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Demand for Organic Farming Technology and Roadmap for Technology Development

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- “KREI Agricultural Policy Focus” relates to analysis and description of the trend of and policy issues of agriculture and rural districts.
- This is also provided at the KREI website (www.krei.re.kr).

◇ **Abstract** ◇

Organic farming is a method of agricultural chemical · chemical fertilizer-free organic cultivation to produce agricultural products and to supply the produced agricultural products to consumers.

As more organic agricultural products are predicted to be produced thanks to the spreading wellbeing trend of consumers and government's support policy, further development of organic farming technology is needed. Therefore, it is very important to identify the demands for organic farming technology, and to suggest a needed roadmap for developing technology, for the mid- and long-term agricultural policy.

The analysis of demands for organic farming technology for farmers in each field reveals high demands for using microorganisms and soil improvers in the field of soil and nutrient management technology. The field of weed control technology showed high demands for developing naturally decomposed vinyl products. The field of harmful insect control technology showed high demands for using organic materials, microorganisms and eelworms. The field of diseases control technology showed high demands for using natural materials and food, for example, egg yolk oil, vinegar, and pyroligneous liquid.

Organic farming experts said the highest priority of 0.219 for the technology of recycling crop cultivation and livestock resources including compost, liquid fertilizers and organic fertilizers in the investigation of applying the AHP method to analyze the priority of developing organic farming technology. The highest priority is followed by 0.125 for bio-agricultural chemical, and then 0.119 for the technology of cultivating green manure crops. It is necessary to develop a key project for each field of higher priority to input research funds for continuous technology development.

The development roadmap for each field is suggested in consideration of priorities of developing organic farming technology. In particular, required is to build a system for recycling crop cultivation and livestock farming by developing technology for organic crop cultivation and livestock recycling; a system for controlling eco-friendly organic farming soil and nutrients by developing technology for controlling organic soil and nutrients; a system for eco-friendly weed control by developing organic weed control technology; an eco-friendly system for controlling organic diseases and harmful insects by developing organic disease and harmful insect control technology; an eco-friendly system for organic seeds and seedlings by developing organic seed and seedling technology. It is essential to establish a technology development direction and the strategy for performance of each field for the R&D investment plan (2013-2022) in the agricultural sector.

Because it is predicted that organic farming will continue to develop as a field of future growth in agriculture, it is necessary to expand R&D investment in related technology development. It is necessary to adopt farmers' and experts' opinion to continue technology development to respond to demands in order to supply safe agricultural products to consumers by means of steady development of organic farming.

1. Current organic farming and technology development

1.1. Concept and meaning of organic farming

Organic farming is a supplement and substitute for the function of agricultural chemical-chemical fertilizer.

○ Organic farming is agricultural chemical-chemical fertilizer-free organic cultivation to produce agricultural products and to supply them to consumers.

- Organic cultivation technology supplements or substitutes the functions of agricultural chemical-chemical fertilizer.
- Its basic principle focuses on natural circulation of the environment.
- The organic farming technology regulates the condition for full representation of natural circulation of the environment, and supplements poor representation of the function, if any, with human labor or other means.

Organic farming tackles the burden on the environment and facilitates natural circulation.

○ Because organic farming does not use agricultural chemicals and chemical fertilizers, it reduces the burden from agricultural activities on the environment and facilitates natural circulation in comparison with conventional agriculture.

- Organic farming is based on the eco-system composed of various creatures, to maximize the function of the nature, and thus to inhibit diseases and harmful insects to cultivate crops.
- Organic farming is carried out in farm land which is a component of the secondary natural environment, and plays a lot of roles in terms

of conserving the natural environment through ideal agricultural production activities, and creating beautiful scenery.

- While organic farming enhances overall safety of agricultural products and lowers the burden on the environment, it needs more labor and more costs for agricultural materials than the conventional farming.
 - The government has enforced the direct payment system for eco-friendly farming to compensate for the initial reduced income and the difference in production costs in relation to organic farming by eco-friendly farming practitioners.
 - The government encourages organic farming through the organic fertilizer support program, and the program for supporting farmers with green manure crop seed cost to encourage organic farming.

1.2. Details of organic farming technology

- The organic farming technology is classified into 4 categories of ‘technology for controlling soil and nutrients’, ‘technology for controlling weed’, ‘technology for controlling diseases and harmful insects’, and ‘other technology’. Table 1 illustrates details and the effect of the aforementioned 4 categories.

Table 1. Categories and description of organic farming technology

Category	Sub-category	Description and effect
Technology for controlling soil and nutrients	Cultivate green manure crops.	<ul style="list-style-type: none"> • Nutrient supply through green manure crops.
	Compost, liquid fertilizer (circulation of crop and livestock resources)	<ul style="list-style-type: none"> • Stimulate microorganism activities in soil to supply balanced nutrients to crops. • Improve physical and chemical properties of soil and microorganisms in soil.
	Organic fertilizer	<ul style="list-style-type: none"> • Nutrients decomposed from soil. • Oil cake, castor been cake, palm cake.
	Microorganisms	<ul style="list-style-type: none"> • Balanced nutrient supply to crops.
	No-till, partial till	<ul style="list-style-type: none"> • Supply quality organic substances by returning cover crops to soil. • Save labor and fuel costs.
Weed control technology	Machine weeding	<ul style="list-style-type: none"> • Use weed controllers compatible with agricultural conditions and environment.
	Covering with organic material	<ul style="list-style-type: none"> • Use covering crops, rice straws, tree bark covering.
	Covering with chemical material	<ul style="list-style-type: none"> • Use vinyl mats, non-fabric mats, shading nets, paper, and naturally-decomposed vinyl mats.
	Using animal resources	<ul style="list-style-type: none"> • Use useful animals including pomacea, ducks and geese to get rid of weeds.
Technology for controlling diseases and harmful insects	Trap	<ul style="list-style-type: none"> • Use attraction lamps, attraction liquid or sticky traps to attract and exterminate harmful insects.
	Natural enemy	<ul style="list-style-type: none"> • Natural enemy keeping plants, aphidoletes aphidimyza, lady bug, nesidiocoris tenuis. • Slow effect, but greater effect when the population increases after natural enemies settle.
	Bio-agricultural chemical	<ul style="list-style-type: none"> • Use effective microorganisms, and germs which cause diseases in insects to control diseases.
	Sulfur, egg yolk oil, animal and plant extract	<ul style="list-style-type: none"> • Use homemade inhibitors for controlling diseases by animal and plant growing farmers.
	Using natural material	<ul style="list-style-type: none"> • Dilute and spray vinegar or sea water on crops to control diseases.
Other technology	Organic seed and seedling	<ul style="list-style-type: none"> • Technology for harvesting, producing growing and cultivating organic seeds.
	Identification of organic agricultural products.	<ul style="list-style-type: none"> • Technology for identifying true organic agricultural products for enhancing reliability.
	Processing organic agricultural products.	<ul style="list-style-type: none"> • Processing technology for enhancing the added value of organic agricultural products.

Note: Re-classification through experts' review in universities and research institutes involved in organic farming related studies on the basis of technology categories in Easy Organic Farming.

Source: Rural Development Administration (2010). "Easy Organic Farming 1." "Organic Farming Technology 7."

1.3. Current development of organic farming technology

Current organic farming technology study concentrates on soil control.

- Soil control study accounts for 51% in the entire eco-friendly and organic farming related study, which implies concentration on soil study (Figure 1).
- The study for diseases and harmful insects and investigation of eco-friendly farming accounts for 10%, respectively. Development of technology for the important fields in organic farming, for example, management, distribution, weed control, species and livestock study is not relatively high.
 - Research and development about biodiversity of Korea in relation to organic farming is just at the stage of beginning.

Cultivation focusing on rice field and rice

- Current study for eco-friendly and organic farming in each field of cultivation is about rice field which accounts for 47.8%, almost a half, and concentrates on rice cultivation (Figure 2).
 - Study for organic crop field cultivation other than rice is not higher than approximately 17%. Study for protected crop cultivation accounts for 22%, and study for orchards does approximately 13%.

Figure 1. Current study for developing organic farming technology (1997-2010)

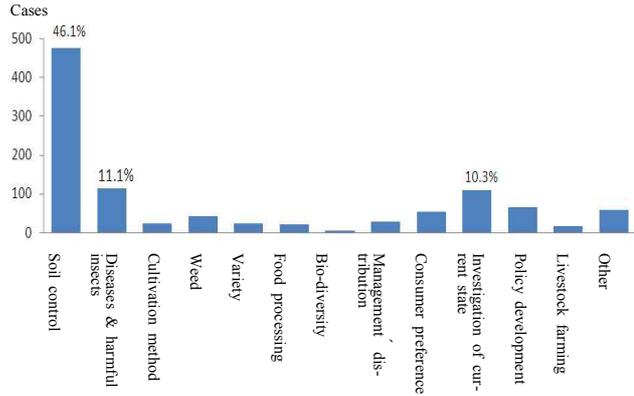
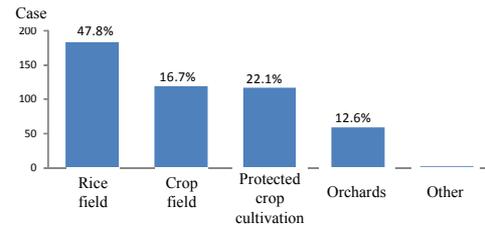


Figure 2. Study for organic farming and development of technology (1997-2010)



Source: Literature for academic database KISS and DBPIA eco-friendly and organic farming

2. Demand for organic farming technology

2.1. Result of investigation of expert opinion about demands for organic farming technology

- It is important to adopt features of each crop in the field of soil and nutrient control.**
 - The field of soil and nutrient control is classified into green manure crop and sod culture, compost and liquid fertilizer and organic fertilizer, soil microorganism, and no-till. It is important to examine and reflect features of each crop.
 - Because agricultural productivity is highly affected by soil fertility enhanced over a long period of time in terms of the features of soil and nutrient control, it is necessary to analyze and study the effect of green manure crops over a long period of time and features of soil in the field of green manure crops and sod culture.
 - Study and disseminate technology related to a system for increasing and providing green manure crop seeds so that farmers can use it. It is predicted that technology of natural early harvesting and mixed crop cultivation will be further demanded.
 - Soil microorganisms which live in soil and decompose organic substances attract great interest.
 - It is predicted that there will be more demands for the technology of selecting effective microorganisms and their mass growth, the technology of using effective microorganisms to make them soil nutrients, and the technology of developing a soil microbial fauna soundness index.

- No-till is a method of cultivating crops by sowing or transplanting crops without tilling land. Leaves or fruits of crops cultivated last year are naturally left in furrows to be compost, and the volume of discharged carbon is significantly reduced because farming machines like tractors or cultivators are not used.

- **Weed control in organic farming needs technology of reducing pollution.**
 - While weed control in organic farming depends mainly on vinyl mulching, vinyl mulching remains in soil to cause pollution, and needs expenses for collection. Therefore, technology is needed to substitute it.
 - Develop covering materials, for example, naturally decomposed vinyl covering, paper covering or non-fabric covering, to be an alternative. Develop non-covering cultivation technology for cultivating crops without mulching.

2.2. Result of investigation about farmer's technology demand for organic farming

- The result of investigation about farmer's demands for organic farming technology in each field reveals 30.3% for using microorganisms and 21.3% for soil improvers among the soil and nutrient control technology.

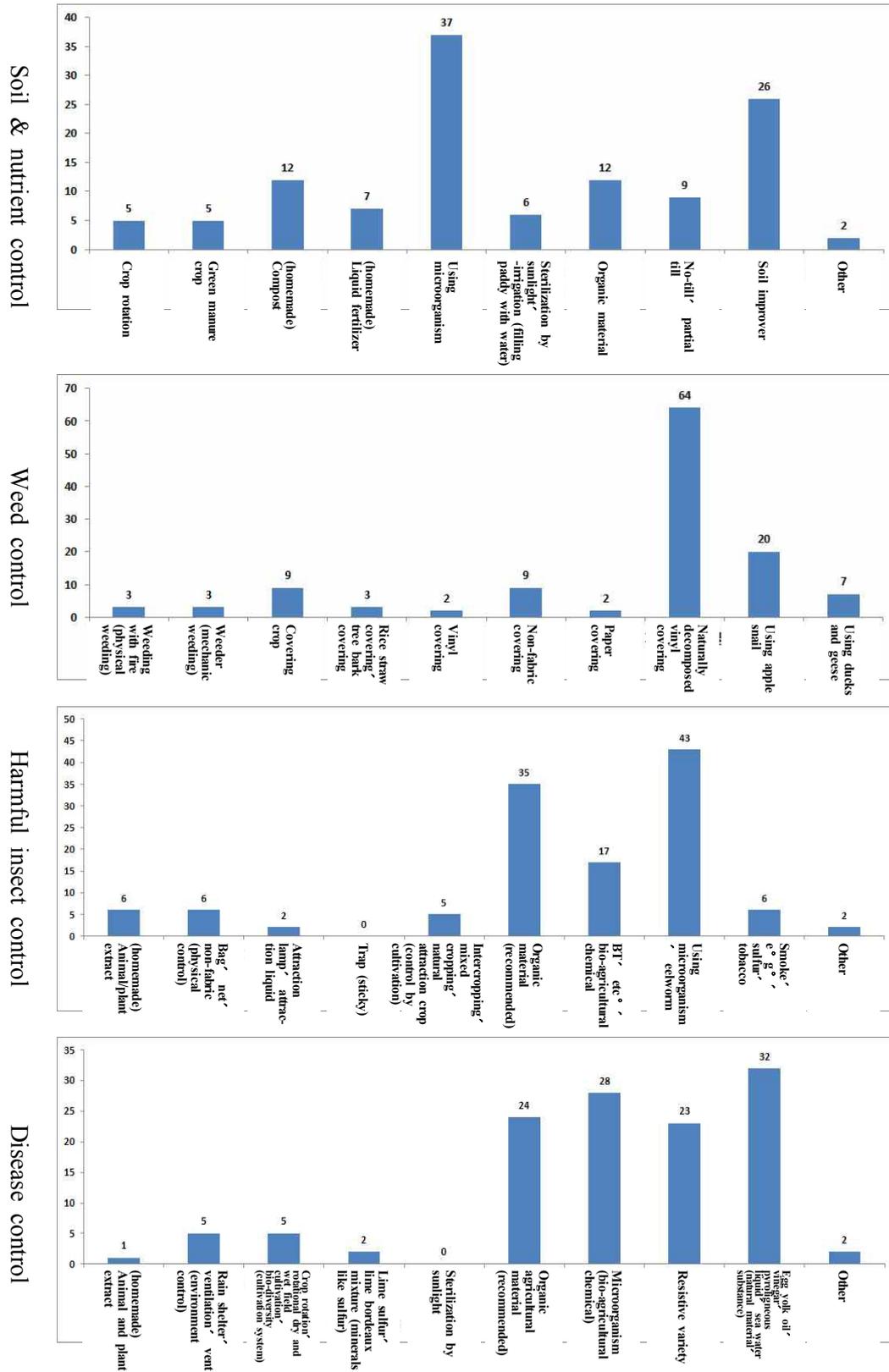
- For weed control technology, naturally decomposed vinyl covering was shown 52.5%, the highest.
 - If the technology for naturally decomposed vinyl covering is improved to reduce negative effect on the environment, it will be widely employed in the field of agriculture.

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- For harmful insect control technology, the demands for developing technology about organic agricultural material currently commercially available in the market and using microorganisms and nematodes were 28.7% and 35.3%, respectively.
 - Although farmers already apply organic agricultural materials currently available in the market, microorganism and nematodes, the price is still high and the effect is yet to be proved. Therefore, there is a need of technology improvement.

 - The highest necessity was 26.2% for using natural substances and material, for example, egg yolk oil, vinegar, pyroligneous liquid, and sea water. The necessity for bio-agricultural chemical including microorganisms was 23.0%, organic agricultural material currently commercially available in the market 19.7%, and resistant species 18.9%.

 - Farmers prefer purchasing and applying agricultural materials for harmful insect control to making and using them for themselves.
 - It is not easy that farmers employ technology for harmful insect control for themselves because of aging labor in rural districts and lack of workforce.

Figure 3. Farmer's demands for organic farming technology in each field



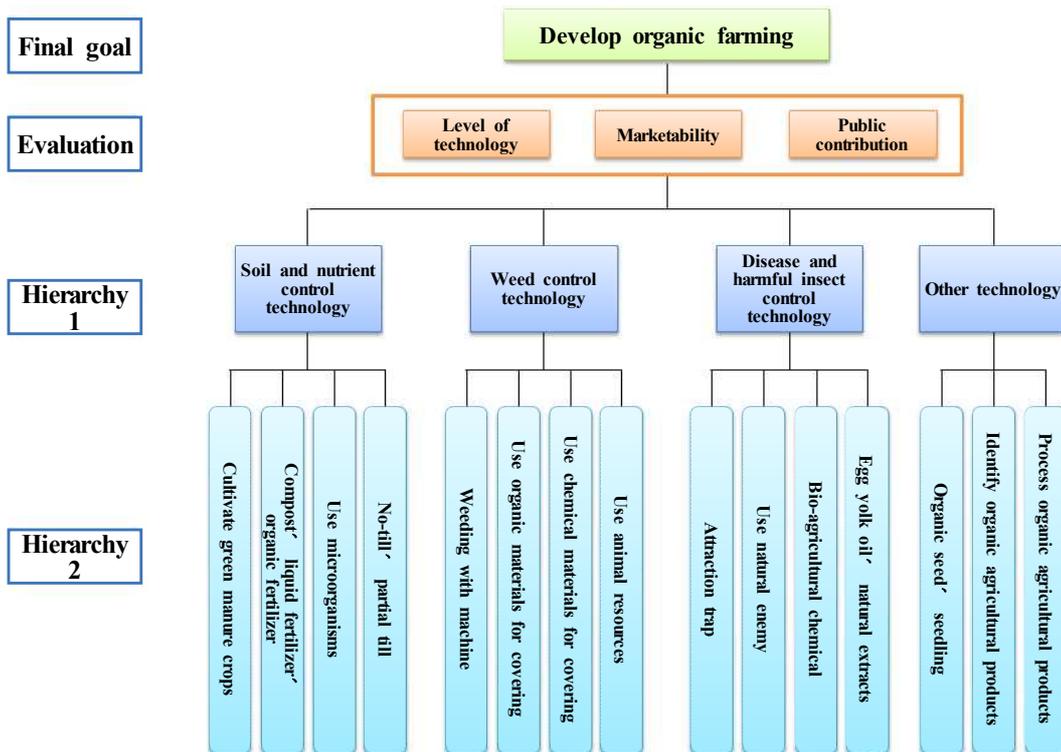
3. Priority of developing organic farming technology

3.1. Technology development hierarchy and overview of investigation

- The organic farming technology is categorized as ‘soil and nutrient control technology’, ‘weed control technology’, ‘disease and harmful insect control technology’, and ‘other technology’. The categorization is based on the level of technology, marketability, and public contribution, to establish a hierarchy shown in Figure 4. The priority of developing organic farming technology is established through AHP (Analytic Hierarchy Process).

- Questionnaire for organic farming experts
 - Period : December 3 to 10, 2012 (8 days)
 - Participants : Experts who study organic farming technology in research institutions, and universities.
 - Method: E-mail and interview to get answers from 14 participants.

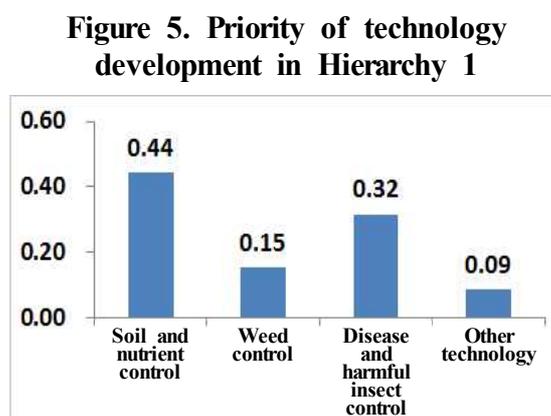
Figure 4. Hierarchy for developing organic farming technology



3.2. Analysis of investigation

□ **The soil and nutrient control technology is the most important in organic farming, and the priority of development should be established on the basis of marketability.**

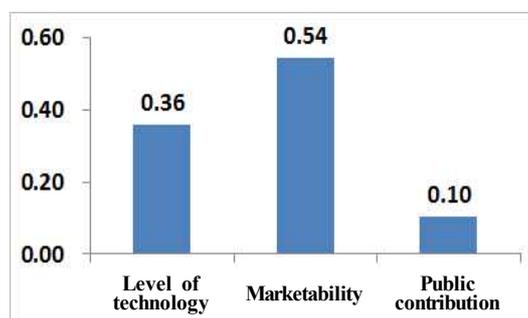
○ For ‘Hierarchy 1’ organic farming technology, development priority is 0.44 for soil and nutrient control technology, the highest, followed by 0.32 for disease and harmful insect control technology, and 0.15 for weed control technology, as shown in Figure 5.



- Soil and nutrient control is the most important in organic farming. Because it has a beneficial effect on disease and harmful insect control and weed control, the technology should be developed first of all.

○ Relative importance among evaluation criteria for organic farming technology is 0.54 and 0.36 for marketability and the level of technology, but 0.10 for public contribution which is quite low, as shown in Figure 6.

Figure 6. Importance of evaluation criteria for technology development

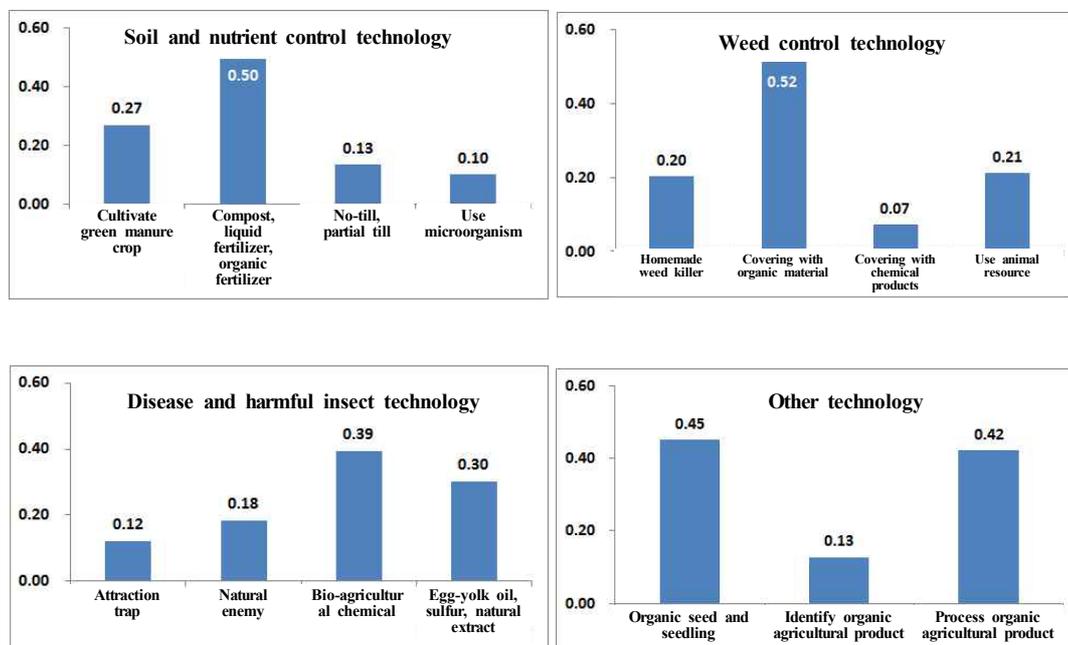


- The reason of low importance of public contribution is because organic farming technology should be studied and developed focusing on

organic farming itself, rather than consideration of its effect on other industry.

- The first priority of developing organic farming technology for each field (Hierarchy 2) is circulation of crop and livestock resources technology, followed by covering with organic matters, bio-agricultural chemicals, and organic seed and seedling technology, as shown in Figure 7.

Figure 7. Priority of developing organic farming technology in each field (Hierarchy 2).



- **Comprehensive evaluation of developing organic farming technology reveals circulation of crop and livestock resources technology is the most important and currently needed the most.**

- The highest priority of developing organic farming technology is decided by generalizing the weight of Hierarchy 1 and Hierarchy 2 is

0.219, for circulation of crop and livestock resources including compost, liquid fertilizer and organic fertilizers (Table 2).

- The next priority is 0.125 for bio-agricultural chemical, followed by 0.119 for the technology of cultivating green manure crops.

Table 2. Comprehensive evaluation about priority of developing organic farming technology

Hierarchy 1			Hierarchy 2		Evaluation criteria			General ¹⁾	
Category	Weight	Rank	Category	Weight	Level of technology	Marketability	Public contribution	Weight	Rank
					0.356	0.542	0.102		
Soil nutrient control technology	0.443	1	Cultivate green manure crops	0.269	0.096	0.146	0.028	0.119	3
			Compost-liquid fertilizer, organic fertilizer [circulation of crop and livestock resources]	0.495	0.176	0.268	0.051	0.219	1
			No-till, partial till	0.134	0.048	0.073	0.014	0.059	6
			Use microorganism	0.101	0.036	0.055	0.010	0.045	8
Weed control technology	0.153	3	Weeding with machine	0.202	0.072	0.109	0.021	0.031	13
			Covering with organic material	0.515	0.183	0.279	0.053	0.079	5
			Covering with chemical material	0.071	0.025	0.039	0.007	0.011	15
			Use animal resources	0.212	0.075	0.115	0.022	0.032	12
Disease and harmful insect control technology	0.316	2	Attraction trap	0.121	0.043	0.066	0.012	0.038	10
			Use natural enemy	0.182	0.065	0.099	0.019	0.058	7
			Bio-agricultural chemical	0.394	0.140	0.213	0.040	0.125	2
			Sulfur, egg yolk oil, natural extract	0.303	0.108	0.164	0.031	0.096	4
Other technology	0.088	4	Organic seed and seedling	0.450	0.160	0.244	0.046	0.039	9
			Identify organic agricultural product	0.127	0.045	0.069	0.013	0.011	14
			Process organic agricultural product	0.422	0.150	0.229	0.043	0.037	11

Note: 1) The general weight is calculated by the weight of Hierarchy 1 × the weight of Hierarchy 2.

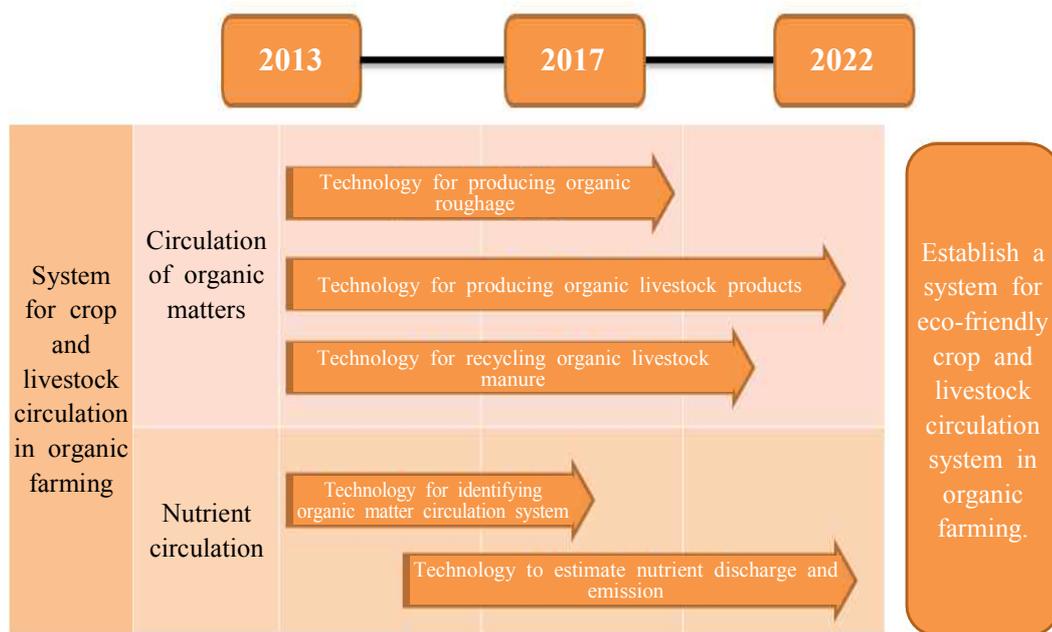
Source: Result from questionnaire for KREI experts.

4. Establishing roadmap for developing organic farming technology

4.1. Developing soil and nutrient control technology

- First need for developing compost, liquid fertilizer and organic fertilizers for circulation of organic matters and nutrients**
 - Soil, compost, liquid fertilizer and organic fertilizers are very important factors to establish a system for crop and livestock circulation, and needed for circulation of organic matters and nutrients.
 - The field of soil, compost, liquid fertilizers and organic fertilizers is on the first place in the general priority evaluation for developing technology.
 - Intensive investment is needed into the technology for producing organic roughage for 5 years until 2018, the technology for producing organic livestock products until 2022, and the technology for recycling organic livestock manure until 2020.
 - Develop the technology for establishing a system for organic matter circulation by 2017 for facilitating nutrient circulation. Make a plan for research and investment into the technology for estimating nutrient discharge and emission from 2015 to 2022.

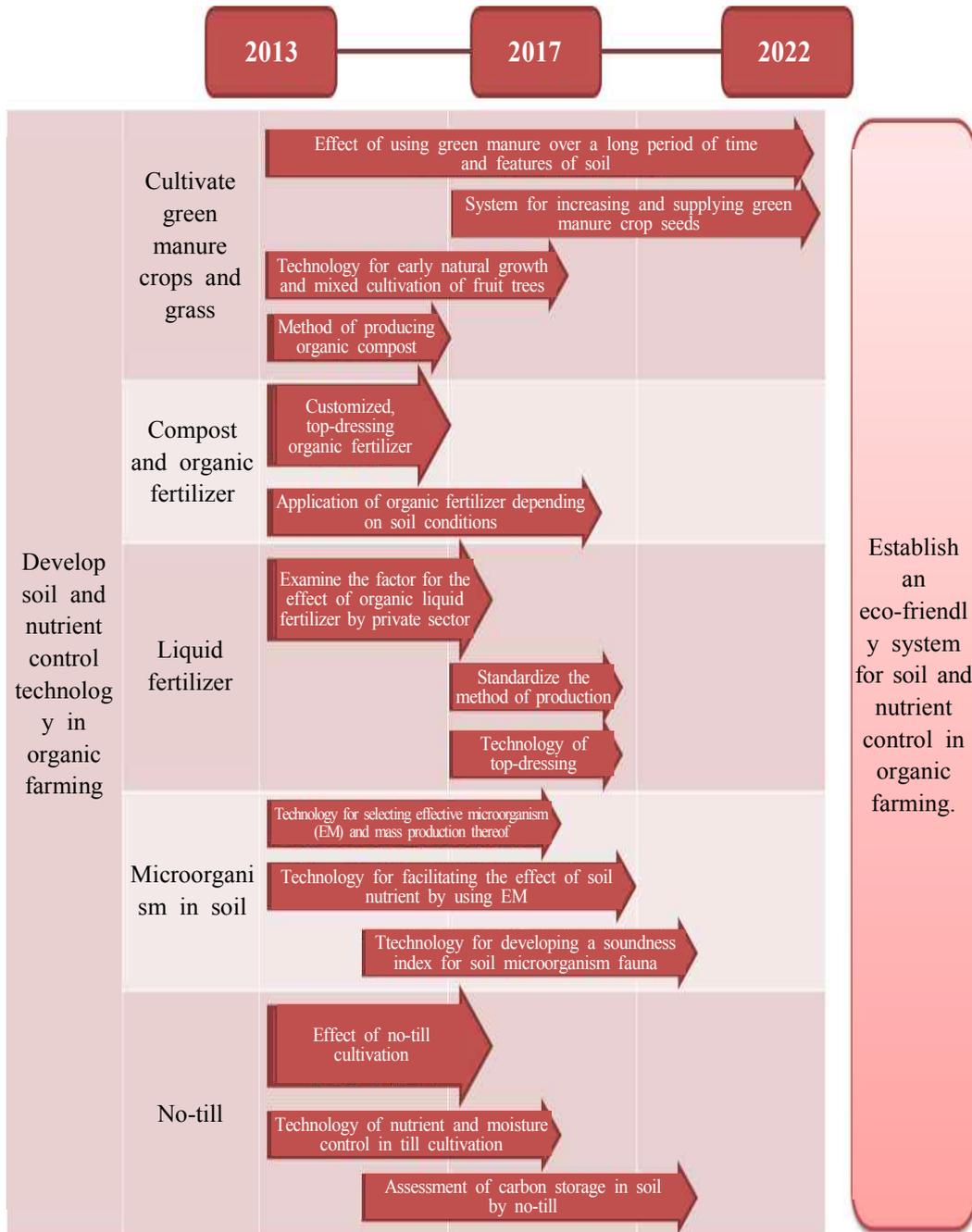
Figure 8. Roadmap for developing technology for the organic crop and livestock circulation system



□ Selecting and developing green manure crops applicable to organic farming step by step

- For efficiently using green manure crops on the third place in the comprehensive priority evaluation for developing organic farming technology, it is necessary to select green manure crops applicable to organic farming in Korea first of all.
- The thing needed for effective use of green manure is to consider the effect when the green manure is used over a long period of time in relation to green manure and sod culture, and the feature of involved soil.
- Because the features of soil are varied over time, it is necessary to study and develop them until 2022.
 - It is necessary to establish a system for increasing and supplying green manure crop seeds from 2016, to supply them to farmers. If the technology for early natural growth and mixed cultivation of fruit trees is developed until 2017 on a mid-term basis, the technology will be stabilized.

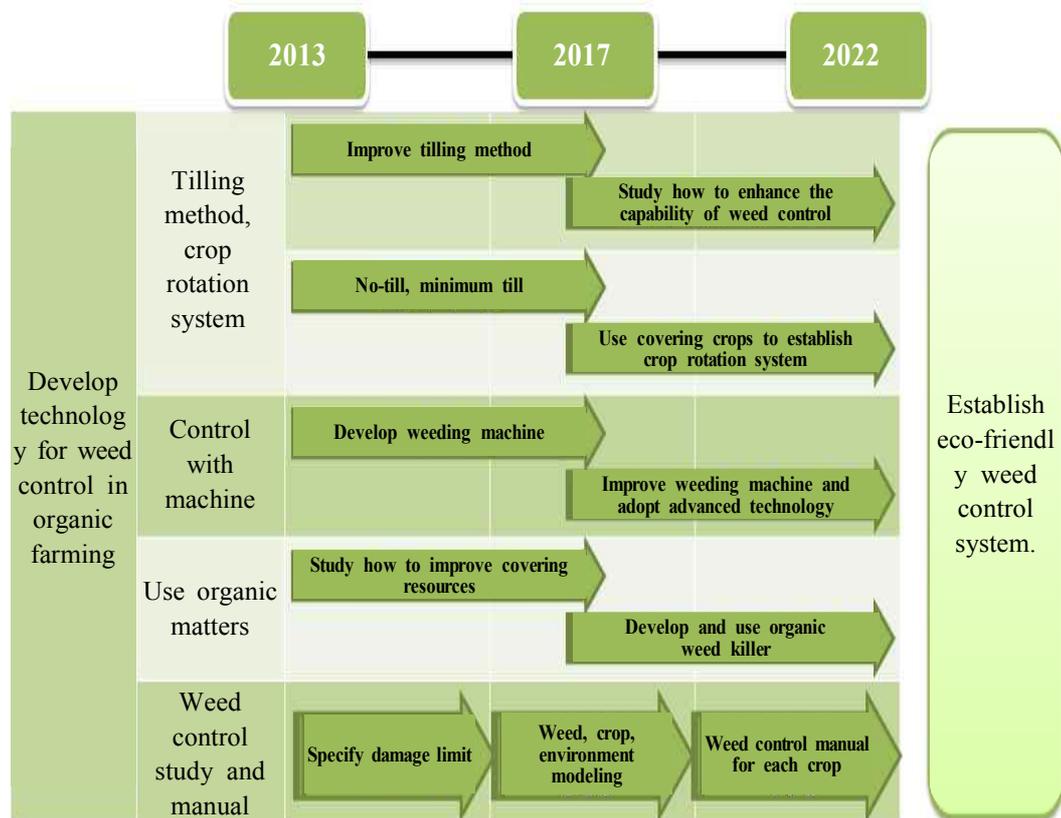
Figure 9. Roadmap for developing technology for soil and nutrient control in organic farming



4.2. Developing weed control technology

- **First, develop technology for covering cultivated land with organic matters in the field of weed control**
 - Study covering resources for using organic matters in the field of covering cultivated land with organic matters on the 5th place in the priority evaluation with respect to developing organic farming technology.
 - Improve the covering resources from 2013 to 2017, to make an eco-friendly basis for using organic matters. Develop organic weed killers and study how to use them from 2017 to 2022.
 - Investigate and analyze the crop rotation system in tilling method other than using organic matters in order to build a system for eco-friendly weed control system, control with machines, weed control study, and provide user manual to enhance the efficiency of studied and developed weed control.
 - Improve the method of tilling and complete technology development for no-till and minimum-till by 2017 in the field of the till and crop rotation system. Enhance weed control capability on the basis of the result, and establish a system for crop rotation by using the covering crops by 2022.
 - Specify the damage limit, carry out weed, crop and environment modeling, and develop user manuals for weed control of each crop and weed control study, step by step.

Figure 10. Roadmap for developing weed control technology in organic farming



- Weeding with machines is very important to cope with lack of labor in rural districts.
 - Study how to enhance the effect of weeding machines until 2017, and improve the developed weeding machines focusing on incorporation with advanced technology.

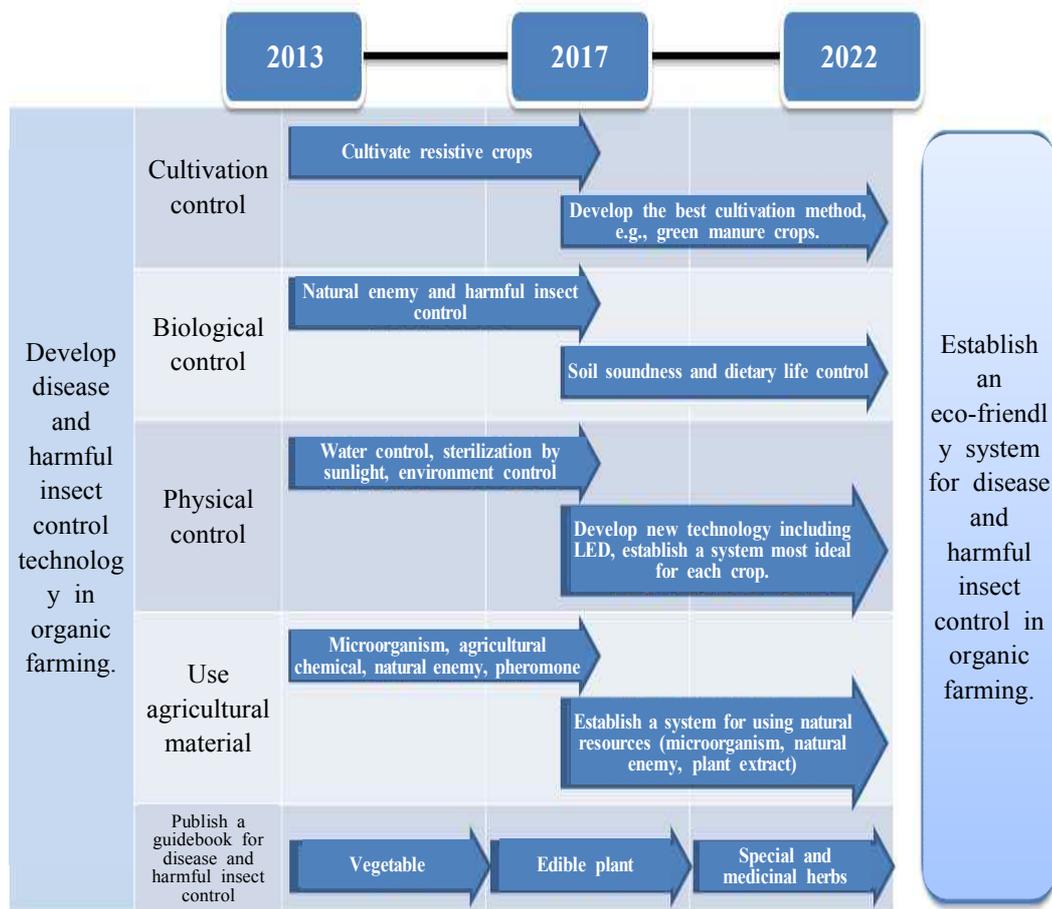
4.3. Developing technology for disease and harmful insect control

Develop natural extract technology after developing bio-agricultural chemicals.

- Because bio-agricultural chemicals are supplied to farmers as agricultural materials and substantially beneficial to them, it is on the second place in the priority evaluation.
 - Develop microorganism-agricultural chemical technology until 2017, with a focus on building a system for using natural resources until 2022 on the basis of the result.

- The 4th priority is on developing sulfur, egg yolk oil and natural extracts, very feasible.
 - Egg yolk oil is made by emulsifying egg yolks with vegetable oil, and used by many farmers who have their own method for disease and harmful insect control.
 - Investigate and verify the technology to standardize the method, and cooperate with leading organic farming practice farmers in each region to apply the technology ideal for the features of each region and crop.

Figure 11. Roadmap for developing technology of disease and harmful insect control in organic farming



5. Implications and future application

View of continuing demands for organic farming technology

- It is predicted that the area of cultivating organic agricultural crops will continue to increase because of people's interest in wellbeing and government's support policy. The volume of the organic agricultural product market will increase from 408.1 billion won in 2012 to 1 trillion 429.6 billion won in 2020 (Agricultural Policy Focus No.55, Kim Chang-Gil, et al., 2013). Accordingly, it is predicted that the demand for organic farming technology will sharply increase.
- While investment in organic farming technology development of Korea is promoted as an agenda of the RDA, the scale is not so great. It is necessary to continue to make an investment in organic farming to meet the future demands for the technology, and to facilitate technology development step by step according to the roadmap for technology development in each field.

Continuous investment in R&D for developing organic farming technology

- Farmers think the organic farming technology reduces production costs for soil and nutrient control, weed control, and disease and harmful insect control, and improves economic values, for example, resulting quality organic agricultural products. The questionnaire for farmers reveals the value of organic farming technology is approximately 95.4 ~ 125.5 billion won.
- Because development of organic farming technology is based mainly on development of organic farming technology, government's positive

investment in R&D is essential for sound development of organic farming. It is necessary to guide investment by the private sector based on government's continuous investment in R&D over mid- and long-period of time.

- Further R&D for technology of compost, liquid fertilizer and organic fertilizer**
 - The highest priority for developing organic farming technology is laid on soil and nutrient control, which needs integration of crop cultivation with livestock farming for good material circulation. Compost or liquid fertilizer made of livestock manure and applied to agricultural crops is a source of nutrients, and reduces the burden on the environment. Crop byproducts can be used as animal feed to reduce the cost for animal feed to attain two advantages at one move.
 - Use compost, liquid fertilizer and organic fertilizer for building a system for sustainable organic farming, and carry out regular training about producing and using it to propagate the technology. Develop and operate a program for connecting crop cultivation farmers with livestock farmers in order to facilitate resource circulation.

- Improve the effect of weed control and disease and harmful insect control.**
 - Farmers experience a lot of difficulty in weed control and disease and harmful insect control. In particular, orchard farmers experience difficulty in applying cultivation technology in Korea's weather condition. Develop a scheme for establishing an 'organic farming technology research center (provisional)' to continue to develop organic cultivation technology for fruit trees.

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- Support people involved in R&D to improve covering resources for weed control to be a basis for using eco-friendly organic matters. Support researchers to development bio-agricultural chemical technology of which the priority is high for disease and harmful insect control. Propagate the developed technology for commercialization through public relations.

□ Training and propagation of organic farming technology

- Propagate the developed or discovered organic farming technology and train farmers for the technology. Prepare and revise the user manual for propagating the organic farming technology. Appoint leading farmers for organic farming as an honored instructor to provide field technology consulting and to propagate organic farming technology.
- Introduce incentive systems for financial support, for example, direct payment system (direct payment for low carbon farming) to propagate technology which contributes to conserving the environment so that farmers can employ it.

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