential, two or more applications are almost always desirable. For optimal performance against pests like pear psylla, applications must coat both sides of the leaves. Applications to tree crops can be conducted using commercial air-blast or high-pressure sprayers that provide enough air turbulence to coat both sides of the leaf, bark and fruit. After application, plant surfaces will usually turn a hazy white colour after drying. Additional applications will turn the plant surfaces deeper white. When dry foliage has lost its white appearance, reapplication is necessary. Heavy rainfall, new growth and wind erosion may affect film quality coverage. After heavy rain it is necessary to re-establish coverage as soon as the surface is dry. However, reapplication may not be necessary if target surfaces remain thoroughly covered, even after heavy rain. Overly thick coverage is not recommended. Surround WP may also be applied by air, taking precautions required in order to prevent any possible drift. Aerial application of Surround WP is usually applied against stress and sunburn conditions and are not effective for controlling most pest infestations.

Agricultural Uses

Surround WP is currently used in agriculture as pest control or suppression agent and as a heat stress and sunburn protectant agent. It suppresses insect's infestation on plant surfaces while at the same time protects against solar induced problems.

Surround WP against sunburn and heat stress

Solar injury, mainly on fruit surfaces, reduces the commercial value of plant products and also makes them vulnerable to decay due to secondary infection by microorganisms. Solar injury occurs in hot regions of the world including semiarid and arid regions as well as areas witha Mediterranean type climate is this last part true? I have not heard this.. The cause is primarily the excessive heat damage of the surfaces exposed directly to the sun (mainly the south and west sides of the plant or orchard). However research has indicated also the damaging role of the ultraviolet radiation (UV) as well as that of infrared radiation (IR) (Glenn et al., 2002). The critical fruit surface temperature is already known for a number of various crops, above which sunburn occurs. Evaporative cooling is an effective way to reduce sunburn damages, but there are concerns over expense, water quality as well as the need to reduce agricultural water use (Glenn et al., 2002). Applications of Surround WP approached the effectiveness of evaporative cooling, in reducing surface temperature. Reflective anti-transpirants, such as Surround WP, unlike polymer film ones that physically block the stomates, lower surface temperature by increasing reflection of IR radiation (Figure 2) (Glenn and Puterka, 2005). Surround WP applications reduce solar injury by mechanisms that include also reflection of harmful radiation, which in turn results in reduced surface temperature (Makus and Zibilske, 2001).

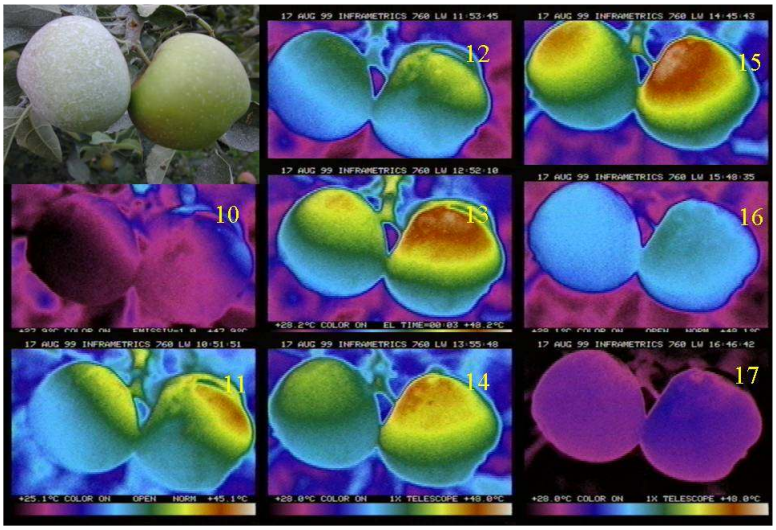

Figure 2. *Thermal Infrared images of an apple cultivar with (on the left) and without (on the right) Surround WP particle film layer.*

Surround WP reflects UV and IR radiation with the degree of reflection depending on the degree of deposition. Kaolin processing technology plays a key role in the ability of the final product to reflect harmful solar radiation. Thus, the specially processed and refined kaolin of Surround WP demonstrates great effectiveness in reducing heat and light load on plant surfaces. IR and UV radiation reflection can reduce surface temperature by in some cases up to 9.7^{0}C (Figure 3), resulting thus in increased plant vigour and yields.

Figure 3. *Surround WP cooling effect and sunburn protection of tomato fruits.*

By reducing leaf temperature, Surround WP ameliorates the vapour pressure gradient between leaf surface and bulk air, which is the driving force behind transpiration. This means that the water use efficiency (WUE) (the ratio of carbon dioxide assimilation/transpiration) is enhanced, especially under conditions that favour water loss through transpiration, such as high temperatures combined or not with high intensity solar radiation.

As it is critical for any product applied to a plant not to interfere with physiological functions such as photosynthesis, it is of great importance that the deposition of Surround WP particles on leaf surfaces enhances photosynthesis rate (Jifon and Syvertsen, 2003). The physical properties of kaolin can be altered by processing, in order to achieve desirable characteristics through specific particle size distribution so as to change light transmission properties (Glenn and Puterka, 2005). The processing techniques applied by now on kaolin mineral enabled Engelhard corporation to achieve desirable characteristics of Surround WP so as in single leaf studies the carbon assimilation, stomatal conductance and water use efficiency to be increased, particularly under conditions of elevated temperature and/or solar radiation.

As a general recommendation of use of Surround WP against sunburn and heat stress one should have in mind that applications have to be conducted before the onset of conditions that lead to sunburn or heat stress. Moreover, in order to achieve a satisfactory level of protection at least two to three applications will be necessary so as to attain an optimal coverage.

Surround WP and insect suppression

Arthropods locate and accept plants as possible hosts by the use of their senses, e.g. touch, taste, sight and smell. During their attempt to find a host all four senses interact with each other in order to accomplish a total aspect of the host, based on which the pests either recognize or fail to recognize the plant as their future host. Plant tissues coated with films are obviously altered visually and tactilely towards pests (Glenn and Puterka, 2005). Thus one of the first modes of action of particle films in general and Surround WP particularly is host camouflaging, making thus plants unrecognisable from their enemies (Figure 4). By camouflaging, Surround WP reduces pest oviposition and the overall pest population in the microclimate of the plant foliage.

Figure 4. *Host camouflaging of Surround WP.*

Repellence is another mechanism of Surround WP action against pests (Glenn and Puterka, 2005). Pests coming in contact with particle film coated plant surfaces are unable to feed, since the surfaces are covered by kaolin film and eventually could starve.
Other mechanisms of pest suppression include a) the reduced survival of larvae born inside such particle film coated leaf environment and b) impeded movement, since micro-particles of the product attach on the pest body making thus its movement across plant surface difficult and reduce its grasping ability on the plant surface.
Surround WP has been already used with success for controlling a broad range of arthropods pests on nearly all major groups of horticultural crops in the U.S.A. In Greece particular interest has been evolved in the use of Surround WP against pear psylla, thrips on grapevine and olive fruit fly.
In order to get licence for commercialising Surround WP as pest suppression agent a number of efficacy trials have been conducted by Hellafarm R & D Department on the pre-mentioned crops against the enemies described as can be seen in the following tables.

Table 1. Efficacy of Surround WP against thrip infestation on grape bunches.

Year / Region	Treatments		Efficacy % control		Efficacy Reference % control	
	Surround® WP Sprays x dose	Reference Product	Nb. Thrips	Scarred Berries	Nb. Thrips	Scarred Berries
2002 / Kavala N. Greece	3 x 2 kg/hl	Savona SL 3 x 1l/hl	56	63	**-34**	**3**
	3 x 3 kg/hl		56	**69**		
2002 / Corinthia S. Greece	3 x 2 kg/hl		**29**	**48**	-32	**32**
	3 x 3 kg/hl		63	49		
2003 / Corinthia S. Greece	3 x 2 kg/hl		55	44	35	31
	3 x 3 kg/hl		**68**	50		
2004 / Imathia N. Greece	3 x 2 kg/hl		67	60	**53**	10
	3 x 3 kg/hl		66	64		

Table 2. Efficacy of Surround WP against pear psylla.

Year/ Region	Treatments		Efficacy Surround WP % Control			Efficacy Reference % Control		
	Sprays x dose	Reference Product	Eggs	Young larvae	Adult larvae	Eggs	Young larvae	Adult larvae
2003/ Imathia N.Greece	**4 x 3 kg/hl**	**Savona SL[1]**	**84.7**	**86.7**	**65.8**	**57.1**	**41.3**	**-7.9**
2004/ Corinthia S.Greece	**7 x 3 kg/hl**	**Helmadix EC[2]**	**95**	**78.6**	**83.6**	**96**	**84.5**	**81.8**
2004/ Kavala N.Greece	**11 x 3 kg/hl**	**Savona SL[1]**	**66.4**	**100**	**89.9**	**11.2**	**-55**	**1.6**
		CPP[3]				**56.5**	**50**	**42.6**

[1] potassium salts of fatty acids 50.5% w/v
[2] diazinon 60% w/v
[3] Crop Protection Program given by the Plant Protection Service of Thermi-Thessaloniki

The results from these first trials in Greece under field conditions are very promising, since Surround WP effectively suppressed psylla infestation compared to either a biological phytosanitary product as Savona (potassium salt of fatty acids) SL or an organophosphorus insecticide as Helmadix (diazinon 60% w/v) EC. Same good efficacy results were obtained against thrips on grapevine compared to Savona SL. From the very first results against olive fruit fly Surround WP seems as a promising organic agent for fruit fly suppression on olive orchards (data not presented).

Research has demonstrated that lady beetles operate well against aphids on plant surfaces treated with kaolin particle films. Generally though, some reduction in parasitism has been noted as the role of predators and parasites should be minimal due to the low number of prey present. On the other hand, the particle film does not generally affect honey bees and other pollinators (Engelhard Surround WP Crop Protectant Product Label) as long as it is not applied while bees forage. Surround is one of the few products that is labeled in the US for applications during bloom. Thus it can be used against thrips and European apple sawfly which require bloom sprays to be effective.
In summary, Surround WP has no specific site of action and multiple modes of action, therefore resistance is unlikely to develop. In order to achieve good pests suppression, applications should be conducted before infestation and may need two to three applications in order to establish a good coverage (this number depends on pest pressure and weather conditions). Due to its unique nature Surround WP is registered for use in agriculture with a pre-harvest interval of zero days.

Fruit Washing Guidelines (Engelhard Surround WP Crop Protectant Product Label)

As Surround WP particle film coating on fruit surfaces may be considered unsightly for consumers, the washing of the fruits is necessary. Surround WP has been designed to have controlled adhesion to fruit surfaces during the season (Figure 5). A wash is required in order to remove any product residue on the edible parts of the plant treated. Brushes with or without washers can be used. For fresh market fruit that will not be washed, the applications should stop when fruits are still small – about ¼ to 1/3 of eventual size. The remaining coating will eventually loosen and fall of as fruit grows or from rain or wind attrition. For delicate fruits (table grapes) applications should stop before bloom. Surround WP is easily removed during processing in wineries and olive oil industries.

Figure 5. *Surround WP has controlled adhesion on fruit surfaces.*

Conclusions

Surround WP is a biological product (PHI: 0 days) with tremendous potential in organic as well as in conventional plant cultivation practice. It protects against sunburn and heat stress,

favours plant growth, and enhances yield under conditions of increased solar radiation and temperature. At the same time, its use enables the suppression of many pests on a wide number of different crops by ways of several modes of action, which prevent development of resistance. In the future, Surround WP should be further tested as suppression agent against more pests or diseases on different crops.

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