

The Plant Variety Protection for Crops in China: A Systemic Review from Application to Enforcement of Rights

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ABSTRACT China is one of the developing countries having large agricultural research system with significant plant breeding capabilities. However, constrained seed markets, ineffective intellectual property rights, and various government regulations hampered the development of its seed industry. The Chinese State Council issued a statement in 2011, which was considered the inception of China's recent reform on its crop variety regulation. Among other measures, the State Council instructed to enhance the enforcement of protections on plant variety rights. Our study examined the trend of applications and approvals of plant varieties for main crops in China, as well as the features and legal consequences of infringement lawsuits involving crop varieties. In this study, the data concerning the application and examination, and the approval for nationwide planting of crop varieties were retrieved from the Chinese Ministry of Agriculture. The court decisions concerning plant-variety infringements were retrieved from a legal database, Westlaw China. This paper contributes to reveal the effect of the reform on crop variety regulation and the enforcement of plant variety rights in China. In particular, although public institutions remains the main force for developing new crop varieties in China, only in a small number of infringement cases they were the sole plaintiffs. It suggests that a significant number of crop varieties owned by public institutions were licensed to private companies.

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I. Introduction

China is very rich in germplasm resources of crops. It ranks third in the world in terms of germplasm resources, only second to Brazil and Columbia (FAO, 2000). It was estimated that China has more than 50,000 local rice varieties and 20,000 soybean varieties (FAO, 2000). Although China, India and Brazil are among the developing countries having large agricultural research system with significant plant breeding capabilities (Srinivasan, 2003), insufficient innovations, weak competitiveness among domestic seed companies, and loopholes in seed management have hampered the development of the seed industry in China (Zhu, 2013).

The Chinese market was congested with seed companies with little or no research capabilities. Meanwhile, many developing countries have policies precluding private sector and foreign participation in plant breeding (Jaffee and Srivastava, 1994). For instance, public institutions have been the main force of agricultural research in China although the distinction between public and private sectors may be difficult to discern (Koo et al., 2006). In 2011, only 100 out of 8,700 Chinese seed companies possessed research capability (He, 2012). On the other hand, although multinational companies' technologies were far ahead of Chinese seed companies, they did not enjoy more advantages in terms of marketing in China due to constrained seed markets, ineffective intellectual property rights, and various government regulations (Koo et al., 2006; He, 2012).

The Chinese State Council issued an opinion in April 2011 concerning the enhancement of its modern crop seed industry (State Council, 2011). The opinion was considered the inception of China's recent reform on its crop variety regulation. The State Council instructed to enhance the enforcement of protections on plant variety rights (State Council,

2011), and the holders' rights under the Plant Variety Protection (PVP) certificates would be strengthened as a result. In addition to the improvement of competitiveness by encouraging vertical and horizontal integration of domestic seed companies, the Chinese government also seeks to strengthen crop variety innovation and close the legal loopholes in seed management.

The Chinese government believes that the increase in market concentration by encouraging horizontal integration among firms would foster the domestic seed companies' competitiveness against multinational companies (State Council, 2011). Measures adopted to encourage merger and acquisition include raising the amount of registered capital required for operating seed companies (State Council, 2011).

In recent years, since the Chinese State Council's announcement of its determination to enhance the development of the seed industry in 2011 (State Council, 2011), the number of seed companies had reduced to 6,296 due to the government's encouragement of merger and acquisition (Zhu, 2013).

This paper seeks to understand the features and trends on the application of PVP certificates in main crops and the corresponding infringement litigations in China. Our study examined the trend of applications and approvals of plant varieties for main crops in China. We also examined the features and legal consequences of infringement lawsuits involving crop varieties. This study employed quantitative content analysis to explore whether significant differences exist between selected variables and the outcome of infringement cases. Variables which were of interest for our study include the status of plaintiffs, the status of defendants, the status of plant-variety holders, and the plant species involved in litigation.

II. The Legal Framework

The Seed Law is the highest legal guidance concerning the government's regulation of seed industry in China. As provided in Article 2, the Seed Law applies to all activities involving the "breeding, selection, production, business operation, usage, and management of seed" in the country. Under the Chinese Seed Law, main crops were referring to rice, wheat, corn, cotton, and soybean.⁴ As effective in February 2014, the amended Rules prescribed two additional main crops, namely oilseed rape and potato.⁵ In this paper, main crops are referring to the five crop species prescribed prior to the amendment in 2014.

Under the Regulations on the Protection of New Varieties of Plants, which are the rules governing the examination and issuance of PVP certificates, the holder of variety rights can exclude any entity or individual from producing or selling the propagating material of the protected variety for commercial purpose, or using the protected variety's propagating material repeatedly to produce the propagating material of another variety for commercial purposes.⁶

Plant and animal varieties are regarded as unpatentable and the only avenue for breeders in

China to protect new plant varieties is seeking PVP certificates (Ding, 2001). The breeders of new plant varieties may apply for PVP certificates if the varieties meet certain criteria. Similar to the plant variety protection laws in other countries, the breeder of a new plant variety would receive a certificate only if the plant variety is new, distinct, uniform, stable, and has an adequate name designation,⁷ provided that the new variety is part of botanical genera and species included in the national list of protected plant varieties.⁸ From June 1999 to April 2013, the Chinese government had published 9 lists, and overall 93 plant species are eligible for protection. Among the listed categories of plant, rice and corn were included since 1999; wheat and soybean were added in 2000, and cotton was not listed until 2005 (MOA, 1999, 2000, 2001, 2002, 2003, 2005a, 2008a, 2010a, 2013a).

Nonetheless, the issuance of a PVP certificate does not grant the holder of the new variety any right to mass produce, sell, or popularize the protected variety in China. These activities are subject to review and approval under other national laws and regulations,⁹ even if the relevant governmental agency has provided the holders of PVP certificates with the right to exclude others from producing or selling the protected varieties.¹⁰ In other words,

⁴ Art. 74(3), *zhonghua renmin gongheguo zhongzi fa 2013* (Seed Law of the People's Republic of China 2013).

⁵ Rule 3, *zhonghua renmin gongheguo zhuyao nongzuowu pinzhong shending banfa 2014* (Rules for the Certification of Main Crop Varieties of the People's Republic of China 2014).

⁶ Rule 6, *zhonghua renmin gongheguo zhiwu xinpinzhong baohu tiaoli 2013* (Regulations on the Protection of New Varieties of Plants of the People's Republic of China 2013).

⁷ Rule 14-18, *zhonghua renmin gongheguo zhiwu*

xinpinzhong baohu tiaoli 2013 (Regulations on the Protection of New Varieties of Plants of the People's Republic of China 2013).

⁸ Rule 13, *zhonghua renmin gongheguo zhiwu xinpinzhong baohu tiaoli 2013* (Regulations on the Protection of New Varieties of Plants of the People's Republic of China 2013).

⁹ Rule 5, *zhonghua renmin gongheguo zhiwu xinpinzhong baohu tiaoli 2013* (Regulations on the Protection of New Varieties of Plants of the People's Republic of China 2013).

¹⁰ Rule 6, *zhonghua renmin gongheguo zhiwu*

though the holder of a PVP certificate can legitimately exclude others from selling or producing the protected variety, the right holder is not permitted to sell, mass produce, or disseminate the new variety without seeking further approval from another governmental agency. The Rules for the Certification of Main Crop Varieties established the system for the review and approval of main crop varieties before the particular varieties can be widely planted.

In 2011, the State Council advised an exit mechanism for the revocation of certificates previously granted for nationwide planting of main crop varieties which were found not suitable for mass planting in the field due to lax in the process of examination or because of environmental change (State Council, 2011). The State Council also instructed raising the standard for the issuance of nationwide popularization certificates for main crop varieties, as well as enhancing the enforcement of plant variety right protections (State Council, 2011).

III. Study Data and Methods

This study used data from several different sources in the analysis. The sources of the data and information concerning the numbers of PVP applications and grants, and the numbers of applications filed by domestic public institutions were retrieved from the Database for the Public Notice of Plant Variety Rights maintained by the Office for the Protection of New Varieties of Plants, Ministry of Agriculture (in Chinese).¹¹ The data and information concerning the numbers of major crop varieties approved for nationwide planting and revocation of approvals were compiled from various public notice issued by the Chinese Ministry of

xinpinzhong baohu tiaoli 2013 (Regulations on the Protection of New Varieties of Plants of the People' s Republic of China 2013).

Agriculture (in Chinese).

The court decisions concerning PVP infringements in China were retrieved from a legal database, Westlaw China. This study collected all decisions published before May 1, 2016 by the Intermediate People' s Courts and the Higher People' s Courts under the cause of action, disputes concerning the infringement of plant variety rights (in Chinese). Decisions having the same plaintiff(s) and defendant(s) were considered the same case and were counted as one case. If one case had more than one judgment, the date of the last judgment rendered was assigned as the date of judgment for that case in this study. This study employed quantitative content analysis to explore whether significant differences exist between selected variables and the outcome of cases. The variables selected in this study included the year in which the court decision rendered (time frame), the plant species involved, and the status of plaintiffs, defendants, and the PVP right holders. By dividing court decisions into three different time frames, this study would be able to examine whether the courts in China have changed their practice in handling infringement cases as reflected in the outcome of cases. In particular, it would also reveal the effects of the central government' s policy on judicial practice in terms of the seed-market reform. By dividing cases according to the status of plaintiffs, defendants, the variety holders and the crop variety involved, this study would be able to examine whether the outcome of infringement cases are associated with either of these variables. In this way, bias in judicial practice could be inferred if significant association was found.

After de-duplication, 514 cases in which the final

¹¹ <<http://202.127.42.47:6009/Home/BigDataIndex>> (last accessed June 22, 2018). The data were retrieved in March 2014.

judgment was either rendered by the Intermediate People's Court or the Higher People's Court were examined. The status of plaintiff and defendant was categorized into five subgroups: public institution (Public Inst.), collective enterprise (Collective Enter.), private company (Private Co.), individual (Individual), and those involving more than one type of entities (Joint). The plant species was categorized into six subgroups: corn, rice, wheat, soybean, others, and unknown. The status of PVP right holder was categorized into six subgroups: public institution, collective enterprise, private company, individual, more than one type of entity was involved, and unknown. The year in which the final judgment was made was divided into three time frames: by 2005 (Period I), from 2006 to 2010 (Period II), and since 2011 (Period III). Collective enterprises in this study were referring to township or village enterprises which are market-oriented public enterprises under the purview of local governments based in townships or villages. The outcome included the final judgment, and the amount of compensation. The final judgment was categorized into four subgroups. One subgroup included cases which were dismissed or withdrawn. The other three groups were cases in which the parties settled, the plaintiff(s) prevailed, or the defendant(s) prevailed. The amounts of compensation were recorded in renminbi (RMB). The variables were coded and SPSS for Windows 21.0 was used in this study. Inferential statistics in this study included chi-square test and one-way ANOVA.

IV. Results

Public institutions in China have been the major

players in PVP application for main crop varieties (**Table 1**). The only exception was corn among five main crops, namely rice, wheat, corn, cotton, and soybean. Specifically, domestic public institutions accounted for 46.71% of filings for corn varieties in Period I, and the rate decreased to 34.44% in Period II. The percentage of PVP applications filed by domestic public institutions in the other four crops were greater than 60% (**Table 1**). Among the five main crops, only the applications for corn varieties filed by foreign entities significantly increased in recent years. Our study showed that, in 2005, only 15 out of 334 applications for corn varieties, which were approximately 4.5%, were filed by multinational companies.¹² In 2012, 49 out of 372 applications, which were approximately 13.2%, were filed by multinational companies.¹³ The data suggest that multinational companies, including Pioneer, Monsanto, KWS and Syngenta had increased their participation in developing corn varieties in China but not for other main crops. Currently, the presence of multinational companies in the certification of crop varieties for nationwide planting in China has been scant. Three crop varieties owned by Monsanto previously approved for nationwide planting have been revoked (MOA, 2010c, 2013b). On the other hand, a subsidiary of Pioneer-Hi Bred International continued to possess seven valid certificates granted between 2004 and 2006 (MOA, 2004, 2005b, 2007). In particular, Pioneer's Xianyu335, a corn variety involved in several infringement suits, has been approved for nationwide planting since 2004 (MOA, 2004). It was the first main crop variety developed by multinational companies being approved for nationwide planting.

¹² Among the foreign applicants, Pioneer filed six applications and Monsanto filed five applications.

¹³ Three were filed by Pioneer; 22 were filed by

Monsanto; eight were filed by KWS; 12 were filed by Syngenta; four were filed by a joint venture between Monsanto and a Chinese firm.

Table 1 Numbers of PVP applications filed (A), PVP certificates issued, applications filed by domestic public institutions (a), and the percentage of applications filed by domestic public institutions (a/A) for major crop varieties by 2010

Crop species	Time frame	No. of application filed (A)	No. of certificate issued	No. of application filed by domestic public institutions (a)	a/A (%)
Corn	By 2005	1169	344	546	46.71
	2006-2010	1443	1018	497	34.44
Rice	By 2005	937	166	696	74.28
	2006-2010	1314	979	890	67.73
Wheat	By 2005	284	76	209	73.59
	2006-2010	367	246	261	71.12
Soybean	By 2005	83	23	73	87.95
	2006-2010	221	98	194	87.78
Cotton	By 2005	78	0	52	66.7
	2006-2010	198	109	121	61.11

*Wheat was not on the list of protection until 2000; soybean was not on the list of protection until 2000; cotton was not on the list of protection until 2005.

Source: the Office for the Protection of New Varieties of Plants, Ministry of Agriculture, Database for the Public Notice of Plant Variety Rights, Beijing, China, available at <http://202.127.42.47:6009/Home/BigDataIndex>.

While privatization has continued in the seed sector, public institutions remain the main force for developing new crop varieties in China. Meanwhile, the greater extent of private participation, domestic or multinational, for the development of corn varieties suggests that the corn sector may generate more profit than investing in other crop species in China, leading to more competition. However, plant variety protection alone is not sufficient to generate profit. The approval for nationwide planting is needed. The fact that few certificates for nationwide planting have been granted to multinationals regardless of the increasing trend for the application of corn variety protection by multinationals suggests

that intangible hurdles, either regulatory or non-regulatory, may exist in the process of acquiring such approvals.

The 514 PVP infringement cases were divided into three time frames based on the date of final judgment. There were 86 PVP infringement cases in Period I, 306 cases in Period II, and 122 cases in Period III. During Period I, only 15.1% of cases were appealed to the Higher People's Court. The percentage increased to 23.2% in Period II, and 31.1% in Period III (**Table 2**). Overall, only 37 plant varieties in Period I, 134 plant varieties in Period II, and 63 plant varieties in Period III were involved in PVP infringement cases, respectively. **Table 3**

provides a breakdown by plant species. As expected, more corn varieties were involved in litigations compared to other main crops, followed by wheat and rice. In Period I, 52.3% of cases were dismissed or withdrawn. The percentage decreased to 44.4% in Period II, and 36.9% in Period III. The percentage of cases in which the plaintiffs prevailed in three different time frames was 32.6%, 29.1%, and 36.1%,

respectively. The percentage of cases in which the parties settled was 12.8%, 23.2%, and 22.1% (Table 4), respectively. The data suggest a decreasing trend of cases being terminated at an early stage of litigation and an increasing trend of settlement. A higher percentage of lower court decision was affirmed by the Higher People's Court in Period I and Period III, while the appellate affirmance rate was lower during

Table 2 The numbers of cases appealed to the higher people's court and the outcome of cases by May 2016

Time frame		By 2005	2006-2010	Since 2011
Total No. of cases		86	306	122
No. of cases appealed		13 (15.1%)	71 (23.2%)	38 (31.1%)
Appellate decision	Affirmed	7 (53.8%)	32 (45.1%)	22 (57.9%)
	Reversed-compensation reduced	3 (23.1%)	4 (5.6%)	3 (7.9%)
	Reversed-compensation increased	1 (7.7%)	5 (7%)	3 (7.9%)
	Settled	1 (7.7%)	20 (28.2%)	6 (15.8%)
	Retrial	0 (0%)	6 (8.5%)	3 (7.9%)
	Reversed-compensation unchanged or no compensation	1 (7.7%)	2 (2.8%)	0 (0%)
	withdrawn	0 (0%)	2 (2.8%)	1 (2.6%)

Table 3 The numbers of cases with known varieties and total numbers of varieties, main crop varieties, and other varieties involved in three different time frames

	By 2005	2006-2010	Since 2011
No. of cases in which the variety involved was known	37	134	63
Total No. of plant varieties involved	20	46	29
Total No. of corn varieties involved	9	21	14
Total No. of wheat varieties involved	5	10	8
Total No. of rice varieties involved	5	11	4
Total No. of soybean varieties involved	0	1	1
Total No. of cotton varieties involved	0	0	0
Total No. of other varieties involved	1	3	2

Sources: compiled by the authors.

Period II (Table 2). In Period I, 23.1% of lower court decisions were reversed and the compensation reduced. The percentage reduced to 5.6% in Period II, and 7.9% in Period III. Since 2006, more cases were settled on appeal and the Higher People's Court ordered more retrials (Table 2).

It is worth noting that collective enterprises were the sole plaintiffs in only 2.3% of cases while they were the sole defendants in 12.1% of cases. Individuals were the sole plaintiffs in only 0.6% of cases but were the sole defendants in 24.7% of cases. Although in 54.5% of the 514 cases the PVPR (plant variety protection rights) holder status were unknown, public institutions still accounted for 27.2% of PVPR holders in suit while they were the sole plaintiffs in only 14.6% of cases. It suggests that a significant number of varieties developed by public institutions were licensed to private companies. One of Pioneer's corn varieties, Xianyu335, was involved in five cases at the level of Intermediate People's Court and Higher People's Court. The aggregate damages awarded were over 6 million RMB. It was the greatest amount of damages awarded for a single crop variety ever, followed by Linao-1-hao, a corn variety owned by a domestic private company, Beijing Origin Seed Technology. In addition to the five cases, two cases involving Xianyu335 were appealed to the Supreme People's Court and were not included in our statistics. The damages awarded in the two cases were 5 million and 2.6 million RMB, respectively. Compared with Xianyu335, Linao-1-hao was involved in four cases and the aggregate damages were approximately 4 million RMB.

The results show the significant differences exist between time frame, PVP holder status, plaintiff status, defendant status, and plant species involved in the 514 court decisions (Table 4). Regardless of the time frame in which the judgment was made, overall our study showed that the final outcome of these cases was as follows: 44% (226) were dismissed/

withdrawn (DW); 21.2% (109) were settled (S); plaintiffs prevailed (PP) in 31.3% (161) of cases; and defendants prevailed (DP) in only 3.5% (18) of cases. The one-way chi-square test shows significant differences between the final judgment and all variables ($p < 0.001$) (Table 4). However, the two-way chi-square test shows significant differences only between the final judgment and three variables, specifically PVP holder status, plaintiff status and plant species involved ($p < 0.001$) (Table 4). Table 4 shows that the final judgment was either dismissed or withdrawn in 73.2% of cases where the status of PVPR holders were unknown and in 73% of cases where the plant species involved were unknown. In cases involving corn, wheat, or rice varieties, the plaintiffs prevailed in the majority of cases. Regardless of the plaintiffs' status, in most cases the claims were either dismissed/withdrawn (33.3-44%) or the plaintiffs prevailed (30.8%-34.2%), except when the plaintiffs were individuals. However, only in three cases the plaintiffs were individuals.

With regard to whether damages were awarded, in 210 (40.9%) cases the plaintiffs received some type of compensation, including settlement. The two-way chi-square test showed significant differences between whether damages were awarded and two variables, namely the PVP holder status and the plant species involved ($p < 0.001$) (Table 4). When the crop varieties involved were corn, rice or wheat, the plaintiffs received some type of damages in around 80% of cases. With regard to the PVPR holder status, the percentage of cases receiving some type of damages were as follows: 87.1% for private companies, 81.3% for joint ownership involving private companies and public institutions, 80% for public institutions, and 60% for foreign companies, respectively. Last, the one-way ANOVA shows no significant differences between the amounts of compensation and all variables except the PVP holder status ($p > 0.05$) (Table 4). The Scheffe's test

Table 4 The significance between the legal consequences of infringement lawsuits involving main crop varieties and the features of the cases

Variables	n(%)	Final judgment, n(%)				X ²	Whether damages were		X ²	Amount of	F ¹
		DW	S	PP	DP		Yes	No			
Time frame											
by 2005	86(16.7)	45(52.3)	11(12.8)	28(32.6)	2(2.3)	8.76 ^{NA}	29(33.7)	57(66.3)	2.27 ^{NA}	217137.517	2.20 ^{NA}
2006-2010	306(59.5)	136(44.4)	71(23.2)	89(29.1)	10(3.3)		128(41.8)	178(58.2)		134022.562	
since 2011	122(23.7)	45(36.9)	27(22.1)	44(36.1)	6(4.9)		53(43.4)	69(56.6)		294882.075	
PVP holder status											
Unknown	280(54.5)	205(73.2)	75(26.8)	0(0)	0(0)	375.86 ^{**}	22(7.9)	258(92.1)	279.07 ^{***}	92590.909	14.806 ^{***}
Public Inst.	140(27.2)	15(10.7)	18(12.9)	97(69.3)	10(7.1)		112(80.0)	28(20.0)		133200.071	
Joint	48(9.3)	5(10.4)	4(8.3)	37(77.1)	2(4.2)		39(81.3)	9(18.8)		132407.692	
Private Co.	31(6.0)	1(3.2)	11(35.5)	17(54.8)	2(6.5)		27(87.1)	4(12.9)		395081.481	
individual	10(1.9)	0(0)	1(10.0)	7(70.0)	2(20.0)		7(70.0)	3(30.0)		6302.571	
Foreign Co.	5(1.0)	0(0)	0(0)	3(60.0)	2(40.0)		3(60.0)	2(40.0)		2083333.333	
Plaintiff status											
Private Co.	386(75.1)	170(44.0)	88(22.8)	119(30.8)	9(2.3)	44.29 ^{**}	158(40.9)	228(59.1)	2.11 ^{NA}	213244.924	0.694 ^{NA}
Public Inst.	75(14.6)	31(41.3)	15(20.0)	25(33.3)	4(5.3)		31(41.3)	44(58.7)		91419.355	
Joint	38(7.4)	20(52.6)	3(7.9)	13(34.2)	2(5.3)		16(42.1)	22(57.9)		123187.500	
Collective Enter.	12(2.3)	4(33.3)	3(25.0)	4(33.3)	1(8.3)		5(41.7)	7(58.3)		116585.600	
Individual	3(0.6)	1(33.3)	0(0)	0(0)	2(66.7)		0(0)	3(100.0)		NA	
Defendant status											
Private Co.	207(40.3)	79(38.2)	43(20.8)	77(37.2)	8(3.9)	19.13 ^{NA}	98(47.3)	109(52.7)	8.20 ^{NA}	277711.439	2.073 ^{NA}
Public Inst.	5(1.0)	2(40.0)	0(0)	2(40.0)	1(20.0)		2(40.0)	3(60.0)		315600.000	
Joint	113(22.0)	57(50.4)	18(15.9)	33(29.2)	5(4.4)		41(36.3)	72(63.7)		162709.268	
Collective Enter.	62(12.1)	33(53.2)	13(21.0)	14(22.6)	2(3.2)		18(29.0)	44(71.0)		64289.333	
Individual	127(24.7)	55(43.3)	35(27.6)	35(27.6)	2(1.6)		51(40.2)	76(59.8)		66772.882	
Plant Species											
Unknown	282(54.9)	206(73.0)	74(26.2)	1(0.4)	1(0.4)	356.82 ^{**}	23(8.2)	259(91.8)	279.36 ^{**}	97260.870	.755 ^{NA}
Corn	166(32.3)	12(7.2)	28(16.9)	115(69.3)	11(6.6)		136(81.9)	30(18.1)		207195.971	
Wheat	36(7.0)	6(16.7)	1(2.8)	27(75.0)	2(5.6)		28(77.8)	8(22.2)		80417.714	
Rice	22(4.3)	1(4.5)	5(22.7)	14(63.6)	2(9.1)		18(81.8)	4(18.2)		311587.222	
Soybean	2(0.4)	0(0)	1(50.0)	1(50.0)	0(0)		2(100.0)	0(0)		60000.000	
Others	6(1.2)	1(16.7)	0(0)	2(33.3)	3(50.0)		3(50.0)	3(50.0)		228236.000	

Note: ¹ F value for complex comparison by the post hoc testing of Scheffe's test.

*** p < 0.001.

shows that when the PVP holder status is foreign companies, the amounts of compensation are much larger compared to other types of PVP holders (Table 4).

V. Discussion

As an incentive to encourage private investment, developing countries adopting PVP regimes are likely to experience a process of consolidation of the domestic seed industry if the countries open themselves to foreign investment (Srinivasan, 2003). As a consequence, the worldwide patterns of concentrated ownership of plant variety rights would be reflected in these countries' national grants (Srinivasan, 2003). That is not the case in China.

Among the five main crops, only the applications for corn varieties filed by foreign entities significantly increased in recent years. Even so, the presence of multinational companies in the certification of crop varieties for nationwide planting in China has been scant. However, Pioneer's Xianyu335, a corn variety involved in several infringement suits, has been approved for nationwide planting since 2004 (MOA, 2004). It was the first main crop variety developed by multinational companies being approved for nationwide planting. Overall, infringement cases involving Xianyu335 were granted the greatest amount of damages awarded for any single crop variety as of 1 May 2016.

Enforceable intellectual property rights and plant variety protection regulations are the premise for most private companies to release their best hybrids. Otherwise it may be very difficult to protect the inbred lines which the breeders used to produce these types of hybrids (Gerpacio, 2003). As Spielman et al. (2014) have noted, several multinationals have refrained from marketing their best hybrids in several Asian countries for fear of losing their valuable inbred lines to local competitors, including in China (Spielman et al., 2014). Although other concerns

preventing multinational companies from directly participating in the Chinese seed industry may have continued to exist (Koo et al., 2006; He, 2012), the case of Xianyu335 suggests that the enforcement of PVP rights in China has improved.

Self-pollinating crops, such as rice and wheat, are considered only having marginal commercial value in terms of developing improved cultivars (Spielman et al., 2014). Private companies aiming at profit-maximization may opt not to invest in developing new varieties for crops in this category. To prevent an undersupply of improved cultivars in the market, Spielman et al. (2014) suggested that public-sector participation may be required either through financing or plant-breeding programs (Spielman et al., 2014).

As expected, more corn varieties were involved in litigations in China compared to other main crops, followed by wheat and rice. Although in more than half of the cases the PVPR holder status were unknown, public institutions still accounted for 27.2 % of PVPR holders in suit while they were the sole plaintiffs in only 14.6% of cases. It suggests that a significant number of varieties developed by public institutions were licensed to private companies.

During Period I, only 15.1% of cases were appealed to the Higher People's Court. The percentage increased to 23.2% in Period II, and 31.1% in Period III (Table 2). The increase of appeals suggests a decreasing trend of cases being terminated at an early stage of litigation. Our data also show an increasing trend of settlement in court. The increasing number of cases appealed to the higher court indicates that using the court system to resolve PVPR infringement has been gaining support and the parties involved are better prepared in judicial proceedings.

VI. Conclusions

Ineffective intellectual property protection has

been one of the main concerns why foreign companies were hesitant to transfer high technologies to China. A systemic review from the application and granting of intellectual property to infringement litigations involving such property would help to clarify whether these are realistic concerns or impressions based on certain high-profile cases. Our study provided a systemic review of crop variety protection by analyzing data from the application and granting of plant variety protection, the approval of nationwide planting, to infringement litigations involving crop varieties. It covers the entire chain of operation rather than piecemeal to clarify misconceptions about the system, if any. Although public institutions have been the main force for the development of new crop varieties in China, they were the sole plaintiffs only in a small number of infringement cases. Apparently a significant number of crop varieties developed by public institutions were licensed to private companies. There is growing reliance on settling PVPR disputes in the Chinese court, especially during appeal. The trend indicates that fewer cases were terminated at an early stage of litigation and more cases were settled in court. The corn seed business in China has more foreign involvement compared with other main crops. The amount of compensation that a multinational company received in an infringement case is at least not less than a similar case in which the plaintiffs are Chinese companies. Overall, the Chinese court system are gaining trustworthiness as a forum to settle PVPR disputes and the parties involved in infringement cases are bettered prepared.

VII. References

Ding, C., 2001. The protection for new plant varieties of American businesses in China after China enters the WTO. *Drake Journal of Agricultural Law* 6, 333-350.

Gerpacio, R.V., 2003. The role of public sector versus

private sector in R&D and technology generation: the case of maize in Asia. *Agricultural Economics* 29, 319-330.

FAO (Food and Agriculture Organization of the United Nations), 2000. Crop Diversification in the Asia-Pacific Region. Expert Consultation on "Crop Diversification in the Asia-Pacific Region," Bangkok Thailand, 4-6 July 2000; Bangkok, Thailand: Regional Office for Asia and the Pacific, Food and Agriculture Organization of the United Nations.

He, N., 2012. Problems in China's corn seed industry. *People's Daily Online*, 22 March 2012. <<http://english.peopledaily.com.cn/90778/7765305.html>> (accessed September 14, 2014).

Jaffee, S., Srivastava, J., 1994. The roles of the public and private sectors in enhancing the performance of seed systems. *The World Bank Research Observer* 9, 97-117.

Koo, B., Pardey, P.G., Qian, K., Zhang, Y., 2006. An option perspective on generating and maintaining plant variety rights in China. *Agricultural Economics* 35, 35-48.

MOA (Ministry of Agriculture of the People's Republic of China), 1999. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People's Republic of China), nongyebu ling di 14 hao, 16 June 1999.

MOA, 2000. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People's Republic of China), nongyebu ling di 27 hao, 7 March 2000.

MOA, 2001. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People's Republic of China), nongyebu ling di 46 hao, 26 February 2001.

MOA, 2002. Zhonghua renmin gongheguo nongye

- zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People' s Republic of China), nongyebu ling di 3 hao, 4 January 2002.
- MOA, 2003. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People' s Republic of China), nongyebu ling di 32 hao, 5 August 2003.
- MOA, 2004. Zhonghua renmin gongheguo nongyebu gonggao di 413 hao, 19 October 2004.
- MOA, 2005a. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People' s Republic of China), nongyebu ling di 51 hao, 20 May 2005.
- MOA, 2005b. Zhonghua renmin gongheguo nongyebu gonggao di 516 hao, 24 June 2005.
- MOA, 2007. Zhonghua renmin gongheguo nongyebu gonggao di 844 hao, 9 April 2007.
- MOA, 2008a. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People' s Republic of China), nongyebu ling di 14 hao, 21 April 2008.
- MOA, 2010a. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People' s Republic of China), nongyebu ling 2010 di 8 hao, 18 January 2010.
- MOA, 2010c. Tingzhi tuiguang guojia shending nongzuowu pinzhong mulu (List of Revocation for Approval of Agricultural Crop Varieties for Nationwide Popularization). Zhonghua renmin gongheguo nongyebu gonggao di 1504 hao, 13 December 2010.
- MOA, 2013a. Zhonghua renmin gongheguo nongye zhiwu xinpinzhong baohu minglu (List of Protection for Agricultural New Plant Varieties of the People' s Republic of China), nongyebu ling 2012 di 1 hao, 11 April 2013.
- MOA, 2013b. Tingzhi tuiguang guojia shending nongzuowu pinzhong mulu (List of Revocation for Approval of Agricultural Crop Varieties for Nationwide Popularization). Zhonghua renmin gongheguo nongyebu gonggao di 2037 hao, 18 December 2013.
- Spielman, D.J., Kolady, D.E., Cavalieri, A., Rao, N.C., 2014. The seed and agricultural biotechnology industries in India: an analysis of industry structure, competition, and policy options. *Food Policy* 45, 88-100.
- Srinivasan, C.S., 2003. Concentration in ownership of plant variety rights: some implications for developing countries. *Food Policy* 28, 519-546.
- State Council (State Council of the People' s Republic of China), 2011. Guowuyuan guanyu jiakuai tuijin xiandai nongzuowu zhongye fazhande yijian (The Opinion of State Council Concerning the Enhancement of a Modern Agricultural Crop Seed Industry). Guo fa [2011] 8 hao, 10 April 2011. <http://www.gov.cn/zwqk/2011-04/18/content_1846364.htm> (accessed on September 14, 2014).
- Zhu, J., 2013. Government to boost seed industry. *China Daily*, 29 January 2013. <http://www.chinadaily.com.cn/china/2013-01/29/content_16182527.htm> (accessed on September 14, 2014).

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