Prospects of Food Crop Research in Korea

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1. Agricultural Status of Korea

With distinct four seasons a year, Korean climate is a typical monsoon and is not favorable for farming; hot and humid in summer, freezing and dry in winter, and uneven precipitation with heavy rains pouring down in July and August. Only 17.4% of the total land area(9,990×103 ha) is arable and paddy and upland are 1,010×103 ha and 727×103 ha, respectively. The average farm size in Korea is 1.45ha, which is very small compared to that in US(200ha) and Japan(1.75ha). Gross value of farm production in 2009 is 41.4 trillion KRW and that of food crops including rice, winter cereals, legumes, potato, sweet potato, and others is 9.9 trillion KRW which is 23.8% of gross value of farm production. Especially, rice, a Korean staple food crop, is the outstanding number one food crop cultivated in Korea and so shares 88.1% of gross value of all food crops in Korea.

So, research of food crops in Korea has been focused on rice production and finally Korea achieved rice self-sufficiency in 1977, resulted from development of 'Tongilbyeo' named as Korean Green Revolution. Hereafter our staple food crop, rice, has been stably supplied to Korean, except for 1980, 1993, and 1995 owing to failure of rice caused by cold stress. However, degree of food self-support including feed grains in Korea is very low, only 26.7% which means other food grains are absolutely dependent on import.

In Korea R&D of food crops has been done by National Institute of Crop Science(NICS) of RDA and several agricultural colleges. Particularly, NICS of RDA is the national institute responsible for the researches on the stable production and provision of food and the enhancement of value-added crops. Researches on crop science of NICS had paved the way for the success into a member of G20 with the development of 'Tong-il' rice in the 1970s. Since then, NICS has contributed to the enhancement of income of farmers and life quality of our nation through developing the novel, functional and high-quality cultivars responding to the various demands of farmers and consumers, and their cultivation technologies.

2. Changes in Agricultural Surroundings and Research Needs in Korea

1) Recent Issues on Agriculture

Recently social, economic and cultural circumstances in agriculture have been greatly changing, and global

warming and climate change are resulting in aggravation of agricultural physical environment, and various technologies are being converged and fused into agricultural science.

FTA contracting countries with Korea are 16 ones and Korea plans to FTA-contract with 64 countries by 2020. Therefore agricultural market opening pressure is getting wider and further.

Recently many countries have experienced food security problem due to world grain price hikes owing to extreme weather events such as drought and flooding, rapid increase of bioenergy, and grain embargo by exporting countries.

Nowadays well-being life style has been so spread worldwide that organic products are being highlighted. In Korea organic farming area, including no- and low-pesticide input farming increased from 1.2% in 2003 to 11.6% in 2009 and also organic farming production increased from 2.1% in 2003 to 12.2% in 2009. KREI examined organic products market in 2008 that market volume was 3.2 trillion KRW, about 10% of total agricultural products market, which was about 47%-increase compared to that last year. KREI had a prospect that organic products market would be 7.1 trillion KRW, about 20% of total agricultural products. So, KREI asserted that market for organic products became a majority from a niche market. World organic products market has expanded by about 20% every year since 2000. Specially, China has been bringing up organic products as a strategic export agricultural item.

2) Change in Research Needs for Food Crops in Korea

As previously mentioned, changes of agricultural surroundings make research needs for food crops to be complex and diverse.

Firstly, excess inventory of rice has been increasing due to rice production increase and rice consumption decrease.

- ○ Production : ('07) 4,408 → ('08) 4,843 → ('09) 4,916 (×103)ton
- ○ Consumption : ('07) 76.9 → ('08) 75.8 → ('09) 74.4 kg per capita per year
- ○ Excess inventory : ('07) 695 → ('08) 675 → ('09) 846 (×103)ton

Therefore, Multi-stakeholders such as farmers, consumers, industries, and policy makers require research and development for consumption diversification of rice and for production adjustment of cooking rice.

Secondly, Well-being life style in fashion calls for premium agricultural and food products with high quality, health functionality and food safety. As of 2009, domestic market size of health functional food is 918.4 billion KRW and increased by 254.7 billion KRW in last three years. As of 2010, global market size of that is 109.0 billion US $ and increased by 36.7 billion US $ in last three years. This premiumization of agricultural and food products can create new profit sources for food crops.

Thirdly, Korean Green Growth Policy requires creation of green technology in agriculture to be a new growth engine. Therefore, new crops with functionality, new materials for food and medicine, and new bioproducts will be highlighted.

Consequently, research target of food crops is greatly changing and should be changed from farmer-oriented to consumer-oriented, from primary production-oriented to highly value-added production- oriented, and from high energy input-oriented to resources circulation-oriented.

Table 1. Premium quality rice cultivars

Cultivar	Issue year	Yield (kg/10a)	Maturity
Samkwangbyeo	2003	569	Mid-late
Unkwangbyeo	2004	586	Early
Gopumbyeo	2004	548	Mid
Hopumbyeo	2006	600	Mid-late
Chilbobyeo	2007	580	Mid-late
Haiami	2008	586	Mid
Jijumi	2008	570	Mid
Yeonghojimi	2009	544	Mid-late

Table 2. Special purpose and functional rice cultivars

Classification		Cultivar	Characteristics
Functional (8)	High lysine	Yeonganbyeo	- high lysine - for nourishing meal and baby food
	Mineral	Goami4	- high Fe, Zn
	Resistant starch	Goami2, Goami3	- for diet food
	Opaque nonwaxy	Seolgaeng	- for brew and fermentation by Monascus pilosus
	Giant embryo	Keunnun	- triple sized embryo and high GAVA - for germinated brown rice
	Sugary	Danmi	- high sugar - for rice cookie and beverage
	High AA	Haiami	- higher essential amino acids by 30%
Waxy (11)		Sinseonchal, Jinbuchal, Hwaseonchal, Sangjuchal, Dongjinchal, Boseokchal, Haepyeongchal, Nunbora, Hangangchal1, Baekseolchal, Baekokchal	- glutinous - for rice cake
Mid-waxy (3)		Baekjinju, Baekjinju1, Manmi	- amylose content 9~13% - for kimbap and diabetic meal
Color (12)	nonwaxy (8)	Heukjinju, Heuknam, Jeokjinju, Heukhyang, Heukkwang, Hongjinju, Heukseol, Sintoheukmi	- black or red coated - for health food and natural dyes
	waxy (4)	Josaengheukchal, Sinmyeongheukchal, Sinnongheukchal, Boseokheukchal	- early maturing - black coated
Aromatic (6)	nonwaxy (4)	Hyangmibyeo1, Hyangmibyeo2, Hyangnam, Mihyang	- popcorn-like odor - for rice cake and a sweet drink made from fermented rice
	waxy(2)	Seolhyangchal, Aranghyangchal	- popcorn-like odor
Others (3)	high amylose	Goamibyeo	- high amylose - for rice noodle, stir-fried rice
	big seed size	Daeripbyeo1	- one and a half size seed - for brew and puff rice
	white core rice	Yangjobyeo	- chalky - for brew

3. Recent Achievements in Food Crops Research in Korea

1) Research on Rice

To improve the quality of people's dietary life and to ensure stable food supply, the research focuses on breeding new cultivars with high quality, disease and pest resistance, and high adaptability to various ecosystems. It also aims to develop multi-purpose and functional cultivars to increase rice consumption.

Research on rice cultivation comprises determination of optimal transplanting dates, recommended application rates of nitrogen fertilizer and harvesting seasons, and focuses on development of low-input and labor-saving cultivation technology, and environment-friendly cultivation technology.

Table 3. Newly developed super high yielding rice cultivars

Ecotype	Cultivar	Yield (kg/10a)	Issue year	Maturity
Tongil(9)	Dasanbyeo	677	1995	Mid
	Namcheonbyeo	663	1996	Mid
	Andabyeo	727	1998	Mid
	Areumbyeo	741	1999	Mid
	Hanareumbyeo	753	2002	Mid
	Dasan1	686	2006	Mid
	Keunseom	719	2006	Mid
	Segyejinmi	701	2009	Mid-late
	Dasan2	706	2009	Mid
Japonica (4)	Namilbyeo	662	2002	Mid
	Hanmaeum	643	2004	Mid-late
	Draechan	652	2008	Mid-late
	Boramchan	733	2009	Mid-late

Table 4. Newly developed rice cultivars for forage

Cultivar	Forage yield (kg/10a)	Issue year	Characteristics
Nokyang	1,652	2006	- stay-green, non-shattering, and tolerant to lodging
Mokwu	2,059	2009	- stay-green, tolerant to lodging, multiple disease resistant

Table 5. Optimum transplanting dates for high-quality rice production

Region	Optimum transplanting dates		
	Early maturing	Mid maturing	Mid-late maturing
Cetral plain	June 9~June 10	May 27~June 2	May 15~May 21
South-western plain	June 13~June 11	May 28~June 3	May 25~June 1
South-eastern plain	June 13~June 19	June 11~June 17	June 5~June 11

Table 6. Optimum harvest time for high-quality rice production

Region	Optimum harvest time(days after heading)		
	Early maturing	Mid maturing	Mid-late maturing
Cetral plain	50	53	57
South-western plain	52	55	60
South-eastern plain	50	54	58

Table 7. Optimum fertilization rate of nitrogen for high-quality rice production

Region	Optimum fertilization rate of nitrogen (kg 10a-1)		
	Early maturing	Mid maturing	Mid-late maturing
Cetral plain	7.7~11	7.7~10	8.3~10
South-western plain	6~9	8~10	8~9
South-eastern plain	8	8~9	9

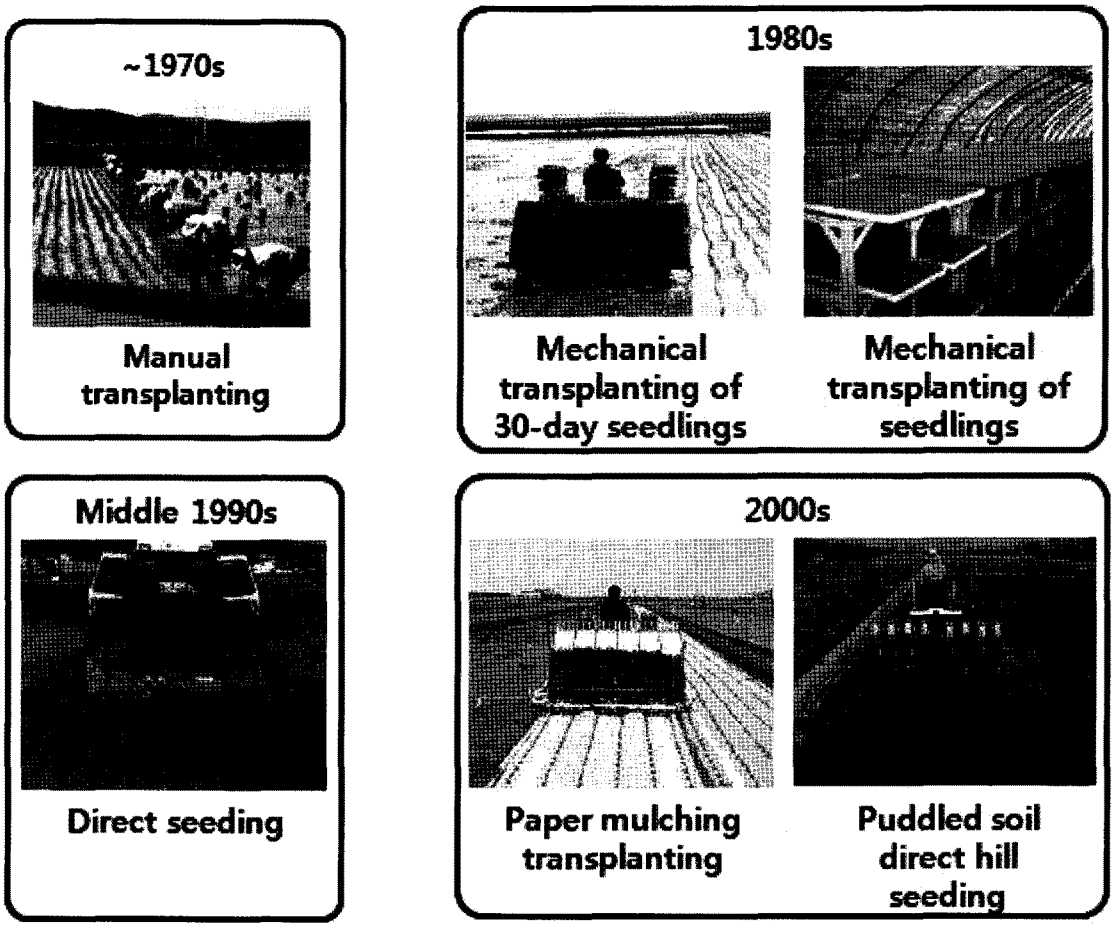

Fig. 1. Transplanting and direct seeding technology for rice in Korea

Table 8. Newly developed cultivars of upland food crops

Cultivar	Yield(kg/10a)	Issue Year	Charateristics
[Barley]			
Hyedang	427	2007	- covered barley and with good malt quality
Borachal	315	2007	- covered waxy and with purple lemma
Jinjuchal	373	2007	- naked waxy and with high β-glucan
Daeanchal	248	2008	- naked waxy and with giant embryo
Boseokchal	356	2008	- naked waxy and with high anthocyanin
Baekho	557	2008	- malting barley
Boanchal	225	2009	- covered waxy and purple coated
Yeongyangchal	284	2009	- naked waxy

Cultivar	Yield(kg/10a)	Issue Year	Charateristics
Ganghocheong	327	2009	- naked nonwaxy and tolerant to lodging
Maekhyang	552	2009	- malting barley
Dami	1,199	2007	- whole crop forage with liguleless
Yeonghan	1,204	2008	- whole crop forage
Yuho	1,155	2008	- whole crop forage
[Wheat]			
Baekjoong	535	2007	- for noodles
Jeokjung	533	2007	- for noodles
Sugang	503	2008	- for noodles
Hanbaek	505	2008	- for noodles
Suan	461	2009	- for noodls
Cheongwu	1,475	2009	- for whole crop forage
[Soybean]			
Nampung	297	2007	- for fermented soy products
Daeyang	258	2007	- for fermented soy products
Wonkwang	305	2007	- for soy sprout
Hoseo	251	2007	- for soy sprout
Sinhwa	307	2007	- for soy sporut
Daeheuk	226	2007	- for cooking with rice and soy tea
Sangwon	1,039*	2007	- for green soybean
Daeha	262	2008	- for fermented soy products
[Soybean]			
Nampung	297	2007	- for fermented soy products
Daeyang	258	2007	- for fermented soy products
Wonkwang	305	2007	- for soy sprout
Hoseo	251	2007	- for soy sprout
Sinhwa	307	2007	- for soy sporut
Daeheuk	226	2007	- for cooking with rice and soy tea
Sangwon	1,039*	2007	- for green soybean
Daeha	262	2008	- for fermented soy products
Cheonsang	234	2008	- for tofu

Cultivar	Yield(kg/10a)	Issue Year	Charateristics
Singang	278	2008	- for soy sprout
Sohwang	269	2008	- for soy sprout
Galchae	251	2008	- for soy sprout
Heukseong	237	2008	- for cooking with rice and black colored tofu
Hanol	204	2009	- for fermented soy products
Sohyun	283	2009	- for soy sprout
Geomjeong5	246	2009	- for tofu
Soheuk	224	2009	- for functional soybean
Cheonghyup	317	2009	- for edible soybean leaf
[Corn]			
Eolukchal1	980	2007	- waxy
Gammichal2	1,093	2007	- super sugary
Pyeonganok	2,084	2008	- for silage
Heukjinjuchal	855	2008	- waxy and black coated
Heukjeom2	967	2008	- waxy and black ad white coated
Guseulok	1,159	2009	- sugary
[Potato]			
Jeseo	4,235	2007	- for double cropping and mid-maturing
Hongyeong	3,112	2007	- with red flesh
Jayeong	3,096	2007	- with purple flesh
Habaek	3,620	2008	- for potato chip
[Sweet potato]			
Daeyumi	2,779	2008	- for bioethanol and starch
Yeonjami	2,596	2008	- with purple flesh
Geonpungmi	2,626	2008	- with high palatability
Jeonmi	2,615	2009	- for bioethanol and starch
[Italian millet]			
Ganghae	218	2009	- adaptable to paddy field
Gyungkwan1	210	2009	- for landscape
Jinbora	208	2009	- for landscape
[Sorghum]			
Gidachal	413	2009	- high yielding and with high phenols
[Common millet]			
Dagang	280	2009	- high yielding and with high phenols

2) Research on Upland Food Crops

The research focus of winter cereals, beans, corn, potato, sweet potato and other food crops is on breeding cultivars with good for various uses and high resistant to diverse biotic and abiotic stresses.

It also aims at developing the stable production technologies with low cost and labor-saving mechanization and environmentally- friendly practice in upland crops.

3) Research on Post-harvest Management and Value-added Promotion

Researches are focused on establishing post-harvest management system for the supply of safe and palatable agricultural products, identifying functional crops and by-products for value-added promotion, and establishing a criterion and an assessment system for high-quality.

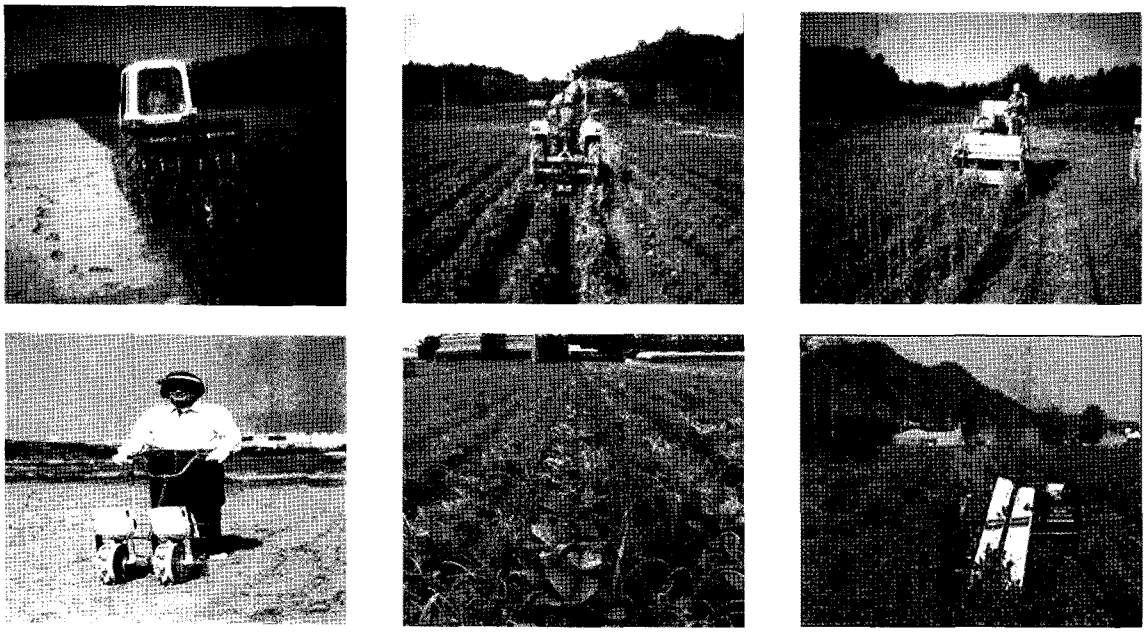

Fig. 2. Labor-saving mechanization and environmentally-friendly practice in soybean

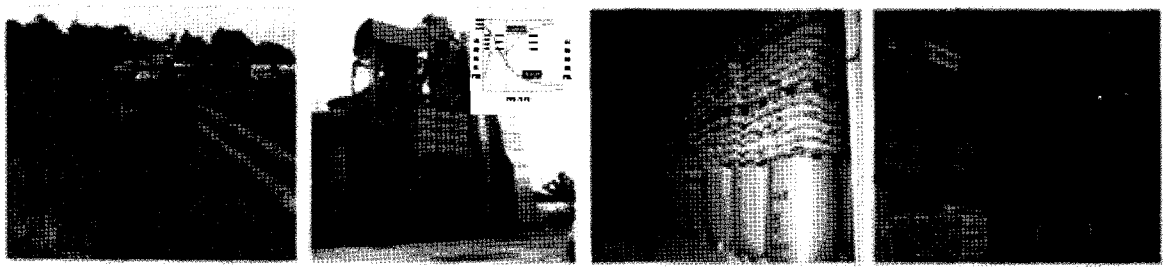

Fig. 3. Development of post-harvest management technology

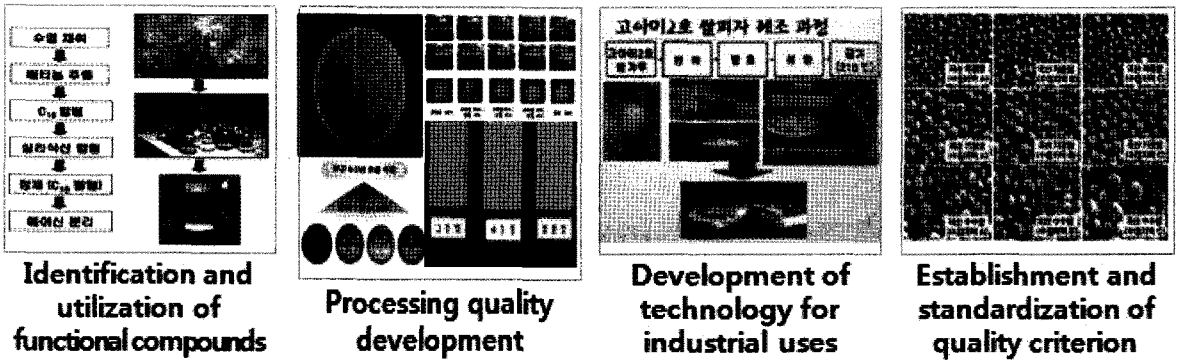

Fig. 4. Enhancement of functionality and value-added and establishment of quality criterion

4) Research on Crop Environment

Crop environment research focuses on establishing eco-friendly and sustainable agriculture with particular emphasis on green manure crops for reasonable use of fertilizers and environmentally-friendly management of disease, pest, and weed. It is also searching for proper ways to preserve agro-environmental resources.

5) Research on Practical Application of Crop Biotechnology

The research on crop genetic engineering focuses on creating new functionality and resistances to insect pests and diseases of food crops, increasing breeding efficiency, and developing a fast and easy screening method by using molecular markers. It is also aiming to develop mass transformation technolgoy to improve the efficiency of producing new functional crops and elite lines.

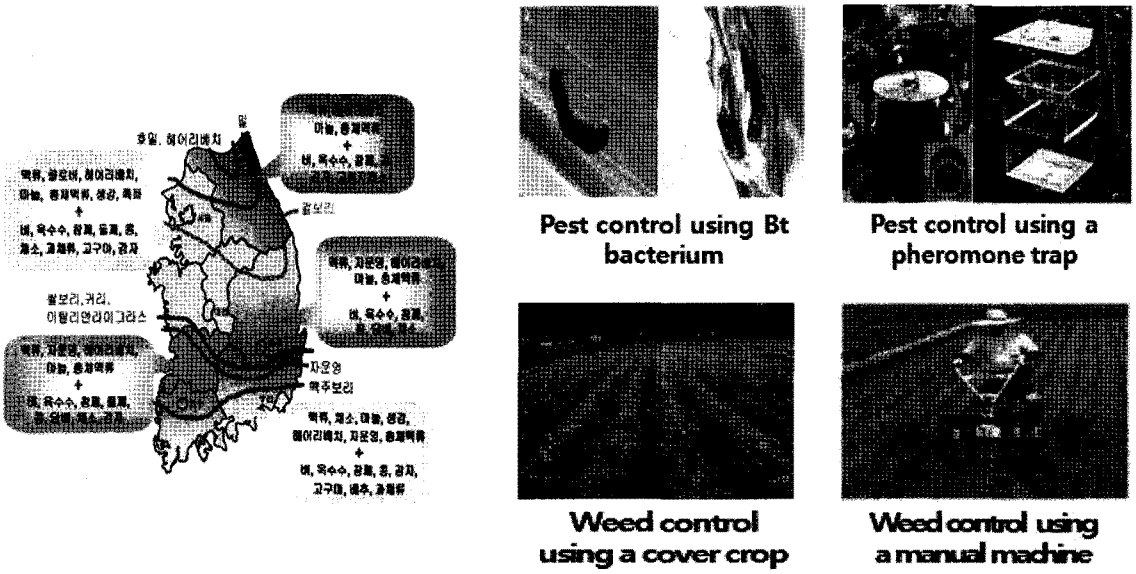

Fig. 5. Cropping system (left) and pest and weed control(right) for eco-friendly agriculture

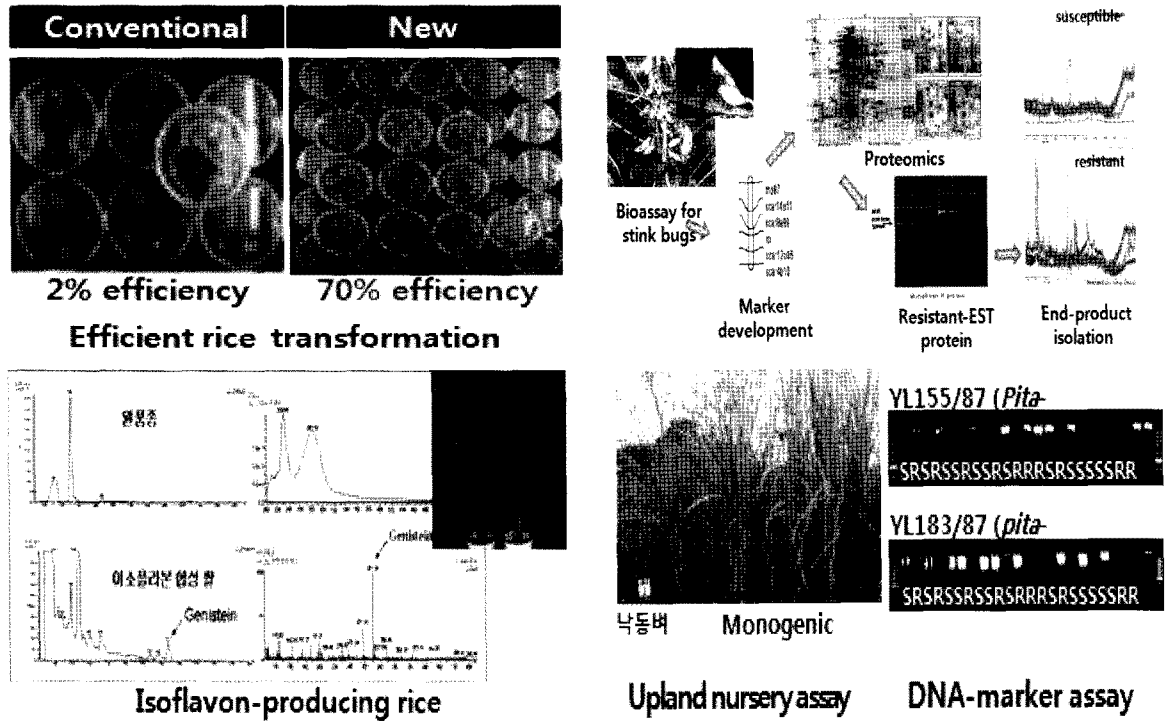

Fig. 6. Trnasformation platform technology and practical application of biotechnology

4. Prospects for Research on Food Crops in Korea

According to changes in research needs and agricultural conditions related to food crops, Research on food crops is to be focused as follows.

Firstly, technologies to stabilize national rice supply are to be developed and improved to deal with excess inventory of rice due to consumption decrease and production increase: 1) development of use-customized rice cultivars for usage to increase rice consumption, 2) new processing technology and products to promote the value-added of rice, 3) development of support technology to promote rice export, 4) development of technology dealing with climate change to stably cultivate rice, 5) campaign for excellence in health of rice based food culture, 6) improvement of low-cost production technology for rice, 7) improvement of safe cultivation technology for alternative crops to paddy rice.

Secondly, technologies to increase degree of upland crops self-support and to fortify quality of upland crops are to be developed and improved: 1) development of new cultivars of upland crops such as soybean and barley with good suitability for processing according to various uses and with special functionality 2) discovery and collection for promising genetic resouces of landrace beans and minor cereals, 3) development of new wheat cultivars with early-maturing and resistance to biotic and abiotic stresses.

Thirdly, research on new bio-materials from crops for functional food, medicine and other industries is very important as a new growth engine: 1) identification and isolation of functionally bioactive

compounds and new industrial materials from food crops, 2) development of natural medicine materials from food crops, 3) technology development to industrialize crop by-products, 4) development of new crops with high value-added using biotechnology.

Fourthly, researches on food crops production suitable for low carbon emission and green growth are to be implemented: 1) development of environmentally friendly practice for food crops with resources circulation, 2) improvement of stable cultivation technology for food crops to deal with climate change, 3) development of bioenergy technology using non-food crops.

In summary, Korean agriculture now has risk factors such as aggravation of agricultural resources and market opening and simultaneously opportunity factors such as premiumization of agricultural food products and convergence and fusion of various technologies. Specially, food crop research can take opportunity factors as well as risk factors as a research subject to deal with favorable and unfavorable changes. So, food crop research can contribute to developmental transformation of agriculture from a primary industry into a highly profitable knowledge-based industry.