

Development of Agricultural Methods and Policies for Insect Pest Control by environment-friendly techniques in Korea

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ABSTRACT

All the countries in the world are following-up sustainable agricultures which produce safe agricultural product to human and environment with high quality. For this purpose, many countries, which have advanced agricultural techniques, are trying in practicing environment-friendly agricultural methods by means of reduced organic chemicals and pesticides. What is more, many international organizations and countries set guidelines and policies, which support environmental-friendly agriculture. Because the desires of agricultural products, which are safe to human and environments are high in Korea, Korea's agricultural systems must be translated from conventional one which mainly use chemical pesticides for pest management into environment-friendly methods with sustainability and soundness.

One of the most serious problems in environment-friendly agriculture are side effects by conventional control methods with pesticides, and organic chemicals in the field. Nowadays, many countries, which have advanced agricultural techniques have overcome those problems by developing environment-friendly methods with non-toxic materials and natural enemies and opening up a new market in agricultural industry.

To cope with these worldwide trends, Korean government makes many kinds of policies for facilitating the bases of environment-friendly agriculture since 1997. Governmental agricultural research institute like Rural Development Administration (RDA) have carried out experiments for controlling pests and disease with its specific crop plants and found out many environment-friendly agricultural methods with no using chemicals and pesticides in horticultural greenhouses. In fruit growing, changing from conventional agricultural methods mainly with chemicals to minimum use of chemicals and environment-friendly control methods, are being carried out in a full-scale. Insect attractant like sex pheromones are actively investigated for timely forecasting of major pests and for reducing the times of pesticide sprays. Moreover, many experiments are being in progress about mating disruptions and mass trappings of pests in the crop fields with synthesized sex pheromones.

Keywords: Environment-friendly agriculture, Natural enemies, Sex pheromone, Sustainable agriculture

INTRODUCTION

By the time 2000, Korean farmer have spent about more than 12kg/ha of synthetic organic chemicals in crop field and this one was the second largest amount among the Organization for Economic Cooperation and Development (OECD) countries. On the contrary, many countries, which have advanced agricultural techniques in Europe and U. S. have spent only about 3~6kg/ha and moreover they are eager to reduce the amount of synthetic organic chemical sprays and substitute chemicals for environment-friendly agricultural methods and biological pesticides. But, we have not coped with these problems well and confronted with the side effects by continual uses of synthetic organic chemicals conventionally. Especially, the toxicities of pesticides and resistances of pest to synthetic organic insecticides make it difficult to achieve adequate control effects of pests with pesticides. The trends of desiring for more safe and environment-friendly agricultural products and restrictions of residuals of synthetic chemicals push us to develop agricultural techniques of more reduced side effects and environment-friendly ones which can be used continually.

Korean Government enacted law for prospering environment-friendly agriculture (the law 7459) in 1997 and set up a policy for prospering environment-friendly and high quality agriculture. By these ways, they have made goals of reduced using of synthetic chemicals by 40% until 2013. As a result, something has been achieved in reducing the uses of synthetic fertilizers but the uses of synthetic organic chemicals are still increasing in comparison with the one in 1997. So, some reasonable actions must be carried out to achieve practical results. Especially, in horticultural agriculture the amount of synthetic organic chemicals used have been increased by more than 25% in comparison with the same periods.

For achieving the Government's plans by facilitating the use of biological and environment-friendly methods in agricultural systems, reasonable developments of policies must be preceded in advance like improvement and amendment of associated laws and activations of technical methods of using biological pesticides and environment-friendly agricultural industries.

In terms of policies, the most important things are train and consult a grower and providing options for controlling pests with developed methods of forecasting the incidences of pests and the conditions of environments which crops are cultivated. Additionally, by standardizing many environment-friendly agricultural techniques and methods of using them, we can increase the environment-friendly agricultural market by discriminate between environment-friendly agricultural products and the one by other conventional methods.

PRESENT CONDITIONS OF ENVIRONMENT-FRIENDLY AGRICULTURES IN WORLD WIDE

Conditions and policies of environment-friendly cropping systems

The demands for safe agricultural products and restrictions on the residuals of synthetic organic chemicals in trading with foreign countries, making us substitute conventional agricultural methods for environment-friendly agricultural ones. By the International Federation of Organic Agricultural Movements (IFOAM) in 2004, the areas of organic farmings are more than one millions hectare in Australia and Italy ranked first but Korea ranked 82 about only 900 hectare, this was one of the lowest grades among 98 countries which were surveyed.

Countries, which have developed agricultural techniques, promote the methods of using biological pesticides and environment-friendly agricultural policies by developing trustworthy agricultural techniques and political supporting of their own. Countries in Europe and North America reduced the amount of pesticides used and setting up sustainable agricultures, which were harmonious with its natural conditions. They are using not only biological pesticides but also many kinds of environment-friendly methods for achieving the Integrated Pest Management (IPM). In the process IPM strategies, cultural and physical controlling methods are used but the most important things are environment-friendly controlling methods based on using many kinds of biological pesticides. Most of biological pesticides developed mainly focused on controlling the pests, nowadays the interests for pheromone and kairomone which can be used as biological controlling agents including natural enemies are being increased for their potential values. Insect pheromone is a substance, which is mainly composed of fatty acid derivatives can be used for communications between same species. Among them, sex pheromones are

used when insects are searching for their own mating partners and we have used these substances for monitoring and controlling of pests. Recently, sex pheromones can be synthesized in laboratory by a large amount and can be used as mating disruptants of major pests by setting many sex pheromone traps with large number in the field. Mating disruptant plays an important role in reducing the number of next pest populations step by step in several years and protecting crops from the major pests. These kinds of biological pesticides differentiate from synthetic organic chemicals by not focusing on complete eliminating of pests but lowering the densities of pests by degrees until the densities of pests below the economic injury level.

Table 1. IPM strategies of some countries (National Institute of Agricultural Science and Technology, 1998)

| Country | Year of legislated | Items | Purpose and contents |
|----------|--------------------|---------|--|
| U. S. A. | 1993 | Policy | Nation wide systemic plans for IPM strategy |
| | | Purpose | Executions of IPM in 75% of total agricultural area, avoid using synthetic organic chemicals, develop sustainable pest control methods with ecology |
| | | Result | Controls codling moth with pheromone, reduce using organic chemicals by 60%, develop natural enemies |
| Canada | 1987 - 2002 | Policy | Reduce using synthetic organic chemicals by 50% |
| | | Purpose | Reduce using organic chemicals by 50% in Ontario, accept the desires of consumer's request |
| | | Result | Success in corn, soy bean, apple, horticulture, using natural enemies |
| Sweden | 1986- 1990 | Policy | Reduce using organic chemicals by 50% |
| | | Purpose | Minimize the dangers by using in organic chemicals in agriculture, reduce using organic chemicals by 50% until 1990 in comparison with in 1986, using natural enemies. |
| | | Result | Biological control in greenhouse vegetables |

| | | | |
|--------------|-----------------|---------|--|
| Korea | 1997-2005, 2013 | Policy | Legislated law for prospering environment-friendly agriculture, use natural enemies in horticultural crops |
| | | Purpose | Use natural enemies in horticultural crops by 50% until 2013, leading and widening environment-friendly agriculture as a new BIO industry, export horticultural products, develop domestic natural enemies |
| | | Result | - |

Conditions of using synthetic chemicals

The most important thing in establishing environment-friendly agricultures and IPM strategies lies on developments of using natural enemies, cultivation technologies and reduced use of synthetic organic chemicals. International organizations and developed countries evaluate the degrees of its country's sustainable development by agricultural environment and environmental contamination index and so forth.

By index of its environmental values (1995) of United Nations Commission on Sustainable Development (CSD, established in 1992), the plans of IPM and Control in Agriculture by using biological control methods, cultivations of resistant varieties, adequate agricultural techniques and reduced using of organic chemicals can be a most suitable options in establishing environment-friendly and sustainable agricultures.

In Environmental Sustainability Index (ESI, 2005) of CSD, Korea ranked 135 in 2002 year and 122 in 2005 year among the 146 countries, still remains in one of the lowest groups. Many developed countries in CSD made strict guidelines for prospering minimum use of synthetic organic pesticides. But, Korea has imported more than 80% of organic chemicals from foreign countries after 2001 year and this amount to 34,000 ton (\$ 350 million) in 2003 and still increasing by an amount. Especially, the quantity of organic chemicals used in horticultural agriculture increased by more than 25% (9.4 kg/ha in 2003) in comparison with that of in 1999 (7.5 kg./ha) against government's environment-friendly agricultural policies.

Table 2. Domestic market of synthetic organic chemical in Korea (Korean crop protection association, 2004)

| Items | 2002 | 2003 |
|-------------------|--------------------------------------|----------------|
| Pesticide | \$ 235,664,000 | \$ 221,970,000 |
| Fungicides | \$ 231,724,000 | \$ 241,992,000 |
| Herbicide | \$ 110,000,000 (except in rice crop) | |

So, It is urgently required strict policies and regulations on license of using chemicals, imposing a charge, reinforcement of pesticide legislations and supporting programs for environment-friendly agriculture farmer, not so much as developing agricultural techniques.

Markets of Environment-friendly agriculture

The worldwide markets of environment-friendly agricultural products are increasing because many countries have executed and tried policies for prospering environment-friendly agricultural methods. In 2004, the amount of environment-friendly agricultural industry was estimated about more than 22 billion dollars by IFOAM. Domestic markets of environment-friendly agricultural products occupies only about 2% of total agricultural products in 2001 year (87,279 ton in 2001 year ? 365,849 ton in 2003) but are increasing more about 40% by every year, and will grow to about 4 billion dollars in 2010. Eagerness of consumers for purchasing safe agricultural products are very high like the trends of developed countries (table 3).

Table 3. Eagerness of consumers for purchasing safe agricultural products in Korea (Prospects of agriculture, 2002)

| Items | Price of eagerness for purchasing (conventional products=100) |
|------------------|---|
| Rice | 151~183 |
| Beef | 148~238 |
| Lettuce | 151~347 |
| Pear | 165~166 |
| Grape | 171~173 |
| Bean curd | 230~273 |

Systems of certification on environment-friendly agricultural products have been practiced in 2001 by dividing them with organic farming products, organic farming products in a transition periods, agricultural products with low synthetic chemicals and agricultural products with no synthetic chemicals. The most serious problems in executing environment-friendly agricultures in Korea are pest problems (Table 4)

Table 4. Serious problems in executing environment-friendly agricultures in Korea (Agricultural economics and horticulture, 2002)

| Obstacles | Frequency | Proportion (%) |
|--|------------------|-----------------------|
| Methods of controlling pests and disease | 80 | 37.2 |
| Methods of controlling weeds | 41 | 19.1 |
| Shortages of labor | 33 | 15.4 |
| Marketing agricultural products | 27 | 12.6 |
| Management of soils | 19 | 8.8 |
| Management of crops | 8 | 3.7 |
| etc | 215 | 100 |

Systems of pest control with Biological controlling methods and effectiveness in Korea

Pest control with biological controlling methods

For accomplishing a environment-friendly agriculture, many kinds of supporting policies must be suggested. Cooperating systems must be organized between all kinds of groups involved like governmental organizations, authorities of the academic world, industries involved and growers.

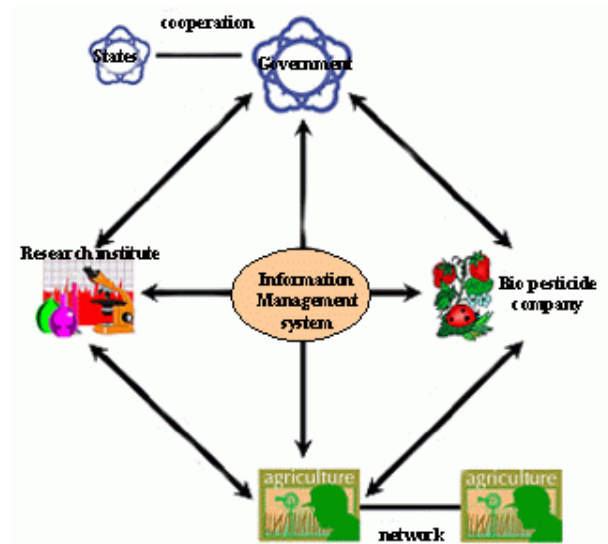


Fig. 1. Information management system for researches in biological pesticides.

Conditions of natural enemy industry in Korea

Natural enemies are known that they have not any negative effects on non-target biological organisms and environments, also International Institute of Biological Control (IIBC) reported the all the biological controlling programs in the world did not have any bad effects (Greathead, 1995).

In Korea, researches of pest management using natural enemies are actively in progress especially in horticultural greenhouses. And now 14 species of natural enemies are being sold commercially and 6 species are have been developed for commercialization. Natural enemies are easily applied as bio-pesticides in lettuce, strawberry crops that has a few species of major pests. But much more researches are needed in cucumber, melon, watermelon crops which were cultivated in hot seasons and paprica, sweet pepper, egg plant crops which has a long growing and breeding periods.

Table 5. Natural enemies commercially sold in Korea (Guides for using natural enemies, 2005)

| Scientific names | Pests aimed |
|--------------------------------|-------------|
| <i>Phytoseiulus persimilis</i> | mite |
| <i>Encarsia formosa</i> | whitefly |
| <i>Orius strigicollis</i> | thrip |
| <i>Amblyseius cucumeris</i> | thrip |
| <i>Hypoaspis aculeifer</i> | thrip |

| | |
|--------------------------------|---------------------------------|
| <i>Aphidius colemani</i> | cotton aphid, green peach aphid |
| <i>Aphidoletes aphidimyza</i> | all kind of aphids |
| <i>Harmonia axyridis</i> | aphis |
| <i>Diglyphus isaea</i> | leaf miner |
| <i>Dacnusa sibirica</i> | leaf miner |
| <i>Trichogramma evanescens</i> | eggs of moths |
| <i>Steinernema carpocapsae</i> | larvae of moth |

By the report of Sesil corporation (company that sells natural enemies) in 2005, costs of pest control using natural enemies fluctuated by the different kinds of crops. But, when the prices are considered the economic values proved to be high (table 6).

Table 6. Comparisons of costs on pest controlling in some (Sesil corporation 2005)

| Crop | Cost on pest control (\$/ha/season) | |
|------------|-------------------------------------|---------------------------|
| | Using natural enemies | Using synthetic chemicals |
| Tomato | 7,000 | 6,000 |
| Strawberry | 6,000 | 3,250 |
| Hot pepper | 7,000 | 4,875 |
| Paprica | 17,100 | 20,000 |

Biochemical pest control agents

The areas of vegetable cropping systems of greenhouse in Korea are increasing. The major pests in greenhouses are aphids, mites, thrips, leaf miners and whiteflies and most of them can be controlled with natural enemies which are sold commercially in minimum use of synthetic chemicals. But, when the pests of moths are occurred in crop field conditions, inevitable sprays of organic chemicals are needed, and cannot use natural enemies together. So, the development of sex pheromone is seriously needed which can be used together with environment-friendly agricultural methods like natural enemies. In a fruit tree field, pests, which directly damage fruits like larvae of moth, can

give fatal damages by lowering the prices of fruits, even in a condition when the densities of pests are low.

Pheromone is a substance, which emitted from a same species can be detected between same species and induce unique behavior to them. Especially, Sex pheromones have been used for effective monitoring tool for timely insecticide application. They also can be used as mating disruption and mass trapping for the purpose of lowering the densities of next generations of pests and reducing the economic damages in fruit field.

Table 7. Comparison between pheromone and synthetic organic pesticide

| Contents | Pheromone | Pesticide |
|-----------------|--|--|
| Toxicity | Non toxic | Toxic to human and environment |
| Decomposition | High (evaporate) | Slow |
| Selectivity | Influence to only to specific pest, not toxic to natural enemies | Influence widely to many species, toxic to natural enemies |
| Resistance | No known | Known for many time |
| Using time | Any time | Specific time |
| Zone | Advise using in wide area | No limitation |
| Cost | Cost highly | Mass produced |

The control strategies of Korea's basic pest management structures in fruit tree fields are different from the ones in the horticultural greenhouses. The principles are sprays of pesticides, which is non-toxic to natural enemies for the purpose of controlling major fruit pests likes Oriental fruit moths and Peach fruit moths below the economic threshold level and control the secondary pests like mites and aphids with natural enemies. So, It is seriously needed connecting the methods of using sex pheromones for effective monitoring tool for timely insecticide applications, mating disruptions, mass trappings and eventually reduce the times of insecticide sprays fundamentally. A conventional control method for fruit pests in Korea relies on periodic sprays of pesticides and reaches about 15 times/year in apples and 14 times/year in

pears. It is highly suggested establishing the methods of reducing the costs of pest controlling in fruit fields in Korea.

In Korean fruit field, growers generally wrap fruits with bags for the purpose of physical barrier from fruit moths but especially the larvae of Oriental fruit moth actively searching the fruits and can penetrate wrapping bags of fruit result in serious damages to growers in low densities of pest. This pest's behaviors of penetrating the fruits and buds of plants makes hard for controlling with pesticides and even induce side-effects likes resistance to pesticides, environmental contaminations, eliminating of natural enemies by sporadic pesticides sprays.

To overcome those defects, which were discussed in previous sections, it is strongly needed for controlling measures of major fruit pests, which were safe to human, and environment. Using sex pheromone as a mating disruption has been said to the promising ones, because this is no harm to human, safe to environment, no resistance of pests. Moreover, Growers can use environment-friendly agricultural methods like natural enemies at the same time because this sex pheromone aims at controlling only specific major pests. In Korea, several kinds of sex pheromones for monitoring are being sold commercially. Six kinds of sex pheromone lures for apples and four kinds of pheromone lures for pear and peach including sticky capturing traps are mainly sold by commercial. The results of capturing data by sex pheromone traps in each fruit fields are being distributed to anyone form internet homepages likes loving apple group (<http://www.apple.go.kr>), information systems for pear (<http://www.pear.go.kr>), loving peach group (<http://ilovepeach.or.kr/>) mainly consisted by growers and researchers who joined voluntary. And, they have contributed much in reducing the times of insecticide sprays by timely forecasting the incidence of major pests.

Mating disruption dispensers are being sold commercially and reported that it is effective in disrupting mating behaviors of specific pests and reducing the populations of next generations. Several kinds of mating disruption dispensers are being sold commercially in Korea, and usually used in apples, pears, peaches, plums, sweet persimmons fruit fields. The cost of mating disruption dispensers including Peach fruit moth, Oriental fruit moth, Smaller tea tortrix and Asiatic leafroller per hectare (1,000 ea/ha) is about 9,00 \$ and remains effective for about 4~5 months period. But, those are mainly used in

experimental clustering fruit field villages with no pesticides or organic farming by governmental supporting programs. And, there are several reports about the defects of mating disruptions. It is surely effective in inner field of fruit farm but this cannot result in estimated effect by mating disruption in wide opening fruit fields because female which completed mating with male can migrate into the fruit field from outer space. Also, we cannot have immediate controlling effects by short periods of time with sex pheromone. The effectiveness of mating disruption can be acquired after 2~3 years of treatments.

CONCLUSION

Korea's agriculture is facing stern challenges including aging farm population, decreasing farm land, and competition in the open markets brought about by globalization and urbanization. So, For the purpose of Korea's agriculture, It is highly recommended switching from traditional agriculture with mainly using synthetic pesticides and chemicals to sustainable agriculture with using environment-friendly agricultural methods like biological controlling methods and reducing the used of pesticides. For these purpose, many kinds of harmonious supporting policies and cooperating systems must be organized between governmental organizations, authorities of the academic world, industries involved and growers

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