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한국과 호주에서의 Biosensor에 의한 농약의 환경영향 조기검출

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Environmental Impacts and Rapid Analysis by Biosensors of Agrochemicals in Korea and Australia

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Abstracts: Pesticide has played important role in Korean and Austrailian agriculture. In addition, pesticides are the most reliable tools pests in agriculture. Recently, it is highly recommended that the use of pesticide should be concerned with both atricultural and environmental aspect, also legislation on environmental contamination has been fortified to the world. Particularly, the attention on agrochemicals has been focused on the soil abuse and the water contamination at present time. In spite of this kind of concern, a few research about pesticides using in Australia and Korean have been conducted to their behaviors under australian and korean environment to avoid environmental contamination by pesticides. Thus, the research organizations need facilities to analyze the characteristics of each pesticide and the environmental fate of pesticides. The conventional analytical method to detect pesticides and their metabolites can not be overcome to reduce time, expenditure, and complexity of analysis even though the methods are accurate and precise. For example, High performance liquid chromatography(HPLC), and gas chromatography (GC) used until now are less choice detectors and often lower sensitive. In contrast to the conventional analytical methods, biosensors are so fast in analysis and has high productivity and analyze multi-sample simultaneously. Therefore, it is biosensing analytical method that we could consider as an alternative method intead of the conventional methods.

Key words : Agrochemical, Biosensor, Environmental Impact, immunoassay.

Introduction

Food and fiber production and environmental health in Korea and Australia would be seriously threatened without pest control. World-wide, research data show that, without effective pest management, pre-harvest crop losses would average about 40 per cent. Korea and Australia are no exception if insects, diseases and weeds could not be controlled, production of crops simply would not be economical. The development of synthetic organic pesticides around 1940 introduced a new era of pest management. For the first time, farmers could achieve excellent control of pests. However, widespread use of these organic pesticides such as DDT, dieldrin and heptachlor led to another unforseen problem - they were persistent and bioaccumulated.

Increasing concerns on the safety of the food supply and the health of the environment due to pesticide use have been extended by Rachel Carsons publication of Silent Spring in 1962. These issues remain today and the pace of the effort to bring agrochemicals with higher safety to the farmer, the environment and the consumer has accelerated as lower use rate, more pest-specificity have entered the marketplace. Therefore, legislation on environmental contamination has been strengthen to the world and in particular the attention on agrochemicals has been focused on the soil abuse and the water contamination.

Manmade pesticides which have used or been prohibited for use are somewhat persistent to the environment. This characteristics of agrochemicals makes

Government regulatory agencies to get data from the manufactories about the environmental behavior of new or older agrochemicals for their reevaluation and registration for use.

In addition agrochemicals are specifically designated for introduction into the agricultural environment in order to control pests such as fungi, insects and weeds or to improve the quality and quantity of crop production. These pesticides have generally single-site modes-of-action leaving themselves more susceptible to resistance development in pests. Recently, Georghiou[1)] listed 504 species of insects and mites for which insecticide resistance has been recorded. He also showed that the rate of increase in the number of insects and mites with resistance to pesticides was lower in the decade from 1978 to 1988 than in the period from 1968 to 1978. However, examination of the number of classes of pesticide to which resistance was recorded indicated that there is still a steady increase in resistance to specific chemicals and that many species are now resistant to several groups of chemicals. With these reasons, the registration process by European Economic Community (EEC) now requires data about resistance possibility for re-registration of older pesticides and the new pesticides. Herein, we report about environmental issues caused by pesticides, their registration and their use rate in relation to the public health in both Korea and Australia.

The role of pesticides in Australian and Korean agriculture and the environmental concerns of pesticides

Todays farming practice in developed countries is like an intensive agriculture that gives low cost for using farm machinery and advances of plant breeding, the use of fertilizers, irrigation and soil improvement techniques. This type of farm practice do not have to rotation of crops, resulting in more specific to one or a few economical crops for farmers. However, a large farming area with one or a few crops may be the most valuable target site of agricultural pests and more efforts could be needed to prevent the increase of ingress of pests. At the present time, pesticides are the most reliable tools to control pests in field or wherever in developed countries. Australia is a developed country and the primary industries are very important for national economy. In 1993, the nation's top export materials contained coal, iron ore, wool, cotton and wheat. Table 1 shows that gross value of Australian grain production and value of Australian grain exports from 1990 to 1995. With these data it is likely that the crop production is very important to the economy in Australia.

Consequently, Australian farmers use very much of pesticides to prevent their crops from pests every year. For example, an organochlorine pesticide endosulfan has been employed for the control of insect pests primarily in cotton but also increasingly in other crop production industry. However it is important that endosulfan fate in the Australian soil environment be understood, particularly in view of its potential toxicity in environment as a result of increased use for the cotton production. In fact, very few studies on its environmental fate have been conducted under Australian conditions. Besides there are so many of pesticides that have been used in farming fields. Thus, all pesticides used in Australia must be studied their behaviors under Australian environment to avoid environmental contamination by pesticides.

Table 1. Gross value of Australian grain production (A$million) and Value of Australian grain exports (A$million, fob). The figures in brackets (*) indicates the values of Australian grain exports.

	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995
Wheat	1988(1710)	2097(1528)	2894(2004)	2723(2314)	1802(1577)
Barley	563(498)	681(421)	793(522)	909(649)	530(344)
Oats	147(34)	182(21)	206(40)	247(33)	224(13)
Triticale	24	29	38	41	23
Maize	34	48	42	71	54
Sorghum	102(25)	204(29)	87(34)	171(32)	198(17)
Rice	139(179)	184(245)	175(229)	282(322)	210(310)
Lupins	133(61)	186(102)	235(148)	289(199)	159(56)
Field Peas	86(62)	115(50)	119(96)	135(93)	59(36)
Chickpeas	69(57)	66(28)	66(73)	68(87)	44(34)
Peanuts(in shell)	30	41	22	36	19
Canola	28	47	61	115	119
Sunflowerseed	42	28	21	51	42
Soybeans	22	22	21	32	12
Cottonseed	101(34)	110(30)	105(35)	108(35)	88(32)
Other oilseeds	6(8)	11(26)	12(36)	20(67)	6(41)
Total	**3514(2668)**	**4051(2480)**	**4879(3217)**	**5298(3831)**	**3589(2460)**

Korea differs from Australia in many ways. Korea is an industrial nation and the government encourages people to be involved in the secondary industries. Korea is also insufficiency of natural resources, so Korean work for the production of high value-added products. With these regards, Korean agriculture has been discouraged since the industrial reformation and the population rate in agriculture is still decreasing as below as 15% of the total, particularly in 1995 the population rate was 10.8 % (4.84 million from 44.4 million) from the total. To make matters worse, GATT urges to Korean to open their crop market freely to the western countries with all kinds of products. Even crops are gradually opened to the world until 2005, it is very important to Korean government to keep cultivating several major crops such as rice in national security strategy. Korean Rural Development Administration is also setting up an export strategy for several major fruit crops, apples and pears. Thus, the current role of pesticides in Korean agriculture is well defined. However, it is very similar to Australia that very few studies on its environmental fate of pesticides used or have been used have been conducted under Korean conditions.

Kinds of Agricultural Chemicals used in both Korea and Australia

Kinds and natures of pesticides used in both countries seems to be very close to each other because the agrochemical producers are now in common and the active ingredients or several additive compounds are shared through the world. The list of major pesticides which are registered and have been used in Korea is shown in Table 2. They are fungicides, insecticides and herbicides. Pesticide usage in Korea is slightly decreasing due to integrated pest management (IPM) programme developed even though the consumption value of herbicide against the total is increased as shown in Table 3. In addition, Table 4 shows yearly changes of the consumption rate of a group of pesticide from the tota[2].

Recently, the use of pyrethroid insecticides is dramatically increased in Korea because of their safety to mammals and selectivity to target insects. Organochlorine pesticides have been banned for use in Korea as well as other developed countries since these chemicals are highly lipid soluble, lengthy exposure to them results in their high accumulation in tissues and organisms, and hence they may produce severe adverse effects in human and on ecosystems. However, endosulfan, an organochlorine insecticide is employed for use to control tobacco budworm in Korea[3]. This compound has its characteristics of being persistent and effective long enough to selectively control the insects of concern while on the other hand of reputedly being sufficiently biodegradable, thus avoiding the accumulation of residue in soils and animal tissues. Table 5 shows several pesticide usage in Australian cotton field. The cotton industry is one of the largest users of chemicals in the Australian agricultural sector. These chemicals are used for insect control, weed control, protection of the crop

Table 2. List of major pesticides used in Korea.

Classification	Compound
Fungicides	Benomyl, Bifenthrin, Bittemol, Captan, Carbendazim, Chlorothalonil, Cyproconazol, Cyprodinil, Dazomet, DBEDC, Dichlofluanid, Diethofencarb, Difenoconazole, Dimethomorph, Dithianon, Edifenphos, Etridiazole, Fenarimol, Fenbuconazole, Fluazinam, Fluoromide, Flusilazol, Folpet, Fosetyl-Al, Hexaconazole, Hymexazol, IBP, Imibenconazole, Iminoctadine, Iprodione, Kasugamycin, Lamda cyhalothrin, Mancozeb, Metalaxyl, Myclobutanil, Nurimol, Oxadixyl, Oxine copper, Penconazol, Polyoxin B, Polyoxin D, Popineb, Procymidone, Propamocarb, Propineb, Pyrazophos, Pyroquilon, Streptomycin, Tecloftalam, Terbuconazole, Thiabendazole, Thifluzamide, Thiophanate-methyl, Thiram, Tolclofos-methyl, Tolylfluanid, Triadimefon, Triadimenol, Triflumizole, Troforine, Vinclozolin
Insecticides	Abmectin, Acephate, Acetamiprid, Acrinathrin, Alphamethrin, Amitraz, Benfuracarb, Bensultap, Beta Cyfluthrin, Bifenthrin, BPMC, Bromopropylate, Buprofenzin, Carbaryl, Carbofuran, Carbosulfan, Cartap, Chlorfenapyr, Chlorofluazuron, Chlorpyrifos, Chlorpyrifos-methyl, Clofentezine, Cyfluthrin, Deltamethrin, Demeton S-methyl, Diafenthiuron, Diazinon, Dichlorvos, Dicofol, Diflubenzuron, Dimethylvinphos, Endosulfan, EPN, Esfenvalerate, Ethofenprox, Ethoprophos, Fenazaquin, Fenbutantin oxide, Fenitrothion, Fenoxycarb, Fenpropathrin, Fenproximate, Fenthion, Fenvalerate, Flufenoxuron, Fluvalinate, Fonofos, Furathiocarb, Hexaflumuron, Hexythiazox, Imidacloprid, Isazofos, Lamda cyhalothrin, Methidathion, Methomyl, Omethoate, Phenthoate, Phorate, Phosmet, Phosphamidon, Phoxim, Pirimicarb, Pirimiphos-ethyl, Pirimiphos-methyl, Profenfos, Propargite, Prothiofos, Pyridaphenthion, Silafluofen, Tebufenozide, Tebufenpyrad, Teflubenzuron, Terbufos, Thiocyclam, Tralomethrin, Triazophos
Herbicides	Aclonifen, Bensulfuron, Betazon, Chlornitrofen, Diclofop, Dicamba, Glufosinate, Mefenacet, MCPB, MCPP, Metolachlor, Molinate, Oxadiazon, Oxyfluorfen, Pendimethalin, Pyrazosulfuron

Table 3. Yearly changes of pesticide usage and cost in Korea.

Classification	1991	1992	1993	1994	1995
Fungicide	8,374	6,334	8,287	5,763	5,288
	1,749	1,517	2,220	1,400	1,228
	A$38,472	A$34,666	A$52,955	A$35,826	A$34,447
Insecticide	34,001	25,912	25,180	21,003	20,123
	2,652	1,825	1,842	1,495	1,326
	A$54,644	A$47,382	A$51,545	A$44,305	A$41,319
Herbicide	19,925	19,260	20,089	17,695	15,602
	1,355	1,310	1,358	1,270	1,177
	A$34,387	A$39,338	A$47,564	A$45,679	A$41,960
Others	246	161	215	131	146
	134	82	108	64	72
	A$691	A$470	A$665	A$410	A$430
Total	62,546	51,667	53,771	44,592	41,159
	5,890	4,734	5,528	4,229	3,803
	A$128,195	A$121,856	A$158,729	A$126,220	A$118,156

Unit; Upper - Formulation quantity: M/T nter - Active Ingredient Quantity: M/T wer - Amount: A$1,000

Table 4. Yearly changes of the rate of the consumption amount of pesticide from the total amount in Korea.

unit; percentage (%)

Classification	1991	1992	1993	1994	1995
Fungicide	23.1	21.8	27.0	21.6	22.4
Insecticide	46.8	42.5	37.7	38.4	38.3
Herbicide	29.5	35.3	34.8	39.6	38.9
Others	0.6	0.4	0.5	0.4	0.4
Total	100.0	100.0	100.0	100.0	100.0

against diseases, to foster productivity and facilitate harvesting, with pesticides being a major proportion of all chemicals used. The figures of Table 5 are only estimates for the most commonly used insecticides, herbicides and defoliants, referred to the year 1991 (260,000ha). More accurate figures are compiled by cotton consultants but there are not readily available for public use. It should be noted that endosulfan and pyrethroids account for 70% of all insecticides applied, or 80% of those used against Heliothis spp. in cotton field4,[5].

According to the cotton comparative analysis of 1992/1993 in Australia[6] pesticides and their application costs account for 20.5% of the total crop production expenses, totalling over A$96 million a year, equivalent to A$370 per hectare as shown in Table 6. On the top of this figure must be added the cost of professional consultants (A$9 million in 1991). Table 6 shows the share of each type of chemical in the expenditure, including the fertilizers for a comparison. As it can be seen, chemical usage make up some 30% of the total crop production costs. The number of sprays applied to a crop varies with the location and the season has led to serious problems average of 10 sprayings per season for insecticides, and 3 applications for herbicides.

New management pratices for Heliothis spp. control are favouring cultivation, and therefore a reduction on herbicide usage is expected. The dependence on pesticides has led to serious problem for the industry in

Table 5. Estimation of cotton pesticide usage in Australia, 1991

Product name	Total litres (1,000)	Litres/ha
Insecticides		
Endosulfan	4,828	5
pyrethroids	1,651	6.4
Profenofos	910	3.5
Chlorfluazuron	650	2.5
Dimethoate	520	2.0
B. thuringiensis	390	1.5
Methomyl	260	1.0
Thiodicarb	130	0.5
Herbicides		
Diuron	602	2.3
Trifluralin	449	1.7
Fluometuron	385	1.5
Pendimethalin	184	0.7
Prometryn	161	0.6
Glyphosate	101	0.4
Atrazine	86	0.3
Metolachlor	24	0.1
Defoliants		
Ethephon	520	2.0
Thidiazuron	24	0.1

Table 6. Cost of chemicals and pesticides used by the cotton industry in Australia surveyed in 1992.

	Total Australia (millions of A$)	Total/ha (A$)	% production cost
Insecticides	6</L>	171.5	9.5
Herbicides	21.5	82.7	4.6
Defoliants	12.6	48.5	2.6
Subtotal pesticides	78.7	302.7	16.7
Application costs	17.8	68.5	3.8
Consultants	9	34.6	1.9
Total Pesticides	105.5	405.8	22.4
Fertilizers	35.1	135	7.2
Total Chemicals	140.6	540.8	29.6

Australia. The main problem arises from excessive usage in order to keep the cotton crops free of pests, with the resistance and environmental problems with it brings. While some growers tolerate a degree of damage to their crops by using as little pesticide as possible, others prefer to use more to ensure there is no pest damage. The latter approach poses an obstacle to the insect resistance management strategy (IRM), which was implemented in 1984 in response to the increased resistance to synthetic pyrethroids the previous year[7,8]. Although the significant use of chemicals is essential for the Australian cotton industry, they are acknowledged as potentially harmful to the environment. Aware of its responsibilities, the industry has promoted several programs aimed at minimising the use of chemicals, thus reducing the negative effects on the environment. The steps towards achieving this goal have been undertaken through the following programs: (1) an independent environment audit, (2) a water quality monitoring program, (3) research to study the impact of pesticides on the riverine environment, (4) management by co-ordinated efforts of several groups and organizations within the industry.

Organizations related to agrochemicals

Valid procedures for re-registration of old pesticides and registration of new pesticides requires data assessing environmental fate of them. If a pesticide is shown to degrade fast in soil or water environment and not to leach in those systems, then limited field work to confirm these predictions should be acceptable. However, the actual regulatory process in developed countries is different and they need more complicated data. The Korean registration authority selects five major tests for registration of pesticides as physicochemical characteristic test, titer test, evaluation data for effect and damage on the environment, residual test and toxicological test. The Korean Registration Authority for pesticides takes officially several national research centers and university or company research centers to undertake this process as shown in table 7. For those evaluations, the research organizations need facilities to analyze the characteristics of each pesticide and the environmental fate of pesticides.

Problem and the need for new, rapid analytical methods for detection of pesticides

Increasing demands to conduct regular monitoring of soil and water contamination by used pesticide have pressured the regulatory authority of both Korea and Australia to consider the efficiency of the current analytical methods including parameters of cost, labor,

Table 7. Organizations selected by Korean Registration Authority for pesticides

Test area	Organizations
Physico-Chemical Research institute</LI>	- National Agriculture, Science and Technology Institute (NASTI) - KIST
Titer testing institution</LI>	- Company Research Stations (22) - NASTI, KIST
Effect and damage testing institution</LI>	- Company Research Stations (13) - NASTI, etc. (42) - Universities research centers (Korea University and 29 other university organizations)
Residual testing institutions</LI>	- NASTI and 15 other national research stations, Korea Ginseng and Tobacco Research Center, Korea Institution of Chemistry - Company Research Stations (12) - University research center (15 other universities)
Toxicological testing institution</LI>	- NASTI, Korea FDA (Acute, Aquatic, Chronic- toxicology research institutions) - University research stations (Acute Toxicology - 2 universities, Aquatic toxicology - 1 university) - Company research centers (Acute toxicology - 2 stations, Aquatic toxicology - 4 stations)

time of analysis, simplicity and the number of samples required for reasonable data. Satisfactory data should contain the fate, toxicity and concentrations of pesticide to enable the relevance of guidelines for application to be verified. Recently, the conventional analytical method to detect pesticides and their metabolites even the methods are highly accurate and precise has been to cope with the demands to reduce time of analysis, expenditure and to increase more simplicity as non-trained people can use the method for detection. In the past two decades, there has been increasingly reported about several new analytical methods such as immunoassay and biosensors using receptors and enzyme such as acetylcholinesterase (AChE).

Immunassays offer a number of advantages in pesticide determination in soil and water sample over the conventional analytical methods such as high performance liquid chromatography (HPLC) and gas liquid chromatography (GLC) which are listed in table 8. HPLC depends on the interaction of compounds with the solid phases while they are being carried in a liquid complex mobile phase. There is less choice of detectors or often lower sensitivity of detectors found in HPLC than in GLC. The most commonly used detector for HPLC analysis is ultra violet, visible, fluorometric and electrochemical detectors. The other conventional analytical method, GLC has employed a wide range of sensitive and selective detectors, for instance electron capture detector, flame photometric detector, thermal conductivity and nitrogen detector. The volatilised pesticide residue can be carried out by a stream of inert gas and be separated according to their interaction to a liquid phase, which is coated either on a solid support packed materials in glass or steel columns or internal wall surface of smaller bore glass and fused silica columns. Even these methods are being used for the analyses of pesticide residues, some problems are still remained. For example, several pesticides are not sufficiently volatile to be detected by GLC or overlapped in one retention time. There are several pesticide metabolites, such as endosulfan diol, diuron, permethrin and 2,4-dichlorophenoxyacetic acid (2,4-D)[9] that need an additive process to be derivatized for improving their sensitivity enough to be detected by used detectors. This derivatisation process of pesticides is a tedious and laborious work[10,11,12], especially if there are many sample to be done by this process.

In addition, sample preparation for the conventional analysis is time consuming, laborious and expensive procedure. Pesticide residue must be discarded from soil, water, air, food, blood and urine, and transferred into an appropriate solvent system for analysis. Clean-up stage is also considered as a tedious work if there are so many sample to be analysed.

In contrast to the conventional analytical methods, immunoassay is so fast in analysis and has high throughput and numerous sample to be analysed simultaneously, and significantly reduing the average analytical time. The cost involved in the pesticide analysis is belong to use reagents, nanograde solvents, the person employed for the technique and the capital cost of instruments. As a result, immunoassays might be more cost-saving method than the other conventional methods. The sensitivity of immunoassay is as good or beeter than those of the instrumental methods, as immunoassay needs less concentration of pesticide in matrics while water is analysed with concentration. Table 9 shows the comparison between immunoassay and the conventional analytical methods with sensitivity, sample preparation, sample size, speed, simultaneous anaylses, cost and field uses. By the way, immunoassays are sometimes unclear to prove individual determination of pesticide metabolites in environment because developed immunoassay may be either compound-specific or group-specific. There are also several disadvantages of this immunoassay: the development time required for new compound to be analysed, unsuitability for multiresidue analysis immnuoassay suitable for two or five related compounds, amount of information delivered and very few immunoassay being currently status officially. Table 10 shows the list of antibodies developed in CSIRO (Commonwealth Science and Industry Research Organization) in Australia.[13]

A rapid monitoring analysis of pesticides used is

Table 8. List of conventional methods used for analyzing agrocheimcals.

Analytical type	Common methodology	Analytical Facility
Physico-chemical analysis	CIPAC method, AOAC method	GC, LC, GC/MS, Spectro- photometer, and etc
titer analysis		refractor meter,
Effect and damage analysis		microscope, colorimeter, and etc
residual analysis		GLC, HPLC, GC/MS, andUV-Vis Spectrophotometertoxi cological analysis
toxicological analysis		pH meter, DO meter,

Table 9. Comparison of instrumental method and immunoassay

Method	Instrumental methods	Immunoassay
Detection	GLC, GC/MS, HPLC	Color change
Sensitivity	0.01 - 1 mg/L after concentration	0.01 - 1 mg/L without concentration
Sample preparation	Water - sometimes Soil - always	Water - No Soil - sometimes
Sample size	Water - 500 - 1000 mL Soil - ~ 25g	Water - < 0.5 mL Soil - 10 - 25 g
Speed	Sample preparation - hours Analysis - minutes	10 min - 1.5 hrs per run
Simultaneous analyses	Of several residues in a single sample	Of many samples for 1-4 compounds
	A$ 20,000 - A$200,000	A$1,000 - A$20,000
Capital Cost	A$20 - 200	A$5- 20
Cost per sample	No	Yes
Field use		

GLC - gas liquid chromatography
GC/MS - gas chromatography/mass spectrophotometry
HPLC - high performance liquid chromatography

Table 10. Insecticide immunoassays developed at CSIRO Plant Inducstry in Australia

Compound	Food matrices	Environmental matrices	Commercial agreement
Organophosphates	grain, cereal foods		yes
fenitrothion	rice, fruit, veg	water	yes
parathion	rice, fruit, veg		yes
methyl-parathion			yes
chlorpyrifos		water, soil	yes
chlorpyrifos-methyl	grain, cereal foods		yes
pirimiphos-methyl	grain, cereal foods		yes
diazinon	fruit juices	water, lanolin	yes
malathion			
Organochlorines			
cyclodienes	fruit, veg, fatty foods	water, soil	
endosulfan	fruit, veg, grain, fats	water, soil	yes
DDA/DDT	milk, fruit, veg, grain	soil	yes
DDE/DDT	milk	water, soil	
dicofol	fruit		
HCH metabolites			
Pyrethroids			
bioresmethrin	grain, cereal foods		yes
phenothrin	grain, cereal foods		
permethrin			
deltamethrin	grain	water, soil	yes
cypermethrin			
cyhalothrin			
Insect growth regulators			
methoprene	grain, cereal foods		
benzyoylphenylurea			

conducted by receptors as sensing elements measure indirectly through the binding determined by spectrophotometer. These receptors are specific for several analytes as the nicotinic acetylcholine receptor (nAChR) for nicotine and nitromethylenes. The g-aminobutyric acid (GABA) receptor is specific for the pyrethroid pesticides as well as cyclodiene endosulfan. However, this method is not available for use due to the hardness of gaining pure receptors from organisms. The use of antiacetylcholinesterase (antiChE) insecticide biosensors are employed for determination of organophosphate and carbamate pesticides. This enzyme is easily to purify from organisms such as electric eel, Electrophorus electricus and easy to handle.

Future works for protection of our environment and conclusions

Since the introduction of DDT has been followed by other synthetic pesticides, the amount of pesticide used in the field is a primary pollutant in soil and water environment damaged to the ecosystem including life of human being. Even these pesticides are a credit tool for preventing crops from a number of pests, every man wants to reduce the use of pesticides, and then not to exposure to the toxic chemicals. The demand to get more precise, accurate data to evaluate the effect of pesticides in environment by people has been increased and this pressure makes Environment Protection Agency in both countries to employ a new, rapid detection method to improve the number of sample and to save the time. The conventional analytical methods using HPLC, GLC and TLC are expensive and time-consuming, and need high-trained labor. In addition, the new pesticides developed by now or released a few years ago are proteins such as BT toxins and are hard or impossible to be detected by the conventional methods. These make hard to predict the fate of new pesticides in the environment. Therefore, immnuoassay and other biosensors employed in the detection procedures is necessary to get a reasonable data for registration of old and new pesticides[15].

Even the immunoassay method has not been used as the detection method for pesticides or other pollutants in Korea, it is strongly suggested that the immunoassay has a big potential to predict the fate of pesticides used and accumulated in the field. Other biosensing analytical methods are also considered as an alternative method instead of the conventional methods.

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References

1. Georghiou, G.P. (1990) "Overview of insecticide resistance," in *Managing resistance to agrochemicals*(Green, M.B., Lebaron, H.M. and Moberg, W.K. (eds)), American Chemical Society Symposium Series 421, pp 18-41, Washington DC: American Chemical Society.

2. Agricultural Chemicals Industrial Association (1996) Agrochemical Year Book 1996, pp. 593.
3. Lee, S.R., H.K. Lee, and J.H. Hur (1996) Information resources for the establishment of tolerance standards on pesticide residues in soils. *Korean J. Environ. Agric.* 15:128-144.
4. Guerin, T.F. and Kennedy, I. R. (1991) Biodegradation of endosulfan in cotton growing soils. *The Australian Cotton Grower* Jan/Feb 91: 12-15.
5. Cox, P. G. and Forrester, N. W. (1992) Economics of insecticide resistance management in Heliothis armigera (Lepidoptera: Noctuidae) in Australia. *J. Econ. Entomol.* 85(5): 1539-1550.
6. Buster, S. (1994) Cotton Production. Mannual for the Certificate and Post-graduate certificate in Rural Science Dept. Agronomy and Soil Science, UNE.
7. Forrester, N. W., Cahill, M., Bird, L. J. and Layland, J. K. (1993) Management of pyrethroid and endosulfan resistance in Helicoverpa armigera (Lepidoptera: Noctuidae) in Australia. *Bull. Entomol. Res. Supplement Series.* No. 1.
8. Fitt, G. P. (1994) Cotton pest management. Part 3: An Australian perspective. *Annual Review of Entomology,* 39: 543-562.
9. Onuska, F. I. (1984) Pesticide residue analysis by open tubular column gas chromatography, trials, tribulations, and trends. *Jounal of High Resolution Chromatography and Chromatography Communications,* 7: 660-670.
10. Kim, Hee-Kwon, J.-J. Park, J.-H. Sim, and Y.-T. Shu (1996) Soil adsorption of herbicide Quizalofop-ethyl. *Korean J. Environ. Agric.* 15:442-447.
11. Park, D.S., Jae. E. Yang, and D.S. Han (1995) Assessment of the residues of Benfuresate and Oxolinic acid in crops. *Korean J. Environ. Agric.* 14:312-318.
12. Lee, Y.D. and J.H. Choi (1995) Evolution of Carbofural in soils treated with its aminothio derivatives, carboculfan, furathicarb, and benfuracarb. *Korean J. Environ. Agric.* 14:179-185
13. Kenneddy, I. R. (1997) *Cotton Pesticides in Perspective.* University of Sydney.
14. Roberts, T. R. (1995) "Environmental fate of pesticides: a perspective", in *Environemntal Behaviour of agrochemicals* (Roberts, T. R. and Kearney, P.C. (eds)), pp 1-12, John Wiley and Sons.
15. Charles, G.W., Constable, G.C. and Kennedy, I.R. (1995) Current and future weed control practices in cotton: the potential use of transgenic herbicide resistance. In: proc. *Workshop on the role of herbicide resistant crops and patures in Australian Agriculture.* March 15-16, Canberra, Bureau of Resource Science.