

Agricultural Engineering for Sustainable Agriculture in Korea

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1. Introduction

The Environment friendly agriculture regarded as harmonization of agriculture and environment towards the sustainable production in agriculture, and eventually increasing the farmer's income along with the conservation in agricultural sector as well as the production of safety of agricultural products.

The Environment friendly agriculture implies the production of safety agricultural and forestry products by the minimum input or no input of agricultural chemicals. The recycling use of agricultural and forestry by-products can enrich the agricultural ecology system, accordingly the system will attain the environmental sustaining agriculture.

The sustainable agriculture was introduced in the latter of 1980s, and it was not only the environment conservation aspect but also the social-economic aspect of rural and farmer's problems.

The National Institute of Agricultural Engineering, Rural Development Administration has been actively developed the machinery that involved in environment friendly agriculture suitable to Korean agricultural situation.

2. Situation in environment friendly agriculture

2.1 Local situation

The input of chemical fertilizer, insecticide and pesticide has been gradually reduced since the 1995. In particular, the input of insecticide and pesticide for rice farming was reduced while the input of herbicide was not so much.

Animal manure was utilized as fertilizer resource by compost dry manure and liquid manure as much as 88.8%, while 7.3% was liquid purification and 4% was treated to distance sea.

Among the livestock farmers, 90% have fertilizer production system and remainder of 10% have liquid purification by active sludge system or entrust treatment to public treatment facilities.

2.2 Production and marketing of environment friendly agricultural products(EFAP)

The production of EFAP annually increased by 30~40%. The consumers have keen interest for the safety food, and government supporting the environment friend farming for both the farmers and consumers.

Table 1 Recent production of EFAP (environment friendly agricultural products)

| Items | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|-------------------------------|------|------|------|------|------|------|------|
| Farms (1,000 households) | 1 | 2 | 5 | 12 | 23 | 29 | 53 |
| Cultivation area (1,000ha) | 1 | 2 | 5 | 11 | 22 | 28 | 50 |
| Production (1,000M/T) | 27 | 35 | 87 | 200 | 365 | 461 | 798 |

- The EFAP among total agricultural products was 4% in the 2005, and the trend of the EFAP will be increased rapidly in the future.
- The EFAP of the total agricultural products
- (' 00) 0.2% → (' 02) 1.1 → (' 04) 2.5 → (' 05) 4
- The type of major EFAP crop was vegetable, and the type of EFAP was low input chemical.
- Type of crops ('05) : serial 12%, vegetable 41%, fruits 36%, special crop 11%
- Type of EFAP (' 05) : low chemical input 61%, no chemical input 30%, organic agriculture (including transmitting stage for organic agriculture) 9%
- The EFAP have large items with small quantity while the consumers are limited, therefore the marketing system are direct commercial transaction between producing farmers and consumer or EFAP special market system.
- The total size of EFAP market estimated around 780 billion Won in the 2005.
- The number of EFAP shops estimated more than 1,000 places, and most of department store or shopping mall such as E-mart and Home-plus etc.

2.3 The EFAP authentication system

To support the environment friendly agriculture and to ensure the consumers' right choosing of agricultural products, the government established the special authentication institute for the food safety and the quality upon strict basis.

EFAP authentication have divided by organic agricultural products, semi-organic agricultural products, no chemical input agricultural products, low level chemical input agricultural products.

In case of the livestock products, EFAP authentication is organic agricultural products and semi-organic agricultural products.

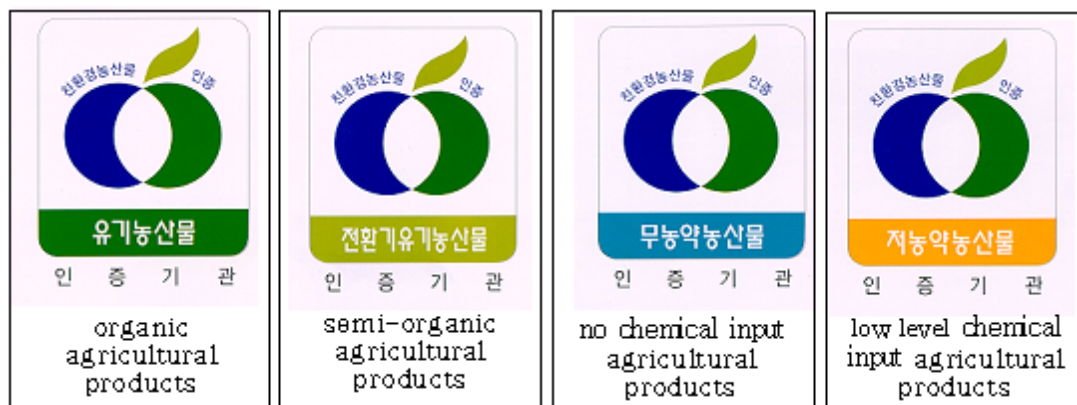


Fig. 1 EFAP authentication symbol

The EFAP authentication procedure is as following;

- Request the EFAP authentication by farmers to agricultural products quality manage office(APQMO) → consideration by APQMO → letter reply → inspection of crop production at field, and agricultural products quality inspection in market → notify the inspection results → authentication of EFAP
- Authentication office : National Agricultural Products Quality Management Office, and 17 private offices for authentication.
- Effective duration of authentication is one year.

3. Government policies for environment friendly agriculture

3.1 Target of environment friendly agriculture

- Reducing agricultural chemical input by 40% till 2013
- Increasing the authenticated EFAP by 10% of total agricultural products
- To assure the farmer's income through EFAP while consumer's can buy EFAP with trust basis.

Table 2 EFAP production rate

| Items | 2005 | 2006 | 2008 | 2010 |
|---------------------------------------|------|------|-------|-------|
| EFAP(1,000ton,A) | 798 | 940 | 1,410 | 1,880 |
| EFAP production rate of total(% ,A/B) | 4 | 5 | 7.5 | 10.0 |

3.2 Vision and policy direction

3.2.1 Vision

Live a people's well-being life and practicing environmental agriculture.

3.2.2 Policy direction

- Settle down of natural recycling environment friendly agriculture through the harmonization of agriculture and environment.
 - Extending the natural recycling environment friendly agriculture for the minimum input of outside materials in arable land through the linkage with the crop cultivation sector and the livestock sector.
 - Minimize the agricultural environment pollution through the effective use of animal manure in crop cultivation.
- Supporting the people's well-being life through the supply of quality and safety agricultural based food source.
 - Supplying of safety agricultural products for consumers.
 - Consumers' demand has changed to quality agricultural products.
- Enhancement of agricultural products' international competition through the production of EFAP.
 - Production of safety and quality EFAP can overcome the low quality agricultural products.
- Increasing agricultural income for the EFAP production farmers'.
 - EFAP production farming can sustain the high level income.
- Contribution to the national environment conservation by the practicing environment friendly agriculture and management of environment resource.
 - Rural space is relaxation space not only for rural residence but also for the nation people.

4. Major supporting activities for EFAP

4.1 Supporting of EFAP production foundation

To reduce the environment pollution in agricultural sector as well as the production of EFAP, supporting the establishment of necessary facilities and equipment for drinkable water resource protection area, and necessary area for practicing the environment friendly agriculture area involved in more than 10 farmers or organized more than 10 ha of agricultural land. The government will establish 1,500 area up to the 2013 for one area in every district.

- Current status
 - Supported No. of the EFAP production area were 742 location during the 1998 and the 2005.
- Major program
 - Micro-organism propagation facilities and equipment.
 - Organic resource production facilities and equipment.
 - Agricultural by-products use composting facilities and equipment.
 - EFAP production and marketing facilities and equipment.

4.2 Green field management in winter season

MAF has been executed the green field management project since the 1998. The project is the cultivation of green manure crop such as Chinese milk, hairy vetch, rape seed etc. to supply the natural fertilizer while to reduce the application of chemical fertilizer. The other is the cultivation of forage crop such as rye and barley for the cattle feed fallow land of rice field in winter season since the 1998.

Table 3 Green field management area (1,000ha)

| Items | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|--------------|------|------|------|------|------|------|------|
| Forage crop | 38 | 48 | 48 | 50 | 50 | 33 | 38 |
| Green manure | 46 | 67 | 78 | 75 | 66 | 105 | 138 |
| Total | 84 | 115 | 126 | 125 | 116 | 138 | 176 |

4.3 Environment friendly farming

4.3.1 Supporting of environment friendly farming

Generally the environment friendly farming may reduce the yield of agricultural products, one hand, government suggested the practicing of environment friendly farming to farmers, therefore government should supplement the reduced farmer's agricultural income annually.

The supporting work of practicing the environment friendly farming will help the farmer's uncertain crop yield and low return of income, and it should be eventually extending the practicing of environment friendly farming.

4.3.2 Execution of EFAP project

- Qualification : EFAP authenticated farmers and the farmers group.
- Request time and offices : spring season at district offices.
- Farming area : 0.1 ~ 5.0ha
- Type(upland) : organic, semi-organic, no chemical use, low input chemical
- Supporting methods : selected farmers have to follow up as the related regulation and guideline.
- Duration for subsidy : 3 years

4.3.3 Supporting the environment friendly agricultural related farming materials

- Organic fertilizer
 - Upon the increasing consumers' demand of quality and safety EFAP, the government's cost subsidy polish for chemical fertilizer had

abolished in the 2005.

- To expedite the environment friendly agriculture, supporting the purchasing cost of organic fertilizers.

Table 4 Supported quantity of organic fertilizer

| Years | 2004 | 2005 | 2006 |
|---------------|---------|---------|-----------|
| Quantity(M/T) | 600,000 | 700,000 | 1,200,000 |

- Support of natural enemy use insect control for horticultural
 - Major program
Substitution from insecticide to biological natural enemy for horticultural crop can reduce the chemical insecticide use. The natural enemy using biological plant protection will be increased to 50,000 ha (50%) of greenhouse up to the 2013.
※ Training of natural enemy consultant of 1,000 persons every year.
 - Support program
- Duration : 2005 ~ 2013(9 years)
- Area : greenhouse cultivation crops for 20,000ha(20% of total)

4.4 Establishment on the foundation of natural recycling agriculture

4.4.1 Establishment of environment friendly agricultural zone

The animal manure annually production in Korea is estimated 41,171,000 M/T, and the resource reuse as dried solid compost is 79.3% and liquid compost is 1.2%, therefore the total reuse will be 80.5%. Besides the reuse as the fertilizer resource, the animal manure treatment methods are 3.4% by water purification with active sludge, 5.7% by public treatment station, 5.7% by transportation and distribution of animal manure in deep-sea and 4.7% by others.

The major constraint in the management of animal manure is the location of livestock farms are not even proportion in geographically, therefore it is much difficult for the application of animal manure and manure by-products to agricultural land because the transportation cost is too high. On the other hand, the transportation and distribution of animal liquid manure to long distance sea method will be reduced annually from 2007, and stop all by 2012 upon the promulgated government regulation in 2006. The organic matters natural recycling agricultural system executing policies are executed by Ministry of Agriculture and Forestry (MAF). The system benefited the maximum use of the nature's ecological function by the materials recycling for the growing crops and raising animal healthy. It is aimed that the natural recycling agricultural system can enhance the agricultural products'

quality and the safety in agriculture under the promoted environment friendly nature for the people's health and safety.

To improve the agricultural environment together with the expedition of natural recycling agriculture, the crop cultivation sector and livestock sector should linkage within river water flow line and boundary of regencies, and the area will be renewed towards the natural recycling, environment friendly agricultural zone.

4.4.2 Executing program

- Duration : 2005 ~ 2013 (9 years)
- Scale of work : total 50 zones (each zone area has 1,000ha)
- Work plan
 - In the 2005 : development of work models, management program, establishment of facility and equipment.
 - In the 2006 : 3 units as the pilot model
 - In the 2007 ~ 2013 : establishment of 6 ~ 7 zones every year
- Support items : crop cultivation and livestock resource recycle centers, environment friendly machine & equipment, production facility, agricultural and livestock production & marketing facilities, on-site marketing and sightseeing facilities.

4.5 Animal manure resource reutilization development

4.5.1 Situation

- Due to the livestock scale has changed big size, animal manure has been increased rapidly since the 1980s.
 - Animal manure production : (' 80) 35.8 → (' 00) 47.8 → (' 05) 50.6mill. ton
- Supporting the animal manure compost and liquid manure treatment facilities for the development of animal manure reuse resource.
 - Animal manure treatment facilities(A) : (' 92) 60% → (' 01) 96 → (' 04) 97.3
 - Resource reuse facilities(B/A) : (' 92) 19% → (' 99) 86 → (' 01) 92 → (' 01) 92
- “ Natural recycling agricultural Division” under the Ministry of agriculture and Forestry manage the animal manure resource.

4.5.2 Executing program

- Supporting the resource reuse facilities for livestock farmers' new and renew animal manure resource reuse facility.
 - Support facilities : (' 02) 1,700 ea. → (' 04) 1,700 → (' 06) 1,700
- Establishment of foundation on animal manure resource reuse facilities

- Establishment of 43 "Animal manure fertilizer distribution center" up to the 2005 for animal liquid manure resource reuse as fermented liquid manure and application to arable land.
The center have liquid animal manure pumping, transportation, liquid manure field application vehicles and equipment.
- Support the extending on construction of animal liquid manure storage container at individual animal farm or crop cultivation field.
- No. of manure storage container : (' 02) 428 ea. → (' 03) 682 → (' 04) 800 → (' 05) 560 → (' 06) 560
- Pilot project on organic livestock has been conducted, and the details on animal raising and management standard by the type of animal were established.

4.6 Expedited production of EFAP and marketing

- Enhancing the consumers' confidence and strengthening the education and information for the environment friendly agricultural products.
 - Education on environment friendly agriculture for farmers and Information on-site field visit tour for urban consumers'.
 - TV advertisement for the EFAP authentication symbol.
- Supporting the direct marketing local Agricultural Cooperatives network and environment friendly agricultural organization.
- Suggestion of market joining on EFAP by local Agricultural Cooperatives

5. Agricultural Engineering for agricultural energy

5.1 Situation

Basis on national energy utilization rationalization law in the No. 4 which was enacted in the 2002, the national energy basic plan has been established. The plan suggested the 5% of total national energy should be substituted by the new and renewable energy, and it should be provided the detail plan and executing necessary action.

The production of environment friendly agricultural energy will devoted the assisting agricultural energy as well as the farmers' new income source.

The consumption of agricultural energy estimated 2,690 thous. kℓ and it is necessary that the development of energy reduction technology for greenhouse farming which occupies 40% of the nation's total consumption of agricultural sector.

The production of the bio-fuel related crop will impact the currently food crop production system, which will leads the renovation of

agricultural related structure towards the future foundation technology.

5.2 Development of energy reduction technology

The energy reduction technology for greenhouses have been conducted different types. The multi-layer thermal curtain system can save heating fuel of 46%, the coal bunt warm air heater can save heating cost of 42%. The heating space reducing device through the center operated inside tunnel system can save heating cost of 60%, and the heat recuperator for warm air heater can also be reduced the heating cost of 10%. The recycling use of ground water filmy supply heating in dual wall green house can increasing the inside temperature of green house.

The agricultural products drier attached heat recuperator has been practically used by farmers. The geo-thermal using horizontal heat exchanger with heat pump system was developed NIAE, and the system will be effectively used as heated greenhouse in the future.

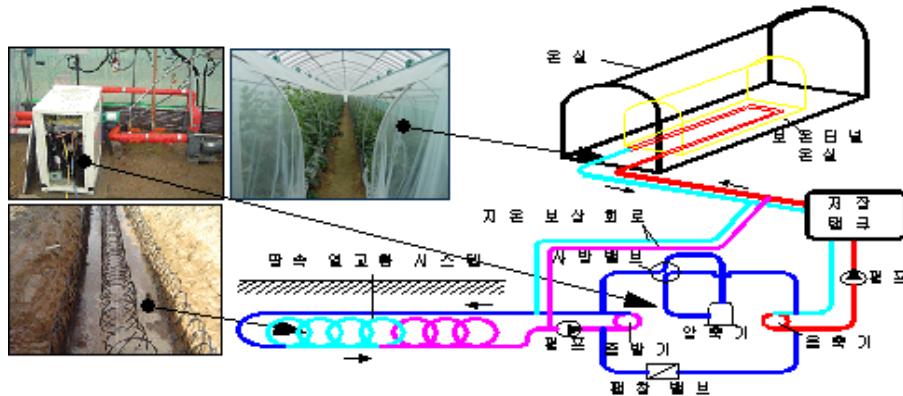


Fig 2 Multi-layer thermal curtain system

The heat exchange capacity of the Coil tube hot water heat exchanger was shown as $409\text{kcal}/3.3\text{m}^3\text{h}$. In case of the outside air temperature is -18°C , the crop growing space can be maintained 14°C , and the coil system has easy handling.



Fig. 3 Coil tube hot water heat exchanger heating

The natural air flow drier has been disseminated since the middle of 1990, however the drier has improved the combination use as the natural air flow drier-cum-low temperature storage bin. The germination rate was increased from 85% in conventional to 97% in the combination use, while the cracked rate was decreased from 19% in conventional to 8% in the combination use. In addition, the improved drier-storage bin use dried and stored rice evaluated 28% higher the value added.



Fig. 4 Natural air drier-cum-low temperature storage bin



Fig. 5 Exhaust heat recovery system for warm air heater



Fig. 6 Exhaust heat recovery system for agri. products drier

5.3 Development of bio-energy technology

The animal liquid manure use bio-gas electricity generation system was developed by National Institute of Agricultural Science and Technology (NIAS, RDA) and National Institute of Livestock Science (NILS, RDA). After the digestion, the liquid manure can be used to arable land as the organic fertilizer source.

As the bio-diesel source rape seed, the high oleic-acid (65%) and cold weather resisting rape seed variety has been developed by National Institute of Crops Science (NICS, RDA).

In addition, the National Institute of Agricultural Engineering had improved the rape seed harvesting device for combine, and farm adaptation field test of mechanized rape seed cultivation system has been conducted since the 2006. The harvesting performance of rape seed for combine was 2h/ha with the 2% of the harvesting loss.



Fig. 7 Field adaptation test for mechanized rape seed production system

6. Natural recycling agricultural system in livestock

6.1 Adoption of animal manure treatment system

In cattle farms, framers generally use sawdust in animal stall as the animal manure absorption material while broiler farms also use sawdust in chick house, and the farmers can ease the composting of animal manure with the sawdust. In the laying hen, chicks manure can be easily dried on cage's belt conveyor which is installed in layer's cage. The chicks manure transported to composting facility as the drying-cum-fermentation station. The pig manure, however, the manure treatment is much difficult technically and high in its management cost, because the quantity of the manure excreted individual pig is too much and the moisture content of the manure is too high.



Fig. 8 Animal liquid manure purification with active sludge

6.2 Animal manure composting fermentation & drying system

Animal manure composting & drying system often adopted the forced aeration fermentation with mixing devices equipped with fermentation & drying composting station. The composting beds filling fermentation media such as sawdust, wood chip or rice husk, and liquid animal manure can supplying to composting beds everyday for the fermentation & drying of animal liquid manure with the emitting thermal energy as well as the various poisonous gases.



Fig. 9 Animal manure fermentation & drying system

The fermentation & drying composting stations are several types such as escalator, rotary and screw type, and the final dried compost can filling as the dried manure to PE film sacks with 20kg size in weight. The final sack filling fermented and dried manure generally sells to crop cultivation farmers. The constraint of the fermentation & drying composting system is high in initial investment cost, and the system emitting hazardous gases such as H_2SO_4 gas, ammonia gas etc. which gases can damage the electric control unit of the system and rusting iron members of the building.

6.3. Liquid animal manure storage-fermentation-spreading system

There are more than four thousand liquid manure storing containers with the size from 200m³ to 500m³, which were constructed in agricultural land or pig raising farms since the 2000. The liquid manure container should be stored more than six months for the fermentation satisfactorily, and the fermented liquid manure can spread into rice field and orchards.



Fig. 10 Liquid manure storage container



Fig. 11 Offensive odor emitting facility for manure tank

The extension workers in Rural Extension Office inspect the total nitrogen (T-N) of liquid manure with the nitrogen measuring devices, and the workers suggest the application quantity of liquid manure per hectare by type of cultivation crops on the basis of each soil fertility data. The National Institute of Agricultural Engineering (NIAE) have been developed and propagated subsurface liquid manure injectors, sloped land adapted liquid manure applicators since the early in the 2000. The animal liquid manure is good fertilizer resource, however the liquid manure has high in handling cost.

For the liquid manure tank cleaner, the destroying of sediment accumulated animal slurry manure tank for 300ton size need only one hour. As the liquid manure mixing performance, the changes of moisture content of the liquid manure before and after the mixed liquid manure

were changed from 70~90% to 75~80%.

The effects on the mixing work were observed the destroying liquid animal manure sediment layers and that made floating scum in liquid manure tanks. So, the mixture of liquid manure and sediments changes the slurry animal manure, and the slurry manure will no more settle down in the bottom of tanks and it can be discharged through a discharge pipe by vacuum pump attached tank spreaders.



Fig. 12 Slope land use animal liquid manure spreader



Fig. 13 Animal manure storage tank sediment cleaner

7. Green field management movement

7.1 Mechanized cultivation of forage crop

Recently, the barley growing area has been increased as the second crop in paddy field during winter and spring season. The whole crop barley can process the wrap silage for cattle feed, which is recognized as a successful case by MAF "green field management movement" in winter season.

The whole crop barley silage is much useful roughage feed and concentrated feed source for cattle raising farms. The natural recycling agricultural system can supply the organic matters to paddy field for the production of whole crop barley and whole crop rice for animal feed.

To expedite the green field management movement, MAF hold a

mechanized forage crop harvesting field demonstration every year for the mutual benefit, the cattle feeding farmers and the rice production farmers.



Fig. 14 Harvest of whole crop barley for cattle feed



Fig. 15 Wrap of whole crop barley for silage feed

7.2 Cultivation of mechanized green manure

Recently, the total input of chemical fertilizer has been reduced in rice field, while the cultivation area of green manure crops such as hairy vetch, Chinese milk and sorghum etc. have been increased in the country. To extending the green manure crops, it is necessary that the treatment of the crop easily and effectively to reduce the treatment cost.

The southern area in the country, widely growing Chinese milk, while northern area growing hairy vetch and rye, however the vetches have low in height and much soft stem than rye. On the other hand, Korean Ginseng field generally growing rye and Sudan grass, so the treatment of long and fiber rich stems and leaves are much difficult in treatment of green manure. NIAE has been studied the easy and economic way for green manure crops plant treatment and land preparation since the 2006.



Fig. 16 Green manure crop Chinese milk



Fig. 17 Green manure treatment for Sudan grass

8. Precision agricultural system

8.1 Vision

NIARE and NIAST put much effort to develop the PA technology and feasible application models. As an alternative to realize EFA, PA enables environmental friendly quality agricultural products through scientific and effective way using agricultural machinery based on information about soil, crop, and weather. Basic IT-applied PA technologies were developed mainly by the National Institute of Agricultural Engineering, RDA, and it is the stage of on-farm performance test for partial implementation of the results.

8.2 Related technology developed

Technologies and devices developed or under development are 1) sensors for bio-environment measurement such as soil sampling system, soil strength measuring device, crop growing condition measuring device, and yield monitoring system that measures rice yield by within-field locations, 2) mapping software to create electronic maps, and 3) variable rate initial and additional fertilizer application system.

Soil strength measuring device measures soil strength, an important soil physical property used frequently for hard-pan detection and

optimum tillage, mechanically and reliably, and commercialization and application to actual farming is expected in the near future.



Fig. 18 Yield monitoring system

One of the devices under on-farm performance test for application to actual farming is an electronic map-based variable fertilizer applicator attachable to a transplanter. The unit uses positioning information (e.g., GPS) and electronic fertilization application map prescribed by soil testing results to apply fertilizer variably by location, and could save 17% of the conventional fertilizer application amount without yield loss.



Fig. 19 Map-based variable fertilizing rice transplanter

8.3 Adaptation of PA technology

As a example of actual on-farm application is being conducted by Pyeongtaek city as the "Ubiquitous-based PA promotion strategy". Pyeongtaek city conducts a project for development and stable extension of PA technology for environment friendly and high-quality safe agricultural products that consumers prefer.

Other local governments have a keen interest in PA and show activities for business plan embodiment and technology adoption, and expansion of PA-based farming operations with technical support is expected.

As described above, Korean PA is in the stage of basic technology

development and on-farm performance test, but for practical application and confirmation of the positive effects, expansion of understanding on PA and development and improvement of Korea-specific application models.

Conceptual approach is more important than technical approach in PA. Instead of simultaneous and full scale application of entire technology, it would be better for Korean agriculture with small sized paddy rice fields to start with application and verification of each technology and expanded step by step based on the bio-environmental information.

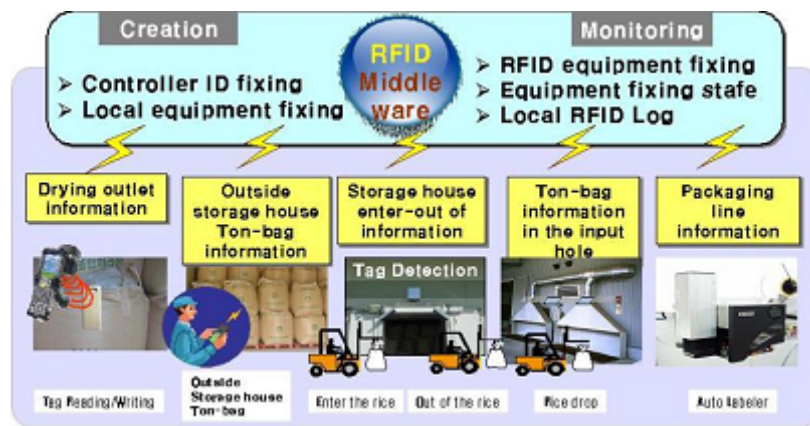


Fig. 20 RFID use rice production history system for PA products

9. Crop production machinery

9.1 Weeding machine for rice cultivation

A walking type 3-row weeding machine that could remove and root out weeds inter- and within- rows was developed for substitution of duck raising rice farming method.



Fig. 21 Weeding machine for rice farming

The walking type weeding machine for rice production could adjust

operating width from 18 to 24 cm according to weeding time, and field capacity was about 1ha/h. In a paddy field with a water depth of 1 cm, the use of the prototype was effective in removing weeds, showing a rate of weed control of 97.2%, which was similar with that of conventional manual weeding operation. This indicated that the prototype could save 94% of weeding labor, and it was suitable for EFA with herbicide free farming.

9.2 Paper mulching rice transplanter

A paper-mulching rice transplanter was developed to grow rice in an environmental friendly way, by preventing weed growth using paper mulching material, instead of herbicides. Weed-preventing mulch paper was developed in cooperation with a company. The bio-degradable paper (PES, 10 μm) was decomposed naturally in 55~60 days after the transplanting, and there was no residues in the environment and crop after decomposition.



Fig. 22 Paper-mulching rice transplanter

Field performance of the paper-mulching transplanter showed that weed control value was 98% and the rice yield was 502 kg/10a. In view of the performance of conventional transplanter, the paper mulched rice transplanter could contribute EFA with no herbicide use farming.

9.3 Strip tillage rice transplanter

A strip-tillage rice transplanter that could apply slow-release fertilizers at the time of transplanting was developed to save labor and cost for rice production. The unit could save tillage energy by till only the strips to be transplanted, and increase fertilizer utilization by applying slow-release fertilizers in front of strip-tillage blades and covering the slow-release fertilizer with soil.

Field performance tests showed that sufficient irrigation for 10~20 days before transplanting resulted in reduction of miss-planted rate and

increase of rice yield about 7%, and it can saved fertilizer application by about 20% compared with the conventional transplanting.



Fig. 23 Strip-tillage rice transplanter

9.3 Partial tillage direct seeder

The partial tillage direct seeding work can be reduced full tillage operation, and the seeder composed of rotary tiller, fertilizer applicator and seeder unit. The seeder attached rotary tiller uses four blades of power cultivator's down cut action and it can make crop cultivation one row and one drainage furrow. The fuel consumption of the machine was 2.5ℓ /ha and it can reduce the 50% of the fuel consumption of the ordinary land preparation and directing seeding operation. The work performance of the partial tillage direct seeder was 3.8h/ha at working speed of 0.5m/s including seeding time and fertilizer suppling time. The working cost can be reduced by 23% compare with the ordinary direct seeder.

9.4 Pesticide & insecticide minimized spraying system

Most of fruit farmers have speed sprayer and the farmers doing application of pesticides and insecticides time to time during fruit tree growing season. However, some of the droplets of chemical solution will partly lost in the space between trees and leaves. The missing droplets during spraying will not only the wasted expense for growers but also the source of environment pollution. The electrostatic sprayer was equipped with spraying nozzle and ring type high voltage electric generation system as much as 7.5kV. As the result of field tests, the coverage rate of droplets for the machine showed 22% at 7.5kV of electric voltage with the 2,500rpm of fan in comparison with that of the 10.6% for ordinary speed sprayer.

10. Agricultural products safety

10.1 Agricultural products cleaning

For the agricultural products cleaning, the hot water washing and drying system is applied for fruits, vegetables and leafy vegetables. NIAE has been developed cleaning system for tomato, apple, fresh perilla leaves, etc. The system can cleaning dust, earth and pesticide chemical free clean fruit and vegetable may packed, and it can eat without wash. And the washed germ free fruit and vegetables can store longer time and the such hygienic agricultural products changes value added commodities.



Fig. 24 Cleaning system for leafy vegetable

10.2 Gems and agricultural chemical detecting technology.



Fig. 25 Fiber-optic bio-sensor for Salmonella detection

For the discrimination of improper ingredients in agricultural products, the rapid detection of food borne pathogens and detection of chemical residues in agricultural products by using up-to-date sensor technologies have been developed. An impedance biosensor for Salmonella detection, a surface plasmon resonance sensor for pesticide detection and image processing technology use detection of foreign objects such as slugs in lettuce etc. were developed.

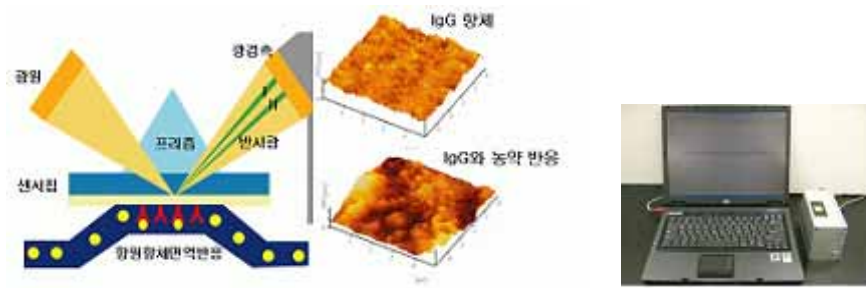


Fig. 26 SPR bio-sensor for pesticide residue detection

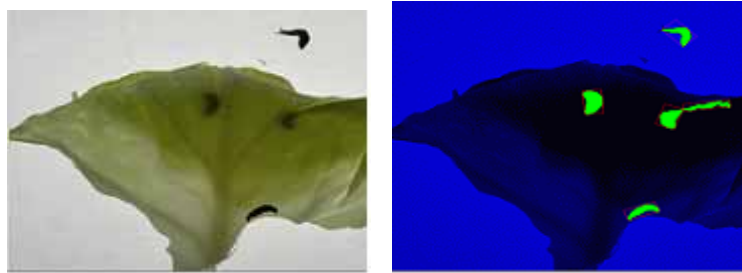


Fig. 27 Image processing use detection of foreign objects