

# The evolving landscape of plant breeders' rights regarding wheat varieties in South Africa

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Addressing the multiple challenges facing global agriculture requires integrated innovation in areas such as seeds, biotechnology, crop protection, grain storage and transport. Innovations related to plant improvement and the development of new or improved plant varieties will only happen at an optimal level if plant breeders' rights (PBR) are properly protected. The objective was to analyse the evolving landscape of wheat plant breeders' rights to address the dearth of empirical evidence of the patterns and trends of wheat varietal improvements in South Africa. We compiled a detailed and novel count and attribute database of wheat varietal innovations in South Africa from 1979 to 2013 using various sources. This data set was then analysed to ascertain the main trends in, and ownership of PBRs for wheat varietal improvements in South Africa over this period. A total of 134 PBR wheat varietal innovations were lodged from 1979 to 2013, an average of 6 applications per year. The administrative delays in granting PBR applications were substantially reduced by 77 days during the post-deregulation period (after 1996), indicating increased efficiency. The main PBR applicants were Sensako (39%), the Agricultural Research Council Small Grains Institute (ARC-SGI) (25%) and Pannar (15%). The ARC-SGI contributed to some of the PBRs owned by private companies through shared genetic resources before Plant Variety Protection (PVP) was implemented. Future innovations and dissemination of wheat innovations can be stimulated by plant variety protection, together with broader variety sector legislation that encourages both public and private sector investment.

## Introduction and background

Integrated agricultural innovations in areas such as seeds, biotechnology, crop protection, agronomic management practices, harvesting and processing are critical to help address the global challenges facing agriculture, such as climate change and decreasing availability of water and farmland, increasing food demand resulting from increasing population size, and demand for food crops for other uses such as biofuels.<sup>1,2</sup> For example, varietal innovations that are high-yielding and drought-resistant are required if farmers are aiming to produce more with less inputs. However, investments in varietal improvements are expensive (in terms of skills, labour, material, resources etc.), take time to develop (10–15 years in the case of many plant species), and the resulting seed products face the risk of being reproduced and 'copied' by competitors, necessitating the need for some form of enforceable commercial protection for plant breeders.<sup>1–3</sup>

For a long time, developing countries have relied on public investments (national and international) for plant varietal improvements.<sup>3,4</sup> Most of the public research investments were implemented through collaborations between national agricultural research institutes and the International Agricultural Research Centres of the Consultative Group on International Agricultural Research such as The International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and the International Rice Research Institute (IRRI) in Manila.<sup>4</sup> Despite the long history of public sector dominance in developing country research, there are growing calls for the private sector to play a major role in agricultural investments, including plant varietal improvements. This would help address the increasing funding challenges being faced by public research institutions. The private sector, on the other hand, requires economic incentives provided by Intellectual Property Rights (IPRs) to invest in plant variety innovations.<sup>5</sup> At the same time, the publicly funded research outputs should be protected, utilised and commercialised for the benefit of the funding country. All of this points to the importance of plant variety protection as being critical to stimulate plant breeding innovation and the dissemination of innovations.<sup>6</sup>

Pardey et al.<sup>7,8</sup> argue that plant varietal rights are subject to controversy and ongoing public policy scrutiny and debate. In order to inform these policy debates, there is a need to understand the evolution of varietal rights and the extent of the varietal rights which are granted. In addition, it is also important to understand the changes which are experienced over time regarding the rights on offer; changing ownership of the rights (including comparison between public and private, as well as domestic and foreign breeders); impacts of plant variety protection on varietal development etc.

In this research, the evolving landscape of plant breeders' rights was analysed regarding wheat varietal improvement in South Africa. The earlier efforts by Stander<sup>9</sup> to undertake a similar exercise were limited by the shorter period of relevant observations, compared to the current study. In addition, we do not know the implications of plant variety protection on public and private investments for wheat varietal improvements in South Africa, or whether the granting of plant breeders rights has enhanced, slowed or changed the nature of genetic improvement. The study therefore focused specifically on the following research questions:

- Which trends can be observed in the wheat varietal improvements subsector in South Africa?
- How have plant breeders' rights for wheat varietal improvements evolved?
- Who are the main plant breeders' rights holders in the wheat sector?

- What are the effects of these developments for diversity and competition in the South African wheat breeding industry?
- Which measures can be taken by the South African Government to restrict or reverse possible negative impacts of these trends in light of relevant policy objectives?

## International experiences in plant variety protection

The protection of intellectual property rights of plant breeders was recognised from the 19th century onwards. The International Union for the Protection of New Varieties of Plants (UPOV), established in 1961, seeks to harmonise plant variety protection (PVP) laws and standards of protection across member countries.<sup>10</sup> Plant variety protection was almost exclusively the protection granted for plant-related innovations, until 25 years ago.<sup>1</sup> Plant variety protection, also called 'plant breeders' rights', is defined as an independent *sui generis* form of protection of new plant varieties for essential features (usually phenotypical).<sup>2</sup> Plant breeders' rights (PBRs) constitute a form of intellectual property right that grants the breeder of a new plant variety the exclusive rights to benefit from his or her variety. In addition, innovations in plant breeding are driven by the need to acquire and/or increase market share.<sup>3</sup> Plant breeders' rights provide legal protection for the plant breeder to exclude others from commercialising the protected variety for a specified number of years, usually five years. This gives protection against unauthorised copying (propagation) of the protected variety for commercial uses by farmers and competitors. At the end of the protection period, the breeder can issue licences to other breeders who might be interested in using any material of the variety in their breeding activities.

Countries are required by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) of the World Trade Organisation to provide plant varietal protection 'either by patents or by an effective *sui generis* system or a combination thereof (TRIPS Article 27(3)(b))'.<sup>1</sup> In addition to the obligation under the TRIPS Agreement for countries to introduce plant variety protection systems, other benefits include providing a system of incentives for individuals and entities (state, private and foreign) engaged in plant breeding to increase the quantity or effectiveness of plant breeding. Plant variety protection contributes to: increasing genetic diversity; improving food security through production of high quality and higher yielding varieties; sustaining agriculture by promoting use of national resources and inputs; and protection of the environment through pest and disease resistant varieties that need fewer chemicals (pesticides).<sup>2</sup>

The standard argument for implementing PVP is that they would stimulate and drive investments in plant breeding research and development of the domestic seed sector.<sup>11</sup> Although PVP provide some incentives for increased plant breeding, evidence from some empirical studies show mixed results with some authors finding that it may not be strong enough to encourage plant breeding investments.<sup>11-14</sup> For example, Tripp et al.<sup>11</sup> studied the potential of PVP to provide incentives for plant breeding in developing countries (China, India, Colombia, Kenya and Uganda). Their findings showed that development of PVP systems in developing countries should be framed as part of a broader strategy for seed system development, as PVP may not be adequate to initiate commercial seed development. In a separate study, Alston and Venner<sup>13</sup> found that the introduction of the PVP Act of 1970 in the USA increased public investments only (with no change in private investments) and did not affect experimental and commercial wheat yields.

Srinivasan<sup>5</sup> explored the levels in the ownership of IPRs over plant varieties, based on data from 30 UPOV member-countries. He argues that the combination of ownership of plant variety rights and growing plant variety protection systems in the developing world would have significant influence on future plant innovations and distribution of market power between companies. This has implications for the structure of the domestic seed industries and gaining access to protected varieties and associated plant breeding technologies. Diez<sup>15</sup> analysed the impact of plant variety rights on public and private research sectors in Spain, focusing on the role of PVP in altering research incentives in the understanding

of intersectoral differences. The study showed that there were positive incentives, particularly for the private sector, for increased investments in plant breeding driven by higher appropriability conditions.

Wright and Pardey<sup>16</sup> argue that with the exception of a few, many public agricultural research institutions in developing countries have made little progress in developing and commercialising their innovations. Related to this, Alston and Venner<sup>13</sup> state that despite plant variety protection providing some exclusive rights to the plant breeder, sometimes the high enforcement costs and the difficulties in monitoring areas planted to a crop, such as wheat, and in determining the source of seed, make it difficult to exclude farmers and seed companies from freely using protected varieties.

## Plant variety protection in South Africa

South Africa became a member of UPOV in 1978. According to Moephuli et al.<sup>17</sup>, the country did not accede to UPOV 1991. In 1976 South Africa enacted the *Plant Breeders' Rights Act (Act 15 of 1976)*. This was later amended in 1996 to conform to the constitution, as well as to align and comply with the UPOV 1991. Plant variety protection in South Africa is also guided by the *Plant Improvement Act 1976 (Act 53 of 1976)*. Granted PBRs are listed in a variety listing and are usually granted for 20 years for all crops and 25 years for trees and vines. However, the national authority may expropriate rights for national interest, such as food security needs. The granted PBRs automatically expire at the end of the prescribed period.<sup>17</sup>

The PBR provides the owner of the variety the opportunity to obtain financial reward from the investments put into breeding and development of the new variety in order to recover the costs incurred. Plant breeders' rights have evolved since the nineteen thirties, when crop improvements became an applied form of genetics practised by specialised institutions and seed companies.<sup>18</sup> The owner of a PBR has the privilege of a sole right period of 5 years and during this period the owner does not award licences, thus securing a chance to obtain return on investment for plant varietal improvements. This means that the breeder is the only one who can use the materials of the variety while it is protected. After the 5-year period, the owner of a PBR can allow the granting of licences through an attorney and the relevant contract should show how royalties are to be paid. These licences allow the owner to receive payment on any breeding material that is used by other breeders from the variety. In the case where the holder of the right refuses to issue licences to other persons who wish to use and market the material from the protected variety in the breeding programmes, the Registrar from the Department of Agriculture, Forestry and Fisheries (DAFF) may issue a compulsory licence (De Bruyn E 2013, oral communication, Jan 22.). After the expiry of the full period of the plant breeders' rights, the variety becomes public property and anyone may propagate and sell it.

The holder of a set of plant breeder's rights is required to maintain the reproductive material during the period of the rights. It is, however, not clear what happens to the said material after the period of the rights has expired. There is a test for the distinctness of the candidate variety: it should be compared with other varieties of the same kind of plant, of which their existence on that date is a matter of common knowledge. The holder is not entitled to exclusively make available plant material after the holder's rights have expired. This is a problem for other interested parties, as such material will then not be available for comparison purposes with other material that enters the market. DAFF does not have facilities to maintain all the plant material of varieties which have been granted plant breeders' rights, so they are sent to the gene bank at the Agricultural Research Council Small Grains Institute (ARC-SGI).

In South Africa, 60% of holders of PBRs on most crops are foreigners that are largely based in Europe and North America, and this asymmetry is not unique to South Africa as a developing country.<sup>18</sup> The plant breeders' rights in South Africa give the holder a limited exclusive right to the variety. However, traditional farming practices, such as re-sowing and saving protected varieties, may constitute infringement of that right. The *Plant Breeder's Right Act (Act No 15 of 1976)* allows farmers to use

(re-sow) protected material on his or her own holding. This expression of farmer rights is known as farmer privileges.<sup>18</sup>

## Research methods and data

Plant breeders' rights (PBR) in South Africa were analysed to assess the sources of intellectual property rights in wheat varietal improvements in South Africa. The paper used secondary information collected from various sources on wheat varietal improvement policies, and changes in wheat plant breeders' rights. Other studies that have analysed changes in plant variety protection, focusing on trends and changes in plant variety protection policies, include Diez<sup>15</sup>, Srinivasan<sup>5</sup>, Louwaars et al<sup>3</sup> and Pardey et al.<sup>7,8</sup> In these studies, trends were analysed to understand the evolution of plant varietal protection. This paper applies the same approach in order to understand the changes that have shaped the South African wheat varietal improvement landscape to date, and to allow a comparison with other countries at a later stage.

A detailed and novel count, and attribute database of wheat varietal innovations in South Africa from 1979 to 2013 was compiled. Consultations were made with key informants from the Department of Agriculture Forestry and Fisheries, ARC and the South African National Library during development of the database. The database provides information to assess changing amounts and forms of wheat plant breeders' rights, and changes in the types and pool of the applicants receiving the rights. The database gathered data on applications, granting, and rejections and surrendering of the PBRs. Additional information captured in the database includes plant variety name, alias name, applicant name, applicant type, application date of PBR, grant date of PBR, withdrawal date of PBR, and date end of sole right of PBR, showing end of sole right month and date of termination of PBR.

Data were manually compiled on wheat variety rights from information on wheat plant breeders' rights applications and granting obtained from the *Plant Variety Journal* of the South African Department of Agriculture Forestry and Fisheries. Additional data were gathered from the South African National Library and the ARC. These different sources of data were used to backfill the data series to come up with a complete database. The data series included 134 applicants for wheat variety rights lodged between January 1979 and December 2013. The empirical analyses were based on descriptive statistics, trend analysis and graphical representation of trends and ownership of wheat varietal improvement PBRs.

## Results and discussion

### Trends in plant breeders' rights for wheat varietal improvements

Figure 1 shows the trends in annual applications for PBRs for wheat varietal improvements lodged in South Africa. A total of 134 PBRs were lodged for wheat varietal innovations from 1979 to 2013, an average of 6 applications per year. Data on the number of PBRs lodged for wheat varietal improvements since 1979 show a fluctuation trend with some years having high numbers of applications, and others recording very low applications. For example, 2012 received the highest number of PBRs for wheat varietal improvements, with 14 applications, while 2004 recorded only 1 application. A possible explanation for the uneven trend in applications could be that some breeders chose to apply for their new varieties to be included on the national variety list but did not apply for varietal protection. The variety would then be included on the national variety list so it could be known by millers and bakers, but unless the owner applied for PBRs, anyone could use any material on the variety without paying the owner for IPRs.

Outbreaks of pests or diseases can trigger more investments in wheat varietal improvements in some years, compared with others. For example, the Ug99 wheat stem rust race group from East Africa was detected in 1999 and since then, 11 pathotypes within the race group have been identified across Africa and a few neighbouring countries. In South Africa, 'four races in the Ug99 lineage have been detected – TTKSF (in 2000), TTKSP (in 2007), PTKST (in 2010) and TTKSF+ (in 2010)<sup>19</sup>. In addition, a new Ug99 variant (race TTKSF+) was identified in South Africa and Zimbabwe in 2012<sup>19</sup>. The identification of new variants of Ug99 in recent years, particularly from 2010, could have triggered increased investments in wheat varietal improvements, leading to high numbers of PBR applications in 2012. Generally, the main triggers for wheat varietal improvements in South Africa include the outbreak of pests and diseases, such as wheat rust, septoria and Russian wheat aphid, and different environmental and climatic conditions.

It is also important to understand the effects of the abolishment of the South African Wheat Board in 1996 and the establishment of the ARC-SGI in 1991 on the number of applications for PBRs for wheat varietal improvements. Analysis of the time periods before and after the abolishment of the Wheat Board shows that 77% of the applications were lodged between 1998 and 2013 (after the abolishment of the Wheat Board). The number of PBR applications increased faster after the abolishment of the Wheat Board, at an average of 6 applications per year, compared with 4 applications per year for the time period 1979–1997.

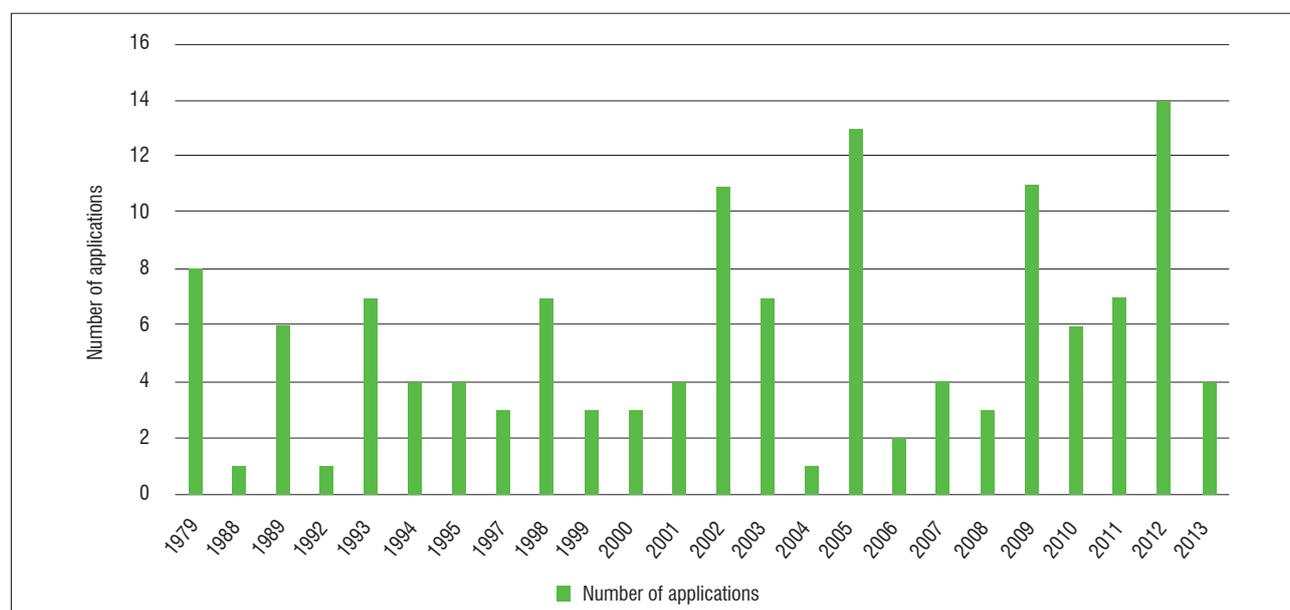


Figure 1: Annual applications for PBRs for wheat varietal improvements from 1979 to 2013, compiled from *Plant Variety Journals*.

In recent years, the numbers of wheat variety PBRs have substantially increased, compared with the past. From the results, the liberalisation of the wheat sector can be argued to have opened competition in wheat varietal improvements and stimulated increases in applications for PBRs on wheat varietal innovations. Further analysis by time period before and after the establishment of the ARC-SGI shows that only 15 applications for PBRs for wheat varietal innovations were lodged before 1991. The rest of the applications for wheat varietal innovation PBRs (89%) were lodged after the ARC-SGI was established, from 1992 to 2013. The rate of applications was six per year after the establishment of the ARC-SGI, compared with five applications per year before the ARC-SGI was established. The decreasing funding for agricultural research might be contributing to the ARC-SGI seeking revenue from their research outputs.

Figure 2 presents an analysis of the wheat varietal improvement PBRs applications, grants and lags. Panel (a) plots PBRs applications and grants

in each year, while panel (b) tracks the lag in days between the application and grant dates of each PBR that was eventually granted a certificate. The average time of waiting between application and granting of protection was around 336 days for the overall period of study. Analysis of the grant lags by pre- and post-deregulation time periods indicates that before 1997 (pre-deregulation period) the grant lag was 451 days and this reduced to 374 days in the post-deregulation period. When the application process starts, the sample seeds and application papers are taken and inspected before being sent for trials at ARC. If the variety is found to be distinct, uniform and stable for two seasons, the variety is then granted the PBRs. This means that the processes would take at least 300 days for PBRs to be granted. If the trials are unstable, more trials may be required and the process would take longer until all the irregularities are checked and rectified (De Bruyn E 2015, Oral communication, Aug 24).

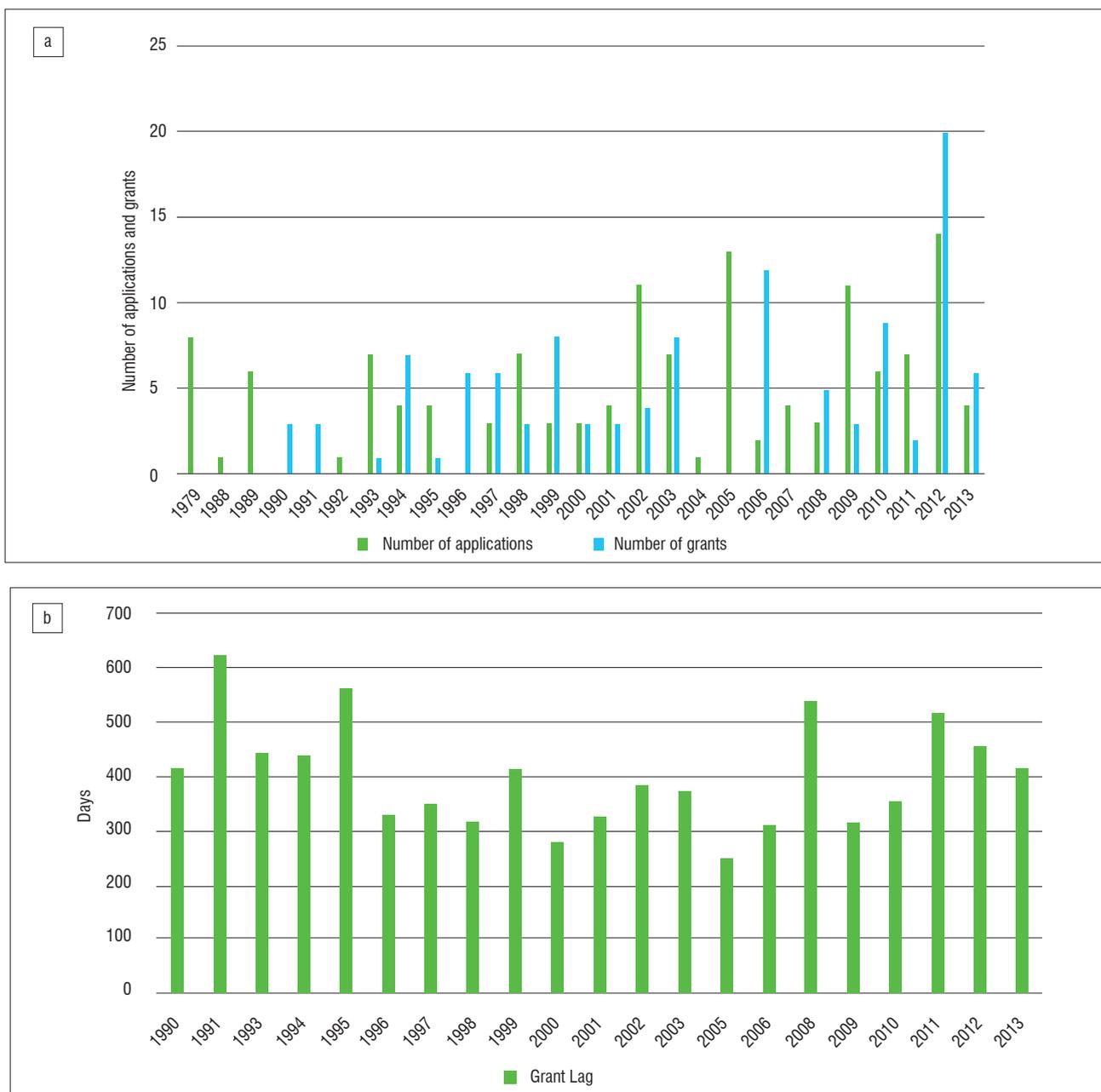


Figure 2: (a) Applications, grants and (b) grant lags in obtaining plant breeders' rights for wheat varietal improvements from 1979 to 2013 compiled from data in South African Plant Variety Journals.

Pardey et al<sup>7</sup> argued that administrative delays substantially lengthened the lags in the processing of applications. The grant lags (of about 300 days) were shorter after the abolishment of the Wheat Board in 1997, as well as after the establishment of the ARC-SGI. This can be considered to be efficient in comparison with the USA, where the average grant lag ranged from 500 days to 1449 days.

The plant variety rights applications can at any time be: granted; abandoned or withdrawn by the applicant; deemed ineligible – such as in cases of incomplete applications; denied by the office; or still pending examination.<sup>7</sup> In the South African context, applications for PBRs may be (a) granted if they meet the required standard by DAFF, (b) surrendered if there is need to do so if the applicant no longer needs protection and also after the completion of the right to be protected – 20 years in the case of wheat, (c) rejected if the application is incomplete and does not meet the required standards, and (d) terminated if the Registrar deems it necessary as in the event of certain irregularities (De Bruyn E 2013, oral communication, Jan 22).

**Table 1:** Changing disposition of plant breeders' rights applications compiled from data in South African Plant Variety Journals

Year	Number of wheat varietal PBR applications			
	Surrendered	Deleted	Rejected	Granted
1990	1	–	2	3
1991	2	2	–	3
1993	–	1	–	1
1994	4	3	–	7
1995	–	–	–	1
1996	3	2	–	6
1997	3	2	–	6
1998	1	1	–	3
1999	1	2	–	8
2000	1	–	–	3
2001	1	–	–	3
2002	1	1	–	4
2003	2	1	–	8
2006	3	–	–	12
2008	2	–	1	5
2009	1	–	–	3
2010	1	–	–	9
2011	–	–	–	2
2012	5	–	–	20
2013	1	–	–	6
<b>Total</b>	<b>33</b>	<b>15</b>	<b>3</b>	<b>113</b>

Table 1 shows the changing status of wheat varietal improvement PBRs, over time. For the period under review, 113 wheat variety rights applications were lodged between 1990 and 2013 and were granted, while 33 of the applications were surrendered, and 15 were deleted. The results show that only 3 cases were rejected from 1990 to 2013. Analysis of the granted PBRs for wheat varietal innovations by decade shows an average grant rate of 4 PBRs/year; 5 PBRs/year and 9 PBRs/year for the periods

1990–1999, 2000–2009 and 2010–2013, respectively. Further analysis by pre- and post-deregulation of the wheat sector shows that the grant rate increased from 4 grants/year before abolishment of the Wheat Board to an average of 7 grants/year from 1998 to 2013. In addition, from 2003 to 2013, the number of granted PBRs for wheat varietal improvements was relatively high, compared with other years, and the highest number was recorded in 2012 (20 PBRs were granted). The results indicate that plant breeders are increasingly seeking protection for their innovations.

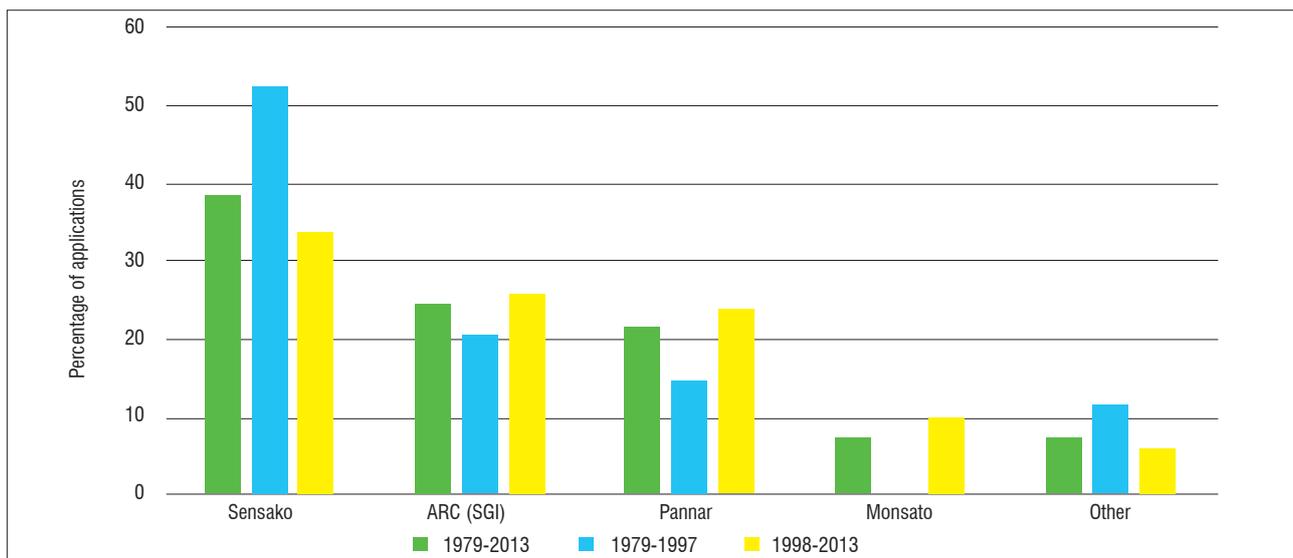
#### Applicants for wheat varietal plant breeders' rights

This section analyses the composition of applicants seeking PBRs for wheat varietal improvements from 1979 to 2013 with the focus on identifying the changing public and private roles among the applicants. Figure 3 presents the composition of applicants for PBRs for wheat varietal improvements from 1979 to 2013. Based on analysis of share of PBRs for wheat varietal improvements since the publication of the *South African Plant Variety Journal* in 1979, the main applicants were Sensako (39%), ARC-SGI (25%) and Pannar (15%). Before 1997, the share of applications from Sensako constituted 53% of all the applications, while that of the ARC-SGI was 21%, and Pannar had 15%. Other applicants, such as CIMMYT, University of Free State, Carnia Seeds, Cargill USA and Gwk Beperk, constituted 12% of the applications. Analysis of the period after the abolishment of the Wheat Board shows that Sensako's share decreased to 34%, while those of the ARC-SGI (26%) and Pannar (24%) increased by 5% and 9%, respectively. The share of applications and grants held by the ARC-SGI is comparable to other countries. In the Netherlands, Louwaars et al.<sup>3</sup> found that the public sector (universities, government bodies and private non-profit organisations) submitted 23.8% of plant-based patents, while in the USA, public bodies were granted 21.9% of the patents. Furthermore, private companies dominated the number of plant-based patents granted in the country.<sup>3</sup>

In many developing countries, national agricultural research systems, such as the ARC-SGI and Consultative Group on International Agricultural Research Institutions (CGIARs), dominate agricultural research, including varietal improvements. The development of new varieties is driven by the exchange of plant varieties and genetic resources between the national agricultural research systems and CGIAR institutions, unencumbered by IPRs.<sup>5</sup> In this case, ownership of IPRs was irrelevant to plant breeding and for accessing plant genetic resources from other countries.<sup>16,5</sup> Similarly, the ARC-SGI did not previously apply for PBRs, despite being actively involved with wheat varietal improvements. However, since the abolishment of the Wheat Board in 1997, the ARC-SGI increased their share of PBRs lodged by 5% to 26%, with most of the applications being made in recent years. It might be that the reduced funding for the ARC-SGI contributed to the institution seeking protection for its varieties as a way to generate additional revenue.

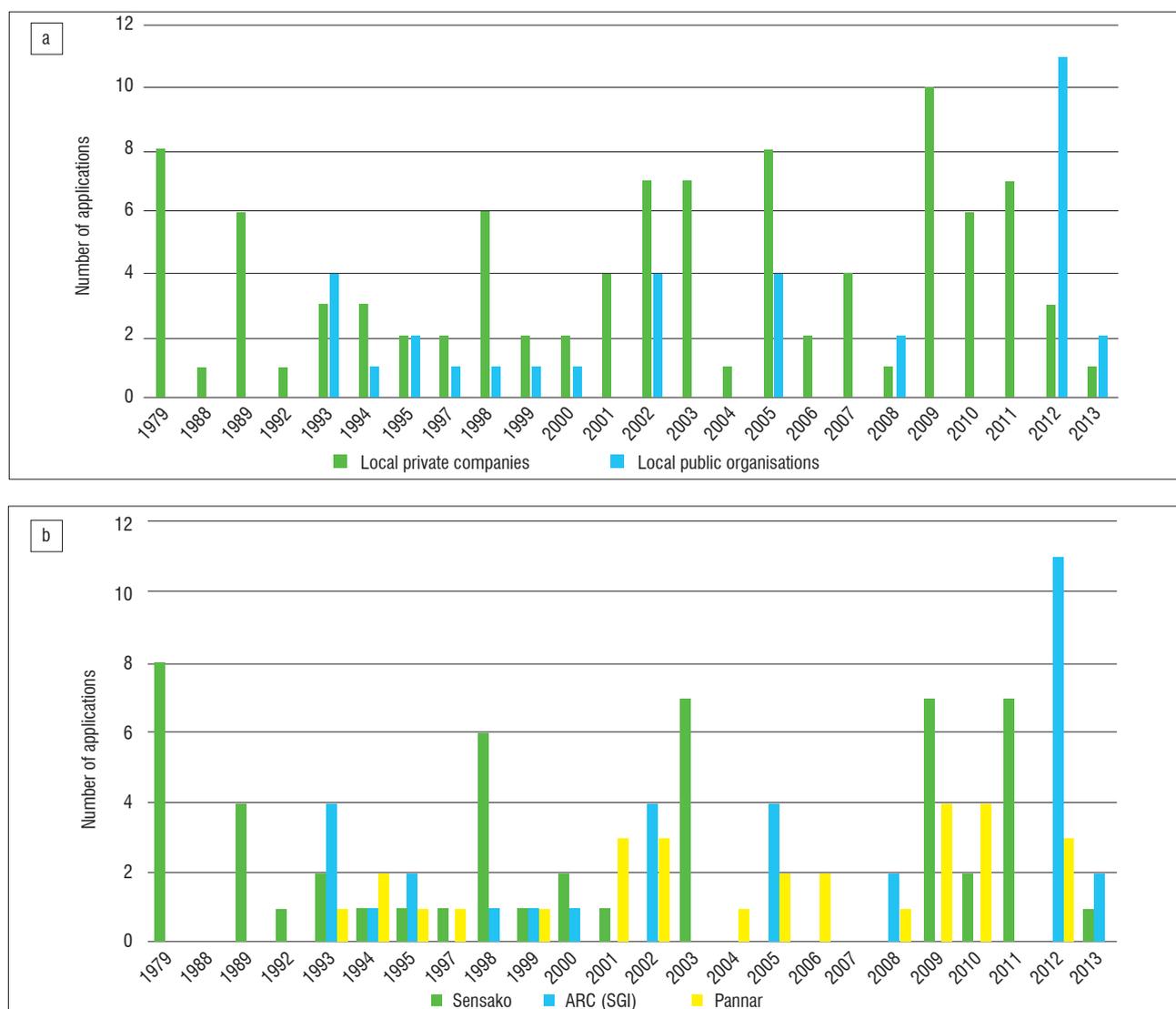
Figure 4 presents the changing composition of applicants for wheat PBRs. The majority of the applications for wheat varietal improvements were filed by private companies (Figure 4a), the two main actors being Sensako and Pannar (Figure 4b). Pardey et al.<sup>8</sup> found that the private sector constituted the largest share in the USA, accounting for 82% of total plant varietal rights, while the share of varietal rights owned by public entities (e.g. US and foreign universities, research foundations and government agencies) was very small, considering the high volume of research they perform. In the South African wheat sector, the public sector, especially the ARC SGI, continues to play a major role in the development of wheat varieties and has PBRs from wheat varietal improvements. Before the establishment of the ARC in 1991, the public sector made no applications for PBRs for wheat variety improvements, but since its establishment, the public sector applications for wheat variety PBRs drastically increased, with 4 applications in 1993, 4 in 2002, 2 in 2005 and 11 in 2012. The public sector made the largest number of wheat variety PBR applications (11) in 2012, compared with 3 from private companies in the same year.

It is important to note that public and private sector institutions freely exchanged plant genetic resources and breeding lines before the advent of IPRs.<sup>5</sup> Public sector institutions used to develop basic breeding lines and made them available for the development of 'finished products' by the private sector. The advent of PVP/IPRs considerably restricted the exchange of plant genetic resources and



ARC-SGI, Agricultural Research Council Small Grains Institute

Figure 3: The structure of applicants for plant breeders' rights for wheat from 1979 to 2013, compiled from data in *South African Plant Variety Journals*.



ARC-SGI, Agricultural Research Council Small Grains Institute

Figure 4: Applications for plant breeders' rights for (a) wheat by private vs public organisations and for (b) wheat made by the main role players from 1979 to 2013, compiled from data in *South African Plant Variety Journals*.

breeding lines between the public and private research institutions.<sup>20</sup> With this background, it can be argued that the ARC-SGI has largely contributed to some of the PBRs owned by private companies through shared genetic resources made available before the PVP/IPRs were implemented.

### *Implications of wheat plant variety protection trends for the Agricultural Research Council*

PBRs are the predominant intellectual asset of the ARC.<sup>17</sup> Other forms of ARC intellectual assets include patents, copyrights (publications), trademarks, trade secrets and expertise. *The South African Intellectual Property Rights from Publicly Financed Research and Development Act No. 51 of 2008* prescribes that publicly funded research and development must be protected, utilised and commercialised. This is to ensure that: it benefits the people of South Africa; recipients of public funding act in a manner conducive to the public good; it acknowledges and rewards innovation; it enables economic growth through enterprise development; and it allows publishing of scientific results.<sup>17</sup> The challenge for public institutions like the ARC-SGI is that, traditionally, their research outputs have been in the public domain and the public sector had to ensure the widest dissemination of innovations.<sup>5,15</sup> Efforts to make public research institutions, such as the ARC-SGI, generate revenue by holding IPRs on plant varieties requires some exclusive licensing, such as is done by US Land Grant Universities.<sup>5</sup> According to Srinivasan<sup>5</sup>, PVP/IPRs ownership by the public sector discourages exchanges of plant genetic resources and development of follow-on varieties. In addition, if exclusive rights are granted to larger companies, small businesses relying on public varieties (or varieties derived from public varieties) would be forced out of business. This would affect the development of the domestic wheat seed sector and create monopolies by big private companies. Concentration of ownership of plant variety rights in a few companies discourages follow-on innovations by other firms and researchers.<sup>5</sup>

The major role played by the ARC-SGI is supported by evidence from around the world indicating that plant-breeding innovations in non-hybrid crops like wheat have largely been sustained by the public sector. For example, Srinivasan<sup>5</sup> found that in cases where the public sector has played a major role in plant breeding, the overall concentration in ownership of plant variety rights was lower, particularly for non-hybrid crops which are less attractive to private sector investment. In addition, Eaton et al.<sup>12</sup> argue that although plant variety protection is expected to stimulate investments in plant breeding, for national agricultural research institutes (NARIs), PVP may address three objectives which are not always compatible: revenue collection, recognition of achievement and technology transfer. Their study found no evidence of potential revenue generation from plant breeding at national agricultural research institutes in Colombia and Uganda. In addition, one of the challenges for NARIs is to retain control of the plant breeding skills and resources for commercially important crops. For example, evidence from India and Kenya showed that the development of the private sector resulted in experienced NARI staff being hired into the private sector, making it difficult for the NARI to retain plant breeding staff and resources.

This implies that although the ARC-SGI is expected to generate revenue to sustain their activities, the concentration of potential revenue generation activities in more commercial crops brings into question public research resource allocations. Public research institutions would still be required to engage in research and plant breeding for mandated crops, such as staples, which might not be very lucrative compared with commercial crops. Such investments would have to be funded by public agricultural expenditures and other sources, making it difficult for NARIs such as the ARC-SGI to focus on revenue generation in their plant breeding activities. Also, the ARC-SGI faces competition from private companies, including in retaining its breeding skills and resources.

## Conclusions and recommendations

This paper analysed the evolving landscape of wheat plant breeders' rights to address the dearth of empirical evidence on the patterns and trends of wheat varietal improvements in South Africa. The aim was to provide evidence on the evolution of varietal rights; the extent of varietal

rights granted; changes of the rights on offer over time; changing ownership of the rights (including comparison between public and private, as well as domestic and foreign breeders) and; impacts of plant variety protection on wheat varietal development. The study compiled a detailed and novel count and attribute database of wheat varietal innovations in South Africa from 1979 to 2013, using information from the *South African Plant Variety Journal*, DAFF, South African National Library, and the ARC. The empirical analyses were based on descriptive statistics, trend analysis and graphical representation of trends and ownership of PBRs for wheat varietal improvements.

A total of 134 PBRs for wheat varietal innovations were lodged from 1979 to 2013, giving an average of 6 applications per year. This might have been driven by some breeders choosing not to apply for varietal protection, as well as by natural triggers such as outbreaks of pests and diseases, and different environmental and climatic conditions. The results indicate that plant breeders are increasingly seeking protection for their innovations. The number of PBR applications and grants for wheat variety innovations increased after the abolishment of the Wheat Board (6 applications per year compared with 4 per year before deregulation). The results also indicate that the administrative delays in granting PBR applications have been substantially reduced (by 77 days) post-deregulation, signifying increased efficiency in the processing of PBRs.

Since the publication of the *South African Plant Variety Journal* in 1979, the main applicants for wheat PVP have been Sensako (39%), ARC-SGI (25%) and Pannar (15%). After deregulation, Sensako's share decreased to 34%, while those of the ARC-SGI and Pannar increased by 5% and 9%, respectively. The results show that the ARC-SGI faces stiff competition from these well-established private companies. Establishing opportunities for collaboration with the private sector would encourage wheat variety innovation development. The advent of PVP/IPRs considerably restricted the exchange of plant genetic resources and breeding lines between the public and private research institutions. The ARC-SGI contributed to some of the PBRs owned by private companies through shared genetic resources made available before the PVP/IPRs were implemented. Future innovations and dissemination of wheat innovations could be stimulated by plant variety protection, together with the broader variety sector legislation that encourages both public and private sector investment.

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## Authors' contributions

C.R.N. conceptualised the article content and compiled the first draft. F.G.L. and J.K. revised and made conceptual contributions, additions, and refined the article.

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