HORTICULTURAL OILS AND SOAPS, ECO-FRIENDLY BIOACTIVE COMPOSITIONS FOR ORGANIC FARMING

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1 INTRODUCTION

The sustainable development of agricultural production systems, which is called to meet the food needs of the world population without damaging the environment, must follow several objectives such as better quality of agricultural products, healthier and better value food, increasing sustainability and reducing the environmental impact of wastes. Agrochemicals play an important role in agricultural practice to prevent loosing of crop yields. Large amounts of toxic residual chemicals found in food, ground water and environment determined stringent restrictions on the use of chemical pesticides, limiting or eliminating from the market many agro-efficient products responsible for human diseases and agro-environmental hazard.

Research must find efficient solutions to create and promote safer, selective and biodegradable products with improved properties as phytotoxicity, staining and killing pests. One of these solutions is the optimal valorisation of natural renewable resources as opportunities for agrochemical industry to manufacture a large variety of eco-friendly products as alternatives to synthetic pesticides. The most convenient is treating and converting organic by-products and wastes from various human activities into bioactive products for cultivated plants nutrition and protection against pests and diseases.

Residual greases resulted from agro-industrial processing or spent edible fats from public food services are potential contaminants of the environment and should be converted into value added useful products with non-food agricultural applicability. Organic residues from industrial processing of greases contain fatty acids, naturally occurring substances in animal and vegetal organs. Ecological technologies can provide a diversity of fatty acid derivatives as active ingredients for biodegradable compositions with good efficacy and low toxicity for plants, humans or pets. Preliminary studies suggested that canola oil, cottonseed oil and soybean oil may serve as fungicides and/or synergists (Lancaster, 2002, Nix, 2010) for horticultural purposes (Fernandez, 2006, Harris, 2008, Iannotti, 2010, Müller, 2005) and several fatty acid derivatives were considered safer alternatives to agrochemicals containing unfixed copper, sulphur, free fatty acids or mineral oils (Cranshaw and Baxendale, 2005).

Present paper proposed some possibilities for treatment and conversion of fatty residual fractions into horticultural oils and soft soaps compositions to be used as safe and biodegradable products for plant protection in organic agricultural practice.

2 MATERIALS AND METHODS

Horticultural oils and soaps compositions were obtained from materials disposed from industrial processing of animal fats and vegetable oils such as residual lipid fractions resulted from soap industry, biodiesel manufacture and spent edible oils. The processing technologies were clean, simple, cost-effective and more environmentally compatible than others, according to the sustainable development strategies focused on promoting and improving ecological products and technologies.

Residual lipid fractions contain glycerol esters with olefin bounds and functional groups easy to convert using mild treatments and simple laboratory installations into various agro-useful products for cultivated plants protection. The conversion of residual fats into horticultural oils involved as main stages: a) lipid extraction, b) trans-esterification and c) formulation as a light oily concentrate. Calcium and copper soaps were prepared using the double decomposition method of saponification which included two reaction steps: a) mild heating saponification of fatty acids containing mixtures from an industrial unit for processing animal greases and vegetable oils; b) the reaction of the crude alkali soap with diluted aqueous solutions of cupric inorganic salts, such as copper sulphate, to precipitate water insoluble copper soap. Soaps prepared from caustic soda yield pure soaps which may be conveniently washed, filtered and dried. The crude copper soap may be ground when cold to give a fine powder or may be obtained as a viscous mass, depending on the fatty acid type. Several samples were fortified with various ratios of natural phospholipids and formulated as wettable powder, concentrated suspension and paste (Popescu et al., 2010).

Horticultural oils and soaps compositions were tested during two continental temperate seasons: winter dormant season and vegetative growing period. The composition consisting in horticultural oil, bioactive enhancer, surfactants and antioxidant was obtained in 5 variants and tested in laboratory conditions following standard procedures. The best variant was selected and tested *in situ* against a dangerous overwintering pest of pear and apple fruit trees in orchards, San-José scale (*Quadraspidiotus perniciosus*). Experiments were performed using the linear method, each of them comprising five trials: 3 different concentrations of water diluted samples (1%, 1,5% and 3%), one trial treated with standard product and one untreated control. Each experimental variant comprised 3 repetitions, one repetition meaning 5 trees. The products were applied by spraying on hard infested bark and sprouts of fruit trees, using a SOLO manual pump of 10 litres capacity, in mild conditions of wind and atmospheric temperature (6-8°C) of the dormant season. The effects of the treatment were registered by *in vitro* and *in situ* monitoring (Popescu et al. 2010). The evaluation of biological action consisted in harvesting, observing pieces of botanical material (5-6 cm^2) and microscopically countering of shields with dead or alive larva before and after treatments (30 and 60 days). Nine variants of formulated copper and calcium salts of fatty acids were obtained and tested in laboratory conditions against various agricultural pests and diseases. Three of them were the most effective against powdery mildew and were subjected to *in situ* experiments. Similar application method and equipments as for horticultural oils were used for soap formulations with the main difference that treatment was applied during the vegetative period, following warning of hard contamination with powdery mildew (*Podosphaera leucotricha)*, on sprouts and foliage of Jonathan and Idared susceptible apple trees. Treatments were applied by spraying of 1% water solution equivalent to 5, 10 and 15 kg/ha using 1500 litres of water/ha/treatment. Experiments were performing using Latin rectangle method, with 21 variants and 3 repetitions, one repetition meaning one tree.

3 RESULTS AND DISCUSSION

Several mixtures of methyl esters of fatty acids from sunflower, soybean and micro algal oils were obtained and formulated as stable light oily concentrates. Table 1 presents analytical data on the concentration of preponderant C10-C22 fatty acid methyl esters in horticultural oil compositions.

TABLE 1 **Analysis results on fatty ester ingredients in horticultural oil compositions**

Methyl esters of fatty acids	**Concentration (%)**
Linoleic C18:2	44-68
Linolenic C18:3	0,2-39
Oleic C18:1	19-43
Palmitoleic C16:1	0-19
Palmitic C16:0	2-11
Stearic C18:0	2-6
Others (caprilic, myristic, lauric, eicosenoic, erucic)	< 2,5

The efficacy of the composition against hibernal larva of *Q. perniciosus* was demonstrated countering the dead and alive individuals found in the hard infested bark 30 and 60 days after treatments. The most significant results were recorded in tables 2 and 3, the efficacy E (%) being calculated using the Savescu-Iacob formula:

$$E = [1-a_2/(N-M_2)] \times 100$$

where: N = individuals assessed after treatment; M_2= dead individuals countered on untreated control; a_2 = alive individuals countered after treatment (30 and 60 days respectively).

The best results were compared with those obtained in two variants: untreated controls and standard product (mixture of a chemical insecticide and a mineral oil) usually applied to destroy overwintering pests.

TABLE 2 **Efficacy of horticultural oil composition against *Q. perniciosus* infesting pear trees**

Time of action (days)	Efficacy (%) Standard (1,5%)	Sample 1 (1%)	Sample 2 (1,5%)	Sample 3 (3%)	Control (no.) alive	dead
30	93,50	88,23	92,40	93,08	1120	185
60	95,48	91,04	95,12	95,98	1210	205

TABLE 3 **Efficacy of horticultural oil composition against *Q. perniciosus* infesting apple trees**

Time of action (days)	Efficacy (%) Standard (1,5%)	Sample 1 (1%)	Sample 2 (1,5%)	Sample 3 (3%)	Control (no.) alive	dead
30	91,16	87,07	91,81	92,73	1380	450
60	96,25	89,90	94,77	95,23	1420	390

Experimental results demonstrated the highest efficacy of spray applications with 1,5% water solution of the original composition, comparable with standard trials even on harder infestation of fruit trees. A small excess of efficacy for 3% sample is not economically justified to double the quantity of product per ha. Winter eggs of spider mites (*Bryiobia rubriculus*) were present too in bark and sprout and disappeared almost completely in the same period of observation. Horticultural oil composition controlled smaller insects and scales by coating and suffocating them, working on all stages — eggs, larvae, nymphs and adults- of the target pest. It also had an insect preventing effect coating plants with a fine oily film that repels egg-laying insects (Lewis, 2010).

(a) **(b)** **(c)**

FIGURE 1 **Biological action of horticultural oil composition against *Q. perniciosus* hibernal larva: alive larva infesting apple bark before treatment (a), dead larva 30 days (b) and 60 days (c) after treatment**

Separately, soap compositions were tested in orchards of fruit bearing apple trees. Jonathan and Idared apple fruit sizes were 0,5 and 2,5 cm when aggressive powdery mildew attach was reported and treatments were applied. Several formulations were prepared, formulated and tested, the best results being registered for three of them: paste of copper oleate/soy lecithin 1:0,25 (sample 1), concentrate suspension of calcium oleostearate/soy lecithin 1:0,25 (sample 2) and concentrate suspension of calcium oleate/soy lecithin 1:0,4 (sample 3).

The best results were compared with those obtained in two variants: control and standard trials, where standard product contained 0,6% wettable sulphur conventionally used to destroy mildew (Vanderlinde, 2010).

TABLE 4 **Efficacy of soap compositions against *Podosphaera leucotricha* infesting apple trees**

Parameters /variants			Sample 1	Sample 2	Sample 3	Standard	Control
Mildew	**Leaves**	**I**	3,0	3,3	5,2	8,7	75,3
infestation		**II**	0,1	0,1	6,3	9,8	27,6
degree (%)	**Sprouts**	**I**	1,2	1,2	3,8	4,2	44,0
		II	0,06	0,04	0,9	3,2	21,5
Fruit yields (kg/tree)			78	77	76	69	53

Treated variants recorded significantly lower infestation when compared to untreated variant which produced small unhealthy fruits and earlier loosing of leaves. The best results for soap compositions were obtained by foliar spraying with concentrations of 1%/ha/treatment and better results than standard which also registered 1% phytotoxicity on leaves and fruit as expected from sulphur. Copper in a fixed oily form was more effective at lower doses than old inorganic compounds, considerably better retained or absorbed by plants, milder than conventional fungicides but better utilized on the surface of plant tissues. The improved composition is a mixture of copper soaps synergistically acting in the presence of natural occurring phospholipids, even at 1% concentration of active ingredients in aqueous solution. A possible mechanism of action is the ability of fatty acids to increase the adhesion to plant leaves and mediates the transport of the fungicidal agent. Phospholipids facilitated the diffusion of fatty acids and soaps through hydrophilic structures of the vegetal tissues, thus contributing to the enhanced fungicidal action. Stable aqueous concentrate suspensions and pastes exhibited excellent spreader-sticker and film-forming properties when applied to plant foliage, tree wounds, soil or stored fruits and vegetables. Also, the lower water solubility of the fatty acid esters and salts compositions decreased their phytotoxicity and dissemination. Neither observable phytotoxic effects to fruit trees nor toxicity to animals or users were reported at required concentrations to control fungi. On the contrary, increased quality and quantity of fruit yields were obtained.

4 CONCLUSIONS

Horticultural oil and soap compositions made of residual fatty acid methyl esters and naturally fortified copper/calcium salts were confirmed as effective and eco-friendly alternatives to the conventional agrochemicals. An efficient control of the dangerous pest San José scale of the fruit trees was achieved in winter treatments with horticultural oil composition and synergistic fungicidal effects of copper and calcium salts of fatty acids with phospholipids were demonstrated. The fungicidal soap formulations were very effective against mildew in apples, thus confirming some experimental results obtained in other studies about mildew control on vines and wheat, brown rust on wheat, cucumber staining profiles and aphids in vegetables (Velea et al., 2009), being appropriate for protection of fruit plantations, vineyards, field crops and greenhouse vegetables, herbs and spices, ornamental trees and shrubs, houseplants, flowers and grass in public and private spaces. Spray applications of horticultural oil-in-water mixtures containing copper and calcium soaps as surfactants represent potential effective control agents with broaden biological activity to be study and tested for cultivated plants protection in integrated management schedules for organic farming.

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