REVIEW

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Horticultural Technology Trends in the Korean Seed Industry

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Abstract

Using 10,625 valid patents registered among six countries and 6,949 plant varieties registered in Korea, we evaluated technology trends in the horticultural seed industry. The six patent indices were investigated to determine the technology stage, such as market capability, technological level, and technological development potential, for different types of crop seeds. In addition, a patent multilayer (PM) model was developed based on vacant technology, future growth, and entry barriers to predict the best directions for technology development. In Korea, seed technologies for horticultural crops have low growth potential, although they are at a mature developmental stage and do not have high market concentration. There is high market competitiveness and development potential for flower seed technologies, whereas technologies for fruit seeds are in a decreasing developmental stage.

Additional key words: horticulture crops, Korean patent strategy, patent index, patent multilayer model, plant variety

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Introduction

Seed is a key factor determining the productivity and quality of agricultural products. The global seed market is predicted to grow by nearly $165 billion in 2020 because of economic growth in developing countries and expansion of the genetically modified-crop market (Shin, 2015). Seed production is emerging as a new growth industry (ISF, 2019), and seed industry was positioned to be a new growth engine in developed countries (Lianos et al., 2016; Fan et al., 2017).

Seed-related intellectual property (IP) can be double protected through the patent system and the plant variety system. The patent system based on patent law provides a way for industries and governments to protect strategic assets for economic and technology development (Choi et al., 2014). The plant variety system based on the special law of the International Union for the Protection of New Varieties of Plants (UPOV) convention legally protects new varieties into which breeders put much effort and time (KSVS, 2019). Generally speaking, patents are the most important type of IP protection.

The well-defined patent index is used to evaluate specific technology levels, research trends, and international competitiveness (Kim et al., 2012; Yoon et al., 2012).

The horticultural seed industry has become the most important of all the seed sectors as public demand for fresh and safe gardening crops has increased along with a growing interest in the promotion of general well-being, health, and quality of life (Weinberger and Lumpkin, 2007; Hewett, 2012). Although grain seeds currently have the largest share of the commercial seed market, many existing patents deal with the use of horticultural plants because horticultural seed production is more profitable than seed production for food grain crops (Weinberger and Lumpkin, 2007).

In Korea, the domestic seed market has stagnated except for horticultural crops, making Korean seed companies reluctant to invest in the development of new technologies (KSVS, 2017). To stay competitive in the global seed market, the Korean government has supported the domestic seed industry through policies such as the Golden Seed project and the establishment of seed breeding complexes (GSP, 2019). Technology trends among patents and plant varieties related to the horticultural seed industry in Korea are unclear, despite some recent reviews of patent prospects for plant seed sectors (Howard, 2015; Bonny, 2017). Therefore, we performed a study to better understand the trends in patents and plant varieties related to horticultural technologies in Korea.

Materials and Methods

Collection of Patents and Plant Varieties

Plant seed-related patents registered in China, the European Union (EU), India, Japan, Korea, and the United States from January 2007 until December 2018 were collected using the Worldwide Intellectual Property Service (WIPS, 2019). The EU collects patents from its 31 member states, all of which are members of the European Patent Treaty. The patents

Table 1. Classification of effective patents among four seed categories with 15 subcategories in six regions

Category	Subcategory	Korea	USA	China	Others^z
Food crops	Pulse	15	1,148	58	12
	Barley	2	34	58	1
	Cereal	60	22	99	17
	Tuber	14	20	5	2
	Grain	4	1,347	57	10
Horticultural crops	Fruit	9	677	42	0
	Vegetable	96	654	148	79
	Flower	45	4,639	75	11
Special crops	Stimulant	8	56	16	6
	Sugar		21	5	2
	Textile	3	91	21	1
	Medicine	3	31	15	0
	Oilseed	11	65	33	6
	Others	10	6	5	0
Others	Others	105	257	283	105

^{z}Others: EU, India, and Japan.

Table 2. Classification of registered plant varieties among three seed categories with 12 subcategories in Korea

Year	Food crops					Horticultural crops			Special crops			
	Cereal	Barley	Grain	Pulse	Tuber	Fruit	Veg.[z]	Flower	Oilseed	Medi.[y]	Others	Mush.[x]
2007	23	8	6	12	7	19	117	310	5	2	4	14
2008	20	11	25	11	3	24	101	277	8	2	1	7
2009	27	8	11	15	12	46	93	287	10	5	10	23
2010	24	6	9	14	4	52	118	300	11	3	9	24
2011	31	11	12	16	3	53	133	283	11	4	14	16
2012	22	15	11	8	1	33	157	296	15	18	16	14
2013	34	8	12	12	4	37	157	292	10	9	9	15
2014	22	10	7	19	4	45	155	322	11	5	7	14
2015	33	7	19	12	10	38	195	391	18	3	14	17
2016	25	7	15	8	8	51	203	311	6	10	3	10
2017	30	3	28	17	7	79	216	277	8	7	8	14
2018	13	0	11	12	2	30	54	152	3	3	4	6

[z]Vegetable.
[y]Medicine.
[x]Mushroom.

were divided into four seed categories (food, horticulture, special, and other crops) and 15 subcategories (Table 1). In addition, the plant varieties were collected in Korea that were granted protection under the plant variant system from January 2007 until December 2018 using the Korea Seed & Variety Service (KSVS, 2019). The plant varieties were divided into three categories (food, horticulture, and special crop) and 12 subcategories (Table 2).

Classification of Patents Screening

The collected patents were verified in three steps to remove noise from the data. First, 16,217 patents were collected from patent registries based on selected keywords. Next, redundant patents were removed on the basis of the application numbers and patent titles. In addition, duplicate patents were removed manually on the basis of the patent abstracts using the country-specific patent searching systems in China (SIPO, 2019), India (IPI, 2019), Japan (JPO, 2019), and Korea (KIPRIS, 2019). Finally, specifications of the patents were analyzed and verified with seed plant experts. The verified dataset included 10,625 effective patents for the four seed categories and 15 subcategories (Table 1).

Patent Indices for Technology Growth and Concentration Ratio

The Patent Portfolio (PP) index is a trend distribution used to evaluate the growth stage of technology sectors (Fabry et al., 2006; Lin et al., 2006). The PP index was calculated for each of the four seed categories in five time intervals: I (2007 – 2008), II (2009 – 2010), III (2011 – 2012), IV (2013 – 2014), and V (2015 – 2016). However, we did not compute the PP index for the period 2017 – 2018 because patents are kept closed for 18 months after registration. The PP index was obtained from Equation (1):

$$PP_{sp} = \sum_{j=1}^{m} PA_j / \sum_{i=1}^{n} AP_i, s = 1\ to\ 4, p = 1\ to\ 5 \quad (1)$$

where s is the seed category, p is the period interval, PA_j is the total number (m) of patents (j), and AP_i is the total number (n) of patent applicants (i).

The technology concentration for technical innovation activities was evaluated using the concentration ratio (CRn) and the Herfindahl-Hirschman Index (HHI). The CRn is a measure of the degree of market concentration in an industrial sector represented by the percentage of patents held by the top n companies in the sector (Dai et al., 2019). The closer the CRn is to zero, the lower the level of market concentration. The CRn was obtained from the Equation (2):

$$CRn = (share\ of\ 1\ applicant) + (share\ of\ n\ applicants) \tag{2}$$

where the *share of* 1 *applicant* is the market share ratio of the first applicant, and (n) is the total number of applicants within the sector. The HHI measures the intensity of competition within an industrial sector by looking at the distribution of market share among patent applicants (Matsumoto et al., 2012). The HHI was obtained from Equation (3):

$$HHI = \sum_{k=1}^{n} (S_k)^2 \tag{3}$$

where S_k is the market share of patent applicant (k) in the sector, and (n) is the total number of patent applicants in the sector.

Patent Indices for Technology Level

The cites per patent (CPP) and patent family size (PFS) indices were used to evaluate the level of technology development for the different seed categories. The CPP gives the number of citations for patents in a given industrial sector. A high CPP value suggests the existence of a core patent or original patent that dominates the sector (KIPI, 2005). The CPP index was calculated using Equation (4):

$$CPP_s = CP_i / RP_j, s = 1\ to\ 4 \tag{4}$$

where s is the seed category, CP_i is the number of citations of patent (i), and RP_j is the registered numbers of patent (j). The PFS shows the importance of patents in commercial markets. A high PFS value is presumed to indicate the existence of an important patent with high market power (Choi et al., 2014). The PFS index was obtained from Equation (5):

$$PFS_s = \sum_{i=1}^{m} FP_i / \sum_{i=1}^{n} TP_i, s = 1\ to\ 4 \tag{5}$$

where s is the seed category, FP_i is the number (m) of family patents owned by patent (i) in a given country, and TP_i is the total number (n) of patents (i) in that country.

Patent Index for Technology Growth Potential

The patent emerging (PE) index was used to estimate the development potential represented by the annual increase ratio of patents in a technology category (Grimaldi et al., 2015). The PE index can be easily visualized in a scatterplot, with the four quadrants of the plot indicating different levels of technological development: upper right, continuous application;

upper left, increase in recent applications; lower left, infancy applications; and lower right, decrease in recent applications. The PE index was obtained from Equation (6):

$$PE_{sc} = 100(TC_k / TP) \cdot (AI_k), s = 1\ to\ 4, c = 1\ to\ 15 \quad (6)$$

where s is the seed category, c is the seed subcategory, TC_k is the number of patents existing in each category, TP is the total patents in each category, and AI_k is the annual increase ratio of patents in each category.

Patent Multilayer Model for Patent Strategy

A patent multilayer (PM) model was developed to present the best direction for patent development in Korea. The PM model is based on three factors: entry barrier, future growth, and vacant technology. Entry barrier indicates anything that prevents a patent registration from starting activities in a given category. Future growth indicates the possibility for future growth in a given category, reflected by an increase in the number of patents (Choi et al., 2019). Vacant technology represents the patent share ratio for a specific category relative to the total number of patents. A high value for vacant technology indicates the existence of undeveloped technologies with few related patents and few major applicants. The PM model was obtained from Equation (7):

$$PM_s = (E \cdot F \cdot V)_i, s = 1\ to\ 4 \quad (7)$$

where s is the seed category, and $(E \cdot F \cdot V)_i$ is the entry barrier (E), future growth (F), and vacant technology (V) values of patent category (i). The PM model was analyzed using distribution-free ordinal logistic regression. The E, F, and V factors were quantified using a Likert scale with five ordinal levels. The Likert points were assigned on the basis of a survey of 16 members of the patent committee of the Foundation of Agricultural Technology Commercialization, National Institute of Agricultural Sciences, and National Institute of Horticultural and Herbal Science in Korea. The significance of the ordinal logistic regression of the PM model was tested using the SAS/STAT version 12.0 software (SAS Korea, Seoul, Korea).

Results

Patents and Plant Variety Trends for the Korean Seed Industry

Among the 10,625 effective patents, the United States had the highest number at 9,068 (85.3%), followed by China at 920 (8.7%), and Korea at 385 (3.7%). Among the four seed categories, the horticulture category accounted for 60.9% of the total patents. Among the 15 subcategories of seed types, the three types with the highest proportions of total patents were flowers (44.9%), grains (13.3%), and pulse crops (11.6%). The international patent trends for seed sectors showed that the numbers of patent registrations decreased until 2009 and then continually increased (Fig. 1A). The decreasing trend before 2009 coincided with the financial crisis in the United States, which started in 2008 and had significant effects on many industrial sectors including the seed industry (Kahler, 2013).

Among the 6,949 plant varieties registered in Korea, 5,704 (82.1%) were horticultural crops, 785 (11.2%) were food crops, and 460 (6.7%) were special crops. The rate of registration of plant varieties rapidly increased after 2015 as a result of the Golden Seed Project, which was implemented in 2012 (Table 2). While the number of registrations of horticultural crops continued to increase, there was little variation in the numbers of registrations related to food crops and special crops over all the time periods. During the study period, 3,498 (50.3%) of the registrations were of flower varieties.

Technology Growth Stage of the Seed Industry

The PP indices showed that the seed industry as a whole is in a growth stage of development because the numbers of patents and applicants continually increased from the third time period to the fourth time period, although they subsequently decreased in the early time periods (Fig. 1A). The growth pattern of the seed industry for horticultural crops (Fig. 1B) is in a mature stage of development, and that of food crops (Fig. 1C) is in a declining stage, reflected by a continuous decrease in the numbers of patents registered during all periods except the first time period. The special crops industry (Fig. 1D) is in the beginning stage and showed no inferable pattern during all of the time periods. However, horticultural crops show a mature stage of development, largely because of a rapid increase in the numbers of patents registered after 2012 in the United States (Fig. 2A) and China (Fig. 2B). Korea (Fig. 2C) and Japan (Fig. 2D) are in a declining stage in that both the number of patent applications for horticultural seed technologies and the number of different applicants decreased after 2012. The technology stages for the EU and India could not be determined because of the small numbers of patents registered in those regions. The measures of market concentration (CRn index and HHI) indicated that the markets for horticultural seeds are highly concentrated in Japan and the EU but not concentrated in Korea, the United States, India, and China (Table 3). China in particular has the closest to a fully free competitive market,

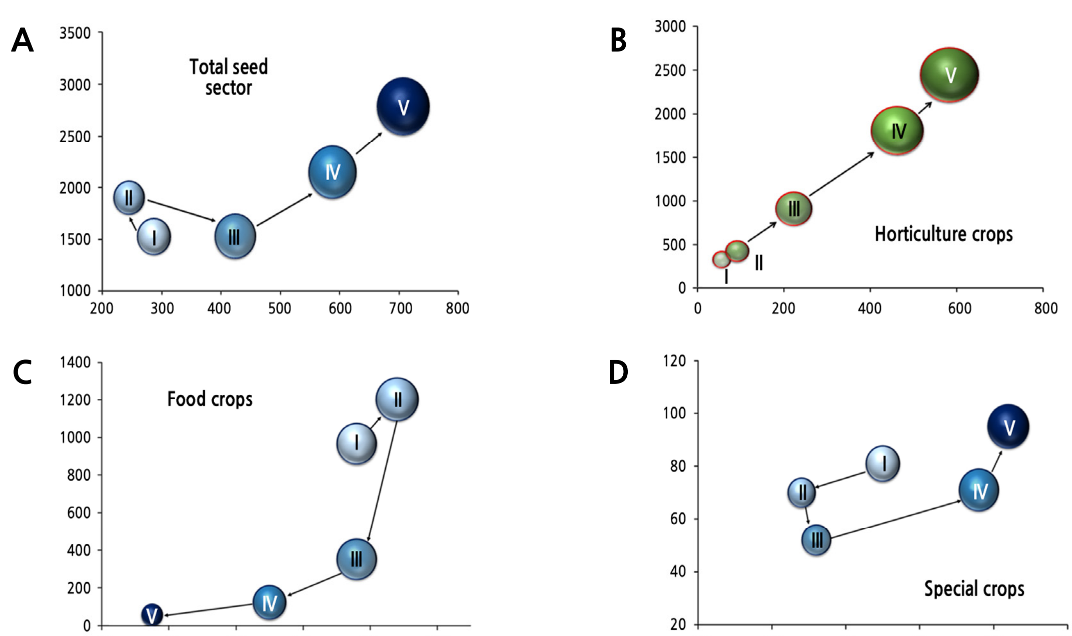

Fig. 1. Landscape of technology growth based on the Patent Portfolio index. The time periods were I (2007-2008), II (2009-2010), III (2011-2012), IV (2013-2014), and V (2015-2016). X-axis: number of applicants. Y-axis: number of patents. The arrow direction is the time flow between the periods. Circle sizes indicate the relative correlation between the numbers of patents and applicants. (A) Technology stage of all seed categories, (B) technology stage of horticultural seeds, (C) technology stage of food seeds, and (D) technology stage of special seeds.

meaning that it is easy to enter the horticultural seed market in China compared with other countries. The markets for food crop seeds are concentrated in Korea, Europe, Japan, and the United States. There is no market for special crops in Japan, the EU, and India. Other crops do not have a high level of market concentration except in the United States.

Technological Level and Development Potential for Horticultural Crops

The CPP and PFS indices indicated that the seed industries for flowers and fruit crops have high market competitiveness and a relatively low technology level, whereas the seed industries for vegetables have low market competitiveness despite of their high technology level (Fig. 3A). Although the flower and fruit seed industries have a low technical level, as

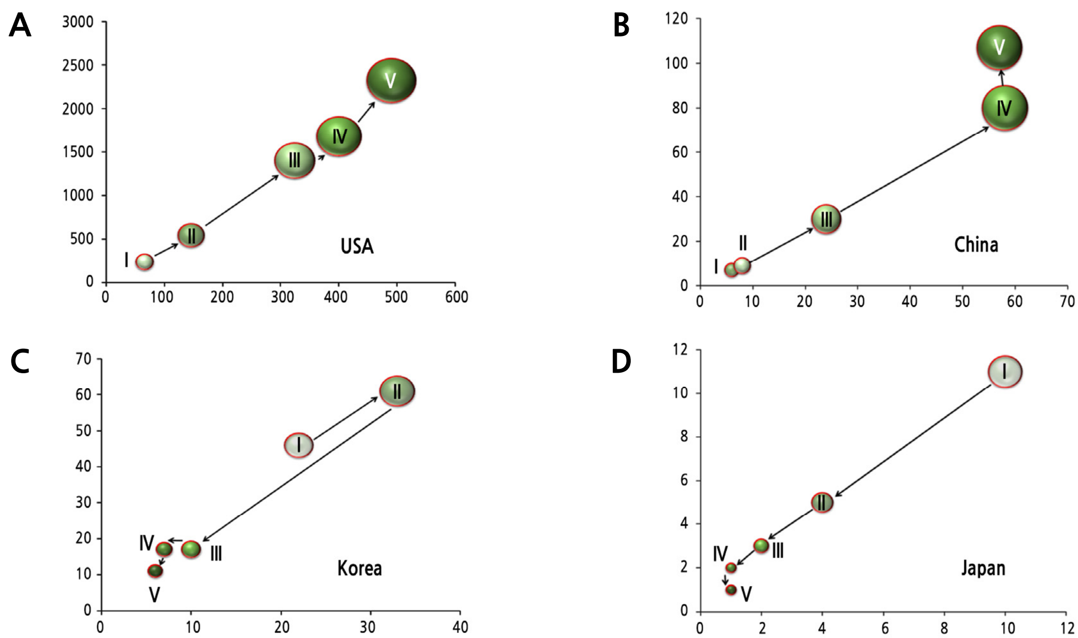

Fig. 2. Landscape of technology growth related to each country based on the Patent Portfolio index of horticulture seed category. The time periods were I (2007-2008), II (2009-2010), III (2011-2012), IV (2013-2014), and V (2015-2016). X-axis: number of applicants. Y-axis: number of patents. (A) US, (B) China, (C) Korea, and (D) Japan technology stages.

Table 3. The patent concentration ratio (CRn) and Herfindahl-Hirschman Index (HHI) for the different seed categories in six regions

Index	Category	China	EU	India	Japan	Korea	USA	Total
CR4	Food crops	27	-	23^z	-	66^z	85	74
	Horticultural crops	13^z	84	-	59^z	36	19	18
	Special crops	27	-	-	-	35^z	43	31
	Others	18	58	-	24^z	49	54^z	22
HHI	Food crops	136	2,593	592	1,837	1,951	2,666	2,027
	Horticultural crops	103	1,995	752	2,894	512	155	144
	Special crops	212	0	0	0	710	744	317
	Others	260	503	577	615	837	1,058	243

^{z}The CR3 value instead of the CR4 value was used.

The dash indicates that the value was not calculated because of few patents.

indicated by low numbers of cited patents, they have high market power because of the high numbers of total patents.

The PE index was used to evaluate the potential for technological development for the three subcategories of horticulture crops (fruits, vegetables, and flowers). The seed industry for flowers has the highest development potential because of its high patent growth rate and low patent share (Fig. 3B). The seed industry for vegetables is in the early stage of technology development, with lower than average growth rate and patent share. The seed industry for fruits shows a trend of decreasing patent applications, with low patent growth rate and above average patent share.

Patent Development Strategy for Horticulture Crops in Korea

According to the three patent indices used to evaluate growth potential for different types of seed development in Korea, horticultural seed development has low growth potential because the share ratio in Korea is significantly lower than the international average and the increasing ratio of patent applications is declining. There is higher growth potential for special crops because the patent share ratio for that sector in Korea is low and the increasing ratio is high (Table 4).

The PM model indicated that seed development for horticulture crops has low growth potential because of few vacant

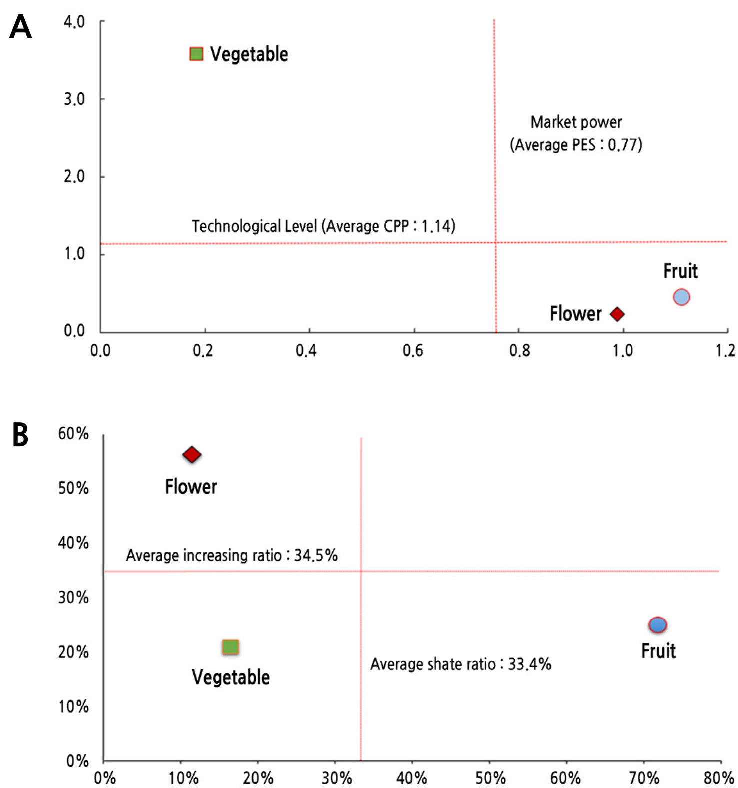

Fig. 3. The landscape of technology level and development potential for horticultural crops. (A) The graph shows the distribution of technology levels and market power based on the cites per patent (CPP) and patent family size (PFS) indices for horticulture crops. X-axis: PFS. Y-axis: CPP. The red lines indicate the average technical level and market power. (B) The graph shows the potential for technology development based on the patent emerging index. X-axis: share ratio of patents. Y-axis: increasing ratio of patents. The red lines show the average share ratio of patents (X-axis) and the increasing ratio of patents (Y-axis). Quadrants based on the red lines: upper right, continuous application; upper left, increase in recent applications; lower left, infancy applications; lower right, decrease in recent applications.

Table 4. Evaluation of patent trends based on three technical factors (share ratio, increasing ratio, and registration ratio) in three seed categories

Index	Country	Food crops	Horticultural crops	Special crops
Share ratio (%)	Korea	1.2	1.5	0.5
	Average	28	61	4
Increasing ratio (%)	Korea	33.8	−35.3	66.7
	Average	−6.8	58.8	5.7
Registration ratio (%)	Korea	85.3	61.3	62.9
	Average	89.4	84.5	66.0

Table 5. Relative Likert scale [0 (lowest) to 5 (highest)] for three technical factors (vacant technology, entry barrier, and future growth) in three seed categories in Korea

Category	Vacant technology	Future growth	Entry barrier
Food crops	1.9	3.2	3.6
Horticultural crops	1.2	2.0	4.5
Special crops	4.2	3.5	2.0

technologies and high entry barriers due to a high patent registration ratio (Table 5). In addition, food crops have low growth potential, whereas special crops have high growth potential because of many vacant technologies and low entry barriers (Table 5). Ordinal logistic regression analysis of the three categories included in the model showed that entry barrier was a significant factor in determining growth potential ($p < 0.01$), whereas vacant technology and future growth factors were not significant.

Discussion

In Korea, IP rights for plant varieties are double protected by patent applications under the Patent Act and by registration of plant varieties under the Seed Industry Act. The numbers of seed patent applications are decreasing in Korea, whereas the registration of plant varieties continues to increase, indicating that Korean seed breeders prefer to protect IP through the plant variety system rather than through the patent system. The United States had the highest patent share at 85.3%, which increased continuously throughout the study period (Fig. 2A). It is presumed that the United States has the highest patent share because of the simplified patent specification process in that country (USPTO, 2019). The plant patent process in the United States simplifies the description of the specification (Article 112 of the US Patent Act), allowing the subject of the patent to be easily protected against plant varieties.

Technologies for horticultural seeds are in a growth stage in China and the United States but a declining stage in Korea. The Korean flower and fruit markets have grown in recent years, but those markets in Korea depend on imported seeds rather than domestic development (Park, 2014a). Horticultural seed technologies in China are in an explosive maturity stage, indicating that Chinese horticulture (especially the production of high-value vegetables and fruits) is entering a new phase because of increasing domestic demand, increased purchasing power, and a rapidly growing middle class in large cities (Park, 2014b; Van den Broeck and Maertens, 2016).

Generally, if the CRn is close to zero, the level of market monopoly is low. However, the CRn index does not include information about all applicants in the field, instead considering only the patents from the top *n* applicants. The CRn does not provide any information about the technical competitiveness of applicants because it does not change with the patent share of the top *n* applicants. Therefore, HHI analysis was performed to compensate for that shortcoming of the CRn index. The market concentration and technology competitiveness make it easy to enter the horticultural seed market in China compared with other countries. Japan, Europe, and India have no markets for special crops. China is therefore expected to take the lead in market preoccupation as domestic seed companies and research institutes develop new varieties of seed.

Among the different types of crops, horticultural crops are considered to be the most favorable for seed patent development because market concentration and technology competitiveness are low compared with other types of crops. The CPP and PFS indices for horticulture crops indicate that there are many core patents for vegetable seeds, whereas other types of plants have a high technology level with low market capability. In the field of horticultural crops, vegetables have low market power but a high technology skill level. On the other hand, patent development for vegetable technologies comes with high risk. Flowers and fruits have high market shares but low technology levels, indicating that the total numbers of patents for flowers and fruits increased, although the technological level has dropped. To secure a market for flowers and fruits, it is necessary to develop new technologies. In addition, marketing and promotion activities are needed to expand the flower and fruit markets.

According to the PE index for horticulture crops, flowers and vegetables have high development potential, whereas fruits have low development potential. The CPP and PFS indices suggest that the technology level of flower and fruit seeds will increase in the future along with the rapidly growing international horticulture market (Park, 2014b; Van den Broeck and Maertens, 2016; Cho et al., 2018). In addition, the PE index suggests that it is more important to acquire many horticultural seed patents for marketing, even if the patents do not have a high technology level.

In terms of a patent development strategy for horticultural crops in Korea, the PM model indicates that special crops have high potential for growth in patent applications, whereas food and horticulture crops have low potential for future patent development. In Korea, horticultural crops have a low level of vacant technology due to a high rate of patent registration, an increasing ratio of −35.3%, and a patent share that is lower than the global average. These factors indicate that horticultural crops have low growth potential due to many existing patents, fewer vacant technology, less growth, and high barriers. It is assumed that the domestic flower market has declined because of lower personal consumption, although the vegetable market has increased in that same period (KOSIS, 2019). However, whole horticultural seed industry is expected to increase because of increased demand for well-being and natural health foods (ISF, 2019).

In conclusion, 10,625 valid patents and 6,949 plant varieties were issued from January 2007 to December 2018 for seed sector crops. Using six patent indices, plant varieties, and a developed PM model, future technology trends were predicted in the seed industry. The new horticultural insights were provided using a newly designed PM model based on vacant technology, entry barriers, and future growth factors. The future trends predicted in our analysis provide information that can be used to estimate patent competitiveness and make development strategies for rapidly expanding markets. In addition, our results suggest patents that will advance the international market and guide the development of a national industrial strategy in Korea.

Literature Cited

Bonny S (2017) Corporate concentration and technological change in the global seed industry. Sustainability 9:1632. doi:10.3390/su9091632

Cho JS, Jang BK, Lee CH (2018) Seed dormancy and germination characteristics of the endangered species Cicuta virosa L. in South Korea. Hortic Environ Biotechnol 59:473-481. doi:10.1007/s13580-018-0062-7

Choi JW, Kim SY, Yu GE, Kim CK (2019) Technology trends and patenting prospects of medicinal plants in Korea. Korean J Med Crop Sci 27:75-85

Choi SW, You YY, Na KS (2014) Forecasting promising technology using analysis of patent information: Focused on next generation mobile communications. J Cent South Univ 21:4303-4310. doi:10.1007/s11771-014-2429-y

Dai Z, Guo L, Luo Q (2019) Market concentration measurement, administrative monopoly effect and efficiency improvement: Empirical data from China civil aviation industry 2001-2015. Appl Econ 51:3758-3769. doi:10.1080/00036846.2019.1584381

Fabry B, Ernst H, Langholz J, Köster M (2006) Patent portfolio analysis as a useful tool for identifying R&D and business opportunities—an empirical application in the nutrition and health industry. World Patent Inf 28:215-225. doi:10.1016/j.wpi.2005.10.004

Fan H, Ding L, Xu Y, Du C (2017) Seed germination, seedling growth and antioxidant system responses in cucumber exposed to Ca(NO3)2. Hortic Environ Biotechnol 58:548-559. doi:10.1007/s13580-017-0025-4

Golden seed project (GSP) (2019) Golden seed project(GSP). http://www.gsp.re.kr/, Accessed 2019. 01. 17

Grimaldi M, Cricelli L, Di Giovanni M, Rogo F (2015) The patent portfolio value analysis: A new framework to leverage patent information for strategic technology planning. Technol Forecast Soc Change 94:286-302. doi:10.1016/j.techfore.2014.10.013

Hewett EW (2012) High-value horticulture in developing countries: Barriers and opportunities. Plant Sci Rev 229:230-246. doi:10.1079/PAVSNNR20127054

Howard PH (2015) Intellectual property and consolidation in the seed industry. Crop Sci 55:2489-2495. doi:10.2135/cropsci2014.09.0669

Intellectual Property India (IPI) (2019) Intellectual Property India(IPI). http://ipindia.gov.in/, Accessed 2019. 01. 08

International Seed Federation (ISF) (2019) International Seed Federation(ISF). https://www.worldseed.org/, Accessed 2019. 01. 10

Japan Patent Office (JPO) (2019) Japan Patent Office (JPO). https://www.jpo.go.jp/, Accessed 2019. 01. 14

Kahler M (2013) Economic crisis and global governance: The stability of a globalized world. Proced-Soc Behav Sci 77:55-64. doi:10.1016/j.sbspro.2013.03.062

Kim KH, Chae MS, Shim W, Kwon OJ (2012) An evaluation for quality of performance of international R&D cooperation by analyzing patent information. J Korea Technol Innov Soc 15:722-743

Korea Institute of Patent Information (KIPI) (2005) Patent Analysis Methodology for Creating Technology Roadmap (Korean only). Korea Institute of Patent Information(KIPI). http://www.kipi.or.kr/,

Korea Seed & Variety Service (KSVS) (2017) Survey on seed industry. Korea Seed & Variety Service. http://www.seed.go.kr/, Accessed 2019. 01. 17

Korea Seed & Variety Service (KSVS) (2019) Korea Seed & Variety Service. http://www.seed.go.kr/, Accessed 2019. 01. 17

Korean Intellectual Property Rights Information Service (KIPRIS) (2019) Korean Intellectual Property Rights Information Service (KIPRIS). http://www.kipris.or.kr/, Accessed 2019. 01. 17

Korean Statistical Information Service (KOSIS) (2019) Korean Statistical Information Service (KOSIS). http://kosis.kr/, Accessed 2019. 01. 28

Lianos I, Katalevsky D, Ivanov A (2016) The Global Seed Market, Competition Law and Intellectual Property Rights: Untying the Gordian Knot. CLES Research Paper Series ISBN:978-971. doi:10.2139/ssrn.2773422

Lin BW, Chen CJ, Wu HL (2006) Patent portfolio diversity, technology strategy, and firm value. IEEE Transactions on Engineering Management 53:17-26. doi:10.1109/TEM.2005.861813

Matsumoto A, Merlone U, Szidarovszky F (2012) Some notes on applying the Herfindahl-Hirschman Index. Appl Econ Lett 19:181-184. doi:10.1080/13504851.2011.570705

Park DB (2014a) Developing strategies to improve policy effectiveness for seed industry. Institute of Planning and Evaluation for Technology in Food (iPEP):1-283

Park KH (2014b) Global seed market trends and prospects. Korea Rural Econ Inst 161:63-79

Shin WS (2015) Current status of global seed industry and role of golden seed project in Korea. J Plant Biotechnol 42:71-76. doi:10.5010/JPB.2015.42.2.71

State Intellectual Property Office (SIPO) (2019) State Intellectual Property Office (SIPO). http://english.sipo.gov.cn/, Accessed 2019. 01. 17

United States Patent and Trademark Office (USPTO) (2019) United States Patent and Trademark Office (USPTO). http://www.uspto.gov/ Accessed 2019. 01. 16

Van den Broeck G, Maertens M (2016) Horticultural exports and food security in developing countries. Glob Food Secur 10:11-20. doi:10.1016/j.gfs.2016.07.007

Weinberger K, Lumpkin TA (2007) Diversification into horticulture and poverty reduction: A research agenda. World Dev 35:1464-1480. doi:10.1016/j.worlddev.2007.05.002

Worldwide Intellectual Property Service (WIPS) (2019) Worldwide Intellectual Property Service (WIPS). http://www.wipson.com/, Accessed 2019. 01. 30

Yoon JY, Ryu TK, Yoon JH (2012) A study on patent indexes for characteristics analysis of IP portfolios. J Inf Manag 43:67-83. doi:10.1633/JIM.2012.43.2.067