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Understanding the Economic Impact of Plant Breeder's Rights in Australia

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EXECUTIVE SUMMARY

This report was commissioned by IP Australia to provide more information on the economic circumstances of Plant Breeder's Rights (PBR) including the rates of commercialisation of new plant varieties as well as the costs incurred by users in obtaining a PBR. The descriptive analysis is based on a representative survey of 130 PBR registering Australian organisations from a population of 350 such entities (with 220 either unwilling or unable to be surveyed).

We found that the average cost of pursuing a PBR (including IP Australia fees, growing trials, employee wages, legal and Qualified Person costs and overheads) was approximately \$25,000. Broadacre and forage crop sectors reported the highest mean costs; however, reported costs across all sectors ranged from \$1,000 to \$300,000. The cost of growing trials is reported to be the biggest component of this cost. By comparison, respondents report investing an average of \$507,000 and 7.3 years on breeding and development. Accordingly, the cost of pursuing a PBR was, on average, only 5.1 per cent of the full cost of breeding a commercially-ready variety. Varieties in the last 5 year that had had some PBR protection, had an average estimated revenue of \$793,000, with this figure likely representing their partial commercial life as many varieties are still being sold commercially. Although the difference in averages is not large, the difference in the weighted average (by the value of the sector) gives a different result.

Ninety-six per cent of varieties with some PBR had been commercialised, however 74 per cent of commercial-ready varieties without PBR had also been commercialised. Having some PBR protection was not associated with higher rates of earned revenue or lower rates of perceived unauthorised use. The reason for this is some varieties that were never the subject of a PBR application have been highly valuable in terms of quality of the variety and the earned revenue (they may have had intellectual property protection in other countries, despite not having PBR protection in Australia or were too similar to other varieties on the market to apply).

One in four PBR surveyed varieties were thought to have been used without authorisation. This suggests an unauthorised use rate similar to patents (28 per cent) (Weatherall and Webster 2010). Only 5 per cent of respondents who had experienced unauthorised use had gone on to pursue legal action, with 60 per cent of respondents reporting no reaction. Varieties that were associated with perceived unauthorised use were also more likely to have alternative forms of protection such as legal contracts or trade marks.

Thirty-eight per cent of respondents indicated that they fund ongoing breeding activities principally by reinvesting revenue earned through plant breeding – such as end-point royalties. A further 43 per cent principally fund their breeding via other operational revenue.



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INTRODUCTION

The Plant Breeder's Rights (PBR) system supports Australian agricultural and horticultural sectors by giving breeders of new varieties monopoly rights over their commercialisation. By enabling breeders to realise a return on the investment required to develop new plant varieties, PBR encourages innovation in plant breeding. This can help in the development of new plants with beneficial traits such as greater productivity, attractiveness, disease resistance and climate tolerance.

In 2022, as part of their PBR Reform Program, IP Australia commissioned Swinburne University of Technology to assess the economic impact of PBR in Australia. In the accompanying report, Swinburne estimated that PBR contributes approximately \$90 million annually to the Australian economy and encourages breeding activity by being responsible for approximately 50 per cent of historical productivity improvements in food and fodder plants.

For continued productivity of Australia's agriculture and horticultural sectors – especially in the face of a changing climate – innovative breeders should be appropriately supported. This means understanding the cost-benefit proposition offered by the PBR system.

This report builds on the initial economic impact assessment, presenting an analysis of the costs and economic benefits of PBR based on a survey of Australia's PBR-using organisations conducted between October 2022 and February 2023.

The goals of this survey were:

- To assess the costs associated with obtaining a PBR;
- To understand the importance of PBR in the commercialisation of new plant varieties; and
- To investigate how the PBR system impacts incentives to invest and innovate in plant breeding.

The survey was divided into two sections: questions pertaining to the respondent's overall experience in plant breeding, and with PBR; and questions about specific plant varieties with which the respondent had been involved.¹

Varieties were classified as having a PBR status of:

- Granted, terminated, expired (i.e., in which the variety was at some stage under full PBR protection) or accepted (i.e., currently with provisional PBR protection)
- Withdrawn, rejected (i.e., in which an application was received but never accepted) or refused (i.e., in which an application was accepted, but variety never had full PBR protection)
- A variety which the respondent took to market but for which no PBR application was ever made.

These points are addressed in Sections II-IV of this report.

¹ i.e., for varieties from the PBR register, where they are recorded as variety applicant or agent



I: SURVEY RESPONDENTS

This report is based on a survey which attempted to contact all the unique Australian organisations recorded as either a PBR applicant or PBR agent (for details see Appendix A).^{2,3} Responses were received from 130 PBR applicants and agents which represented 37 per cent of the estimated population of 350 currently active Australian PBR-using organisations.⁴ Respondents comprised 106 PBR applicants and 24 PBR agents. Ten per cent indicated that their variety was sourced from a foreign partner.

These 130 organisations have been responsible for a total historic count of 2,099 unique PBR applications. This is approximately two thirds of the 3,283 PBR applications filed by Australian organisations since the inception of the PBR system in 1988⁵, giving confidence that survey responses reflect a good cross-section of the PBR user experience.⁶ Twenty-two of these 130 organisations had not had a PBR granted in the previous 5 years.

An organisation's sector was determined by mapping a varieties plant genus/species with the category of agricultural, horticultural, or other commodity in which that plant type is most typically used.⁷ The sector categories used are given in our previous research. The sector in which an organisation most frequently applies for PBR protection is presumed to be their major operating industry.

² Private individual applicants were excluded from the target survey population for a combination of analytical and practical reasons. First, previous analysis has shown that Australian individual applicants are less prolific users of the PBR system than Australian organisational applicants. Using the country and applicant type classifications from IPGOD, we found that individuals have been responsible for only 27 per cent of historical PBR applications from Australian entities, and that these individuals submit only 2.4 applications each on average, compared to an average 4.9 applications per Australian organisation. They are also less likely to have "active" (i.e., granted or accepted) PBR applications (these make up only 32 per cent of applications from AU individuals, versus 61 per cent of applications from Australian organisations), so may be less likely to remain active and able to be reached. Further, the significant challenges of locating contact details for private individuals made pursuing this minority applicant pool a less efficient approach than simply concentrating on organisational applicants. Finally, we observed that many of the most prolific individual PBR applicants were already being targeted as survey respondents, having been identified as the relevant representative for one or more organisational applicants.

³ The PBR applicant, or "title holder" is the entity holding a variety's PBR, and typically the developer of the variety. PBR agents may play a range of roles, but may help develop, propagate, and/or commercialise a variety, as well as undertaking PBR administration on behalf of the applicant.

⁴ We tried to reach all respondents who had ever used the system and can be reached on an active phone line or having other definite indications of being active. Our questions only related to the previous 5 years.

⁵ Or 20 per cent of the total historical PBR applications. These counts are as indicated by the country_code and party_type variables in the reference database, IP Australia's IP Government Open Data (IPGOD 2020), available at <https://data.gov.au/data/dataset/ipgod2020>.

⁶ There have been about 10,000 total PBR applications to IP Australia, the remainder were from individuals (about 1,200) and foreigners (about 6,000).

⁷ We refer the reader to the full discussion in Hegarty et al. (2022) for details of this mapping and its limitations.



II: COST OF PURSUING A PBR

Total cost of pursuing a PBR application (excluding breeding and development costs)

All respondents were asked:

- “What would you estimate as the typical cost of pursuing a PBR application? As well as the IP Australia fees, think about what you spend on growing trials, employee wages, legal or Qualified Person fees, overheads and other costs”.

This estimate excluded breeding and development costs.

As shown in Table 1, the mean reported cost of pursuing a PBR across all sectors was \$25,675 (\pm \$5,001), with a median of \$10,000. The highest mean costs were reported in forage crops (\$68,571 \pm \$39,077, with a median of \$30,000), followed by broadacre crops (\$32,786 \pm \$16,177, with a median of \$10,000). Other sectors reported a mean cost of between \$15,000 and \$20,000, and median of \$9,000 or \$10,000.

Overall, reported costs of pursuing a PBR are reasonably consistent across sectors. Similarly, there is little relationship between the dispersion of costs and “share of organisation’s activity devoted to plant breeding in the organisation”, as shown in Table 2.

Table 1: Reported costs of pursuing a PBR application*, by sector

Sector	N	Mean cost (\$)	Error (\$)	Min cost (\$)	Max cost (\$)	Median (\$)
Broadacre crops	14	32,786	16,177	2,000	225,000	10,000
Forage crops	7	68,571	39,077	10,000	300,000	30,000
Fruit and nuts	16	18,781	5,239	3,000	75,000	10,000
Nurseries	43	19,935	4,644	1,000	100,000	10,000
Vegetables [†]	4	15,000	8,505	2,000	40,000	9,000
Overall	84	25,675	5,001	1,000	300,000	10,000

Note: There were 130 respondents surveyed but 84 respondents answered this question.

[†] Small sample size indicates the value may not be representative of the sector.

* Includes IP Australia fees, growing trials, employee wages, legal and Qualified Person costs and overheads.

Table 2: Reported costs of pursuing a PBR application*, by share of activity devoted to breeding

Share of activity devoted to breeding	N	Mean cost (\$)	Error (\$)	Min cost (\$)	Max cost (\$)	Median (\$)
All	12	48,917	24,981	2,000	300,000	10,000
Most	2	14,000	6,000	8,000	20,000	14,000
About half	13	19,215	7,872	3,000	100,000	10,000
A minority	40	28,398	6,687	1,000	225,000	12,000
None	17	9,176	1,052	2,000	20,000	9,000
Overall	82	19,899	319	1,000	100,000	10,000

Note: There were 130 respondents surveyed but 84 respondents answered this question.

* Includes IP Australia fees, growing trials, employee wages, legal and Qualified Person costs and overheads.

Many respondents were able to provide clear reasoning for their estimates, others – most often, but not exclusively, smaller operators – were less confident, and often much less able to identify and estimate overhead costs. Perhaps unsurprisingly, those (N=8) who explicitly indicated that their PBR is handled by another party (such as an agent, partner, or accountant) were often unable to provide an estimate of the costs.

Twenty-three respondents were not able to make any estimate of the cost of PBR. Several of these reported that the cost is “too complicated” to estimate, whereas others indicated that they do not treat PBR-related expenses as separate budget items, but simply subsume the costs into their overall operational budget. These comments were associated with small and large organisations alike, suggesting a widespread uncertainty around the cost of PBR.

Some respondents clearly underestimate the overall cost of pursuing a PBR application, estimating it at \$2,000 or less; figures which fail to cover even the cost (~\$2,300) of the standard application and examination fees, let alone additional overheads. In fact, despite being instructed to take all overheads into account, several respondents made remarks explicitly downplaying their overheads, particularly around staffing: saying, for example, that “the cost is negligible since I do it myself”, “we just do it after hours”, “we have no QP costs because one of our staff members is a QP”, or that “we rely heavily on goodwill and free labour”.

It is less clear whether any respondents overestimate the costs of PBR. There were two outlier respondents who reported PBR costs more than \$200,000 – one in broadacre crops and one in forage crops. Both reports come from well-established larger organisations and were submitted via the digital version of the survey, rather than over the telephone. This may mean that these respondents are likely to have access to robust budget records, and to have had the time to review them before responding, so we did not discard these data points.

Finally, we note that several respondents commented that economies of scale apply when there was more than one variety under PBR consideration at a time. This may be more likely to apply to breeding-intensive organisations.

Costliest items in PBR application process

Respondents were asked:

- “Which aspect of the PBR application and examination project is typically most costly to your business?”.

This was a multi-choice question, with four options offered, as well as an option for “other”. The count of responses received for each of these options, broken down by sector, are reported in Table 3.

Although growing trials are consistently rated as the costliest part of the PBR process, a non-negligible proportion of the community find IP Australia’s fees the most significant part of PBR – especially in the nurseries sector.

Table 3: Breakdown of reported costliest aspect of PBR, by sector

Sector	Cost of growing trials*	IPA fees	QP fees	Legal advice	Other	Did not answer/ know
Broadacre crops	12	3	0	1	1	3
Forage crops	7	1	2	0	0	1
Fruit and nuts	11	3	3	2	0	5
Nurseries	19	19	8	1	9	18
Vegetables†	2	0	0	1	1	1
All sectors	51	26	13	5	11	28

Note: There were 130 respondents surveyed but 51 respondents answered this question.

* Small sample size indicates the value may not be representative of the sector.

† There is no data on what proportion of applications (in the sample population) required a growing trial. A growing trial is not required if there is sufficient data from comparable distinctiveness tests for other IP offices.

Respondent comments indicated a link between plant growth periods and the cost of growing trials; varieties for which several generations can be produced within a short period can be trialed quickly, efficiently, and often space- and resource-effectively. With such plants often ornamental varieties, this may partially account for the lower proportion of respondents in the nurseries sector who reported growing trials as their most significant cost.

We also assessed the costliest aspect of the PBR process by degree of involvement in plant breeding. For all levels of breeding intensiveness, the cost of growing trials was the most significant, followed by IP Australia's fees. This is shown in Table 4 and is in accordance with findings by sector.

These figures also accord with comments from respondents, where growing trials and administrative fees were the first and second most mentioned issues, respectively. Other items which respondents described as particularly costly were the cost (in money and time) of quarantine when bringing candidate varieties and/or comparators in from overseas, and the cumulative cost of yearly PBR renewal fees.

Table 4: Breakdown of reported costliest aspect of PBR, by activity devoted to plant breeding

Org. activity devoted to plant breeding	Cost of growing trials*	IPA fees	QP fees	Legal advice	Other	Did not answer/ know
All	8	2	0	0	0	5
Most	3	0	0	0	0	0
About half	7	5	3	0	1	0
A minority	25	12	8	3	4	11
None	8	5	2	2	3	11
Overall	51	24	13	5	8	27

Note: There were 130 respondents surveyed but 51 respondents answered this question.

* There is no data on what proportion of applications (in the sample population) required a growing trial. A growing trial is not required if there is sufficient data from comparable distinctiveness tests from other IP offices.

Development costs

We emphasise that the preceding discussion in this section has focused on the standalone costs of the PBR application and examination process. These are distinct from, and additional to, the costs organisations incur in the process of developing new varieties. However, it is helpful to contextualise the cost of pursuing PBR protection over a new variety by understanding how it compares to the costs incurred in developing that variety.

Respondents were asked to indicate:

- *“In years, how long does it typically take you to develop a new variety? Try to think from the very start of the development process until the variety is commercial-ready”;*⁸ and
- *“In total, how much does it typically cost you to develop a new variety? Again, try to think from the very start of the development process until the variety is commercial-ready - and remember to include employee wages and overheads”.*

Variety development can look very different across different sectors and different plant species. As a one-size fits all definition of the development period, we assumed the breeding/development time to be the time elapsed from the very start of the breeding/development process until the time the variety is a viable “commercial candidate”. However, we note that it can be challenging to define the beginning of development for a single variety within an overall breeding program.

Table 5 summarises responses to these questions, broken down by sector. The mean time taken to develop a new variety was the lowest in the nursery sector, at 5.7 years, and highest in the forage crop sector at 9.8 years. The overall mean time investment is 7.3 years. Table 6 shows, the typical total cost is also lowest in nurseries at \$103,593 – less than ten per cent of the \$1,254,167 typical cost in broadacre. The overall mean cost of developing a new variety is \$507,478.

⁸ This measured the time from the very start of the development process until the variety is “commercial-ready”. This is probably most similar to “until the time of PBR application”; since commercialisation and application would be expected to be reasonably close in time (or required to be, if commercialisation comes first). PBR-specific language has purposefully been left out of this question to allow for non-PBR'd varieties.

Table 5: Reported typical time taken to develop a new variety, by sector

Sector	N	Mean (years)	Error (years)	Min (years)	Max (years)	Median (years)
Broadacre crops	20	8.5	0.46	5.0	12.0	8.5
Forage crops	19	9.8	1.62	3.0	25.0	7.0
Fruit and nuts	10	9.2	0.29	7.5	10.0	9.3
Nurseries	55	5.7	0.52	0.0	20.0	5.0
Vegetables [†]	3	6.7	0.88	5.0	8.0	7.0
All sectors	107	7.3	0.43	0.0	25.0	6.5

Note: There were 130 respondents surveyed but 107 respondents answered this question.

[†] Small sample size indicates the value may not be representative of the sector.

Table 6: Reported typical cost incurred to develop a new variety, by sector

Sector	N	Mean (\$)	Error (\$)	Min (\$)	Max (\$)	Median (\$)	PBR cost as % of mean
Broadacre crops	12	1,254,167	316,375	100,000	4,000,000	1,000,000	2.6
Forage crops	14	922,964	566,541	-	8,000,000	23,500	2.0
Fruit and nuts	8	1,010,000	390,063	55,000	3,500,000	937,500	6.9
Nurseries	45	103,593	35,625	-	1,000,000	10,000	19.2
Vegetables [†]	3	300,000	180,278	50,000	650,000	200,000	5.0
Overall	82	507,478	123,591	50,000	8,000,000	50,000	5.1

Note: There were 130 respondents surveyed but 82 respondents answered this question.

[†] Small sample size indicates the value may not be representative of the sector.

The final column of Table 6 reports the costs of pursuing PBR protection (from Table 1) as a proportion of the total costs of developing a variety. It shows that the median cost for forage crops and nurseries was much smaller than the mean. This indicates that the mean cost was skewed by a few very costly varieties. Overall, the costs of pursuing PBR was 5.1 per cent of the cost of developing a variety. However, a distinct difference by sector is evident: the proportional cost of PBR is as low as 2.0 per cent in the forage crop sector, and as high as 19.2 per cent in the nurseries sector.



III: IMPORTANCE OF PBR IN COMMERCIALISATION

Overall commercialisation and PBR behaviours

To establish a baseline understanding of how commercialisation and PBR behaviour interact, we asked respondents to indicate:

- *“How many varieties they had released commercially in their last 5 years of activity, and what proportion they had submitted as an application for PBR (but not necessarily been accepted)”*
- *“How many of their commercial-ready varieties had failed to go to market, and what proportion of these they had been the subject of an application for PBR”.*

Using these recalled experiences, we constructed tables of the numbers of varieties with and without PBR and whether the organisation took the variety to market (i.e. commercialised). Table 7 shows that 96 per cent of varieties with some PBR were commercialised compared with 74 per cent of those that had never been the subject of a PBR application.

Similar proportions were found across all sectors. According to Table 8, at least 98 per cent of the PBR varieties in broadacre crops, forage crops and nurseries had been commercialised. Vegetables was the lowest sector at 73 per cent. However, 74 per cent of varieties without a PBR application had been commercialised. Nurseries had the greatest number of varieties that were not subject to a PBR application, but 78 per cent of these had been commercialised.

Together Tables 7 and 8 indicate that commercialisation is less tightly coupled to PBR than might be anticipated. We note that our previous research has suggested that PBR is likely to have most importance in open-pollinated broadacre crops.

According to Table 7, 546 commercial-ready varieties had been developed but not taken to market. Of these, only 29 were the subject of a PBR application. The main reason for not releasing a variety commercially was that the variety was not deemed competitive in the marketplace by the respondent (42 per cent commercial-ready). This was followed by a perception that the market was either unsuitable or too small (18 per cent). Eight per cent of responses related to PBR factors (either not PBR-eligible 5 per cent or cost-benefit of enforcement 3 per cent). A breakdown of all reasons for not pursuing PBR is outlined in Table 9.

Table 7: Commercialisation rate for varieties with and without PBR, last 5 years

	Commericalised		Not Commericalised		Total	
	(N)	(%)	(N)	(%)	(N)	(%)
Applied PBR	772	96	29	4	801	100
Not apply PBR	1483	74	517	26	2002	100
Total	2255	81	546	19	2801	100

Note: Based on 130 respondents' best guestimates. Totals may not be exact due to rounding errors.

Table 8: Commercialisation rate for varieties with and without PBR, by sector

Sector	PBR status	Commericalised		Not Commericalised		Total	
		(N)	(%)	(N)	(%)	(N)	(%)
Broadacre crops	Applied PBR	332	98	8	2	340	100
	Not apply PBR	66	38	109	62	175	100
Forage crops	Applied PBR	55	100	0	0	55	100
	Not apply PBR	20	63	12	38	32	100
Fruit and nuts	Applied PBR	88	89	11	11	99	100
	Not apply PBR	9	56	7	44	16	100
Nurseries	Applied PBR	289	98	7	2	296	100
	Not apply PBR	1387	78	387	22	1774	100
Vegetables [†]	Applied PBR	8	73	3	27	11	100
	Not apply PBR	2	50	2	50	4	100
All sectors	Applied PBR	772	96	29	4	801	100
	Not apply PBR	1483	74	517	26	2000	100

Note: Based on 130 respondents' best guestimates. Totals may not be exact due to rounding errors.

[†] Small sample size indicates the value may not be representative of the sector.

Table 9: Reason commercial-ready varieties were not released commercially

Reasons	%
Variety was not competitive	42
Market unsuitable/ too small	18
Inherent problem or consideration specific to plant	8
Marketing considerations or difficulties	6
Lack of resources to do so (e.g. staffing, funding)	6
Not PBR-eligible	5
Avoid competing with respondent's other varieties	5
Other internal commercial considerations	5
Fear or uncertainty	3
Cost-benefit analysis of PBR and/or enforcement was unfavourable	3

Nurseries were the most prolific breeders with an average of 25.4 new varieties in the past 5 years. According to Table 10 the maximum number of varieties per nursery organisation was 350. Vegetable organisations were the least prolific with only 2.0 varieties per organisation and a maximum of 5 varieties in 5 years.

Table 10: Degree of PBR usage for commercialised varieties, by sector, last 5 years

Sector	Commercialised varieties	Varieties/ respondent	Max varieties by respondent
Broadacre crops	400	19.9	150
Forage crops	97	4.4	15
Fruit and nuts	75	6.8	30
Nurseries	1675	25.4	350
Vegetables [†]	10	2.0	5
All sectors	2255	18.2	350

Note: There were 130 respondents surveyed.

[†] Small sample size indicates the value may not be representative of the sector. This reflects the low number of Australian organisations which are deemed to be in the vegetable sector (40 as of end 2021).

Comparison of commercial outcomes by PBR status

Each respondent was asked to report on up to three specific plant varieties in the following categories:

- A variety with PBR granted, terminated, expired, (i.e., which was at least at some stage under full PBR protection) or accepted (i.e., with provisional PBR protection)
- A variety with PBR currently withdrawn, rejected, or refused (i.e., a variety which never had full PBR protection, and does not currently have PBR protection)

- A variety which the respondent took to market (the most recent within the last 5 years) but for which no PBR application was ever made.

This gave us 218 responses. The aim of this approach was to enable a comparative statistical analysis of outcomes and experiences across three scenarios: in the presence of some PBR protection, the presence of a PBR application without current protection, and the total absence of PBR.

Table 11 gives a summary of the frequency with which each status was reported, by sector, whereas the rest of this section compares commercialisation outcomes by status.

Table 11: Counts of reported varieties, by sector and PBR status

Sector	Some PBR protection (N)	PBR refused, withdrawn (N)	PBR never applied (N)	Total (N)
Broadacre crops	22	7	8	37
Forage crops	14	4	5	23
Fruit and nuts	23	9	5	37
Nurseries	57	24	34	115
Vegetables [†]	4	1	1	6
All sectors	120	45	53	218

Note: 218 varieties surveyed.

[†] Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

We investigated the characteristics of varieties that were never the subject of PBR (within the last 5 years) or were refused/withdrawn compared with varieties with PBR. We asked respondents to:

- *Rate the quality or performance of each variety compared to its competitors in the market on a scale of 1-10, with anchors being “1 - much worse than competitors”, “5 - about the same as its competitors”, and “10 - much better than its competitors”.*

Table 12 shows that on average, the respondent rated quality was highest (7.0) for varieties that were never the subject of a PBR application but lowest for those refused/withdrawn (5.5). The PBR never applied group were also more likely to have an international plant variety protection (37 per cent compared with 25 percent for those with a PBR) and to indicate that the variety was bred by another party overseas.

Table 12: Mean rated quality (out of 10) and number per variety, by sector and PBR status

Sector	Some PBR protection		PBR refused, withdrawn*		PBR never applied		Total	
		N		N		N		N
Broadacre crops	6.6	21	2.7	7	7.3	7	6.0	35
Forage crops	8.2	12	6.7	3	7.5	4	7.8	19
Fruit and nuts	7.0	20	4.4	8	6.0	5	6.2	33
Nurseries	6.3	54	6.5	21	7.1	32	6.6	107
Vegetables†	8.3	4	10	1	6.0	1	8.2	6
All sectors	6.7	111	5.5	40	7.0	49	6.6	200

Notes: There were 218 varieties surveyed but quality ratings were only given for 200 varieties.

† Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

* If the variety began selling immediately after submitting an application, it may have peaked in the market before examination and hence withdrawn.

We also directly asked respondents why they did not apply for PBR – there was no typical reason and the answers included similar to another variety on the market; the market being too small; being hybrid (an F1 hybrid cannot be used for on-breeding due to its genetics) and not being worried about infringement. The nurseries sector was most likely to indicate the cost of PBR.

We also asked respondents why they believed they were refused PBR or withdrew the application. The numbers here were small (N=11) but response centred around the variety being superseded or for market reasons.

For each variety, respondents answered the question:

- *“If you are happy to disclose, approximately how much revenue has this variety brought in, in total?”*

The mean estimated revenue from all varieties surveyed was \$718,000, but this varied by PBR status and sector. Note that as many of the varieties are still in the marketplace, this revenue should be regarded as incomplete.

As Table 13 shows, varieties, in the last 5 years that had had some PBR protection brought in the most total revenue at \$793,000 on average. This was dominated by the broadacre crops at \$2,900,000 and fruit and nuts at \$750,000.

There were some very valuable varieties that had never applied for PBR, especially in the vegetable and broadacre sectors. We investigated this group of varieties with high revenues who never applied for PBR further and found that: about a quarter bought the IP from another breeder; about half had no other forms of legal protection, nor were they hybrids.

Table 13: Mean (all years) revenue (\$) per variety and number, by sector and PBR status

Sector	Some PBR protection	N	PBR refused, withdrawn*	N	PBR never applied	N	Total	N
Broadacre crops	2,872,500	10	0	6	35,000	3	1,517,368	19
Forage crops	421,250	8	0	3	5,000	1	281,250	12
Fruit and nuts	750,333	15	32,857	7	2,838,000	4	878,346	26
Nurseries	358,760	35	20,435	20	75,093	19	194,487	74
Vegetables†	146,667	3	0	1	3,687,500	2	1,302,500	6
All sectors	793,614	71	17,262	37	698,751	29	563,862	137

Note: There were 218 varieties surveyed but revenue data was only given for 107 varieties.

† Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

* If the variety began selling immediately after submitting an application, it may have peaked in the market before examination and hence withdrawn.

Respondents were also asked about two other indicators which spoke to a variety's overall commercial success – the length of its overall commercial life, and the time taken to reach peak market share.

Table 14 reports the latter. On average, varieties where a PBR application had been refused or withdrawn took 2.8 years after they were initially released to reach their peak market share. This was slightly faster than those who had their PBR

application granted (3.8 years) but considerably faster than varieties that never applied for a PBR (5.2 years). Broadacre and forage crops tended to achieve the fastest take-up, whereas the fruit and nut crop sector saw the slowest take-up. Anecdotal remarks from respondents suggest that much of this is down to the slower maturing of trees versus ornamentals and wheat. This implied both a longer development time and longer time to be adopted by the community, since it takes a while for them to get a mature planting they can fully exploit.

Table 14: Mean years to peak market share and number per variety, by sector and PBR status

Sector	Some PBR protection	N	PBR refused, withdrawn*	N	PBR never applied	N	Total	N
Broadacre crops	3.6	13	0.3	3	2.8	5	2.9	21
Forage crops	2.7	10	3.0	1	4.1	4	3.1	15
Fruit and nuts	5.7	13	4.0	3	6.5	4	5.6	20
Nurseries	3.5	44	3.1	17	5.7	25	4.1	86
Vegetables†	5.0	1	0.0	1	3.5	1	3.3	3
All sectors	3.8	81	2.8	25	5.2	39	4.0	145

Note: There were 218 varieties surveyed but mean years for prevalence was only given for 145 varieties.

† Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

* If the variety began selling immediately after submitting an application, it may have peaked in the market before examination and hence withdrawn.

As reported in Table 15, the overall average commercial life of varieties with PBR is reported as 14.9 years. This is considerably longer than varieties where a PBR has been refused or withdrawn (6.8 years), but similar to varieties for which no PBR

was sought (14.1 years). Vegetables and fruit and nuts had the longest expected life (20 years) and broadacre crops the shortest life (6.4 years).

Table 15: Mean years for commercial life and number per variety, by sector and PBR status

Sector	Some PBR protection	N	PBR refused, withdrawn*	N	PBR never applied	N	Total	N
Broadacre crops	7.8	18	0.3	4	6.6	5	6.4	27
Forage crops	16.3	10	10.0	1	12.0	5	14.5	16
Fruit and nuts	21.4	16	18.1	4	16.3	4	20.0	24
Nurseries	14.5	44	5.9	18	15.0	24	12.8	86
Vegetables†	23.3	3	0.0	1	30.0	1	20.0	5
All sectors	14.9	91	6.8	28	14.1	39	13.2	158

Note: There were 218 varieties surveyed but mean years for commercial life was only given for 158 varieties.

† Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

* If the variety began selling immediately after submitting an application, it may have peaked in the market before examination and hence withdrawn.

Factors impacting commercial success

A variety's commercial success is a function of many interacting variables. Respondents were asked to:

- Report their relative marketing spend for each variety – “more”, “less”, or “about the same” as they would typically spend.

According to Tables 16 and 17, the responding organisations indicated that for about 60 per cent of the varieties under consideration the organisation had spent more on marketing than was typical. This was similar for varieties with some PBR protection and PBR protection never applied.

Table 16: Percentage reporting more or less marketing spend (relative to typical), by sector

Sector	More	About the same	Less	Total
Broadacre crops	54	35	12	100
Forage crops	53	35	12	100
Fruit and nuts	61	22	17	100
Nurseries	62	34	3	100
Vegetables†	80	20	0	100
All sectors	60	33	7	100

Note: There were 218 varieties surveyed but mean commercial life years was only given for 153 varieties.

† Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

Table 17: Percentage reporting more or less marketing spend (relative to typical), by PBR status

Sector	More	About the same	Less	Total
Some PBR	64	31	6	100
PBR refused, withdrawn	44	48	8	100
PBR never applied	63	28	9	100
Total	60	33	7	100

Note: There were 218 varieties surveyed but mean commercial life years was only given for 153 varieties.

Assessing the impact of PBR on commercial success

Varieties which were never the subject of a PBR application reported having – on average – similar inherent quality, commercial life, and (incomplete) overall revenue. In principle, organisations might be expected to prioritise PBR protection for their best and most promising plants – and, in principle, the end-point royalties earned and additional protection from infringement with a PBR might be expected to produce varieties with a higher overall commercial return.

However, even controlling for confounding variables such as sector, we were unable to detect a statistically significant relationship between a plant's PBR status and its overall revenue return. Our multiple regression analyses found a weak and statistically insignificant correlation between quality and revenue, even after controlling for sector, marketing spend, and PBR status.

As factors which may contribute to this finding, we note that: First, for varieties which had been the subject of a PBR application, we used a semi-random algorithm to preselect varieties for discussion with each applicant, ensuring a relatively representative cross-section of varieties should

be selected. However, varieties without any PBR application are not on record, and could not be preselected. Instead, we asked respondents to think of "the most recent" variety they had commercialised which had never been the subject of a PBR application (if any). Despite the instruction to think of their most recent such variety, it is possible respondents chose instead to discuss their most successful such variety, inflating the metrics in this category. We are aware, for example, of some particularly successful plants reported on in this category which were commercialised prior to the 1988 inception of the PBR system (however these were excluded from the data analysis in this report).

We did not detect any statistically significant correlation between a plant's reported inherent quality and overall revenue return.

On the available evidence, however, we do not observe any strong relationship between a plant's PBR status and its commercial outcomes. This may go some way to explaining the lower-than-anticipated rates of PBR usage reported across commercialised varieties (Table 8).



IV: IMPORTANCE OF PBR FOR INCENTIVES TO INVEST

Respondents were asked about their background protecting their intellectual property with PBR through a series of questions about perceived unauthorised use and enforcement experiences.

Experiences of unauthorised use

Respondents were asked whether they were aware of the variety being used without authorisation. This was reported to have occurred in approximately one out of five cases for all varieties, but one in four for those with some PBR protection, as shown in Table 17.

However, this may be an underestimate of the true rate: approximately 1 in 10 total respondents indicated that they were not aware of any unauthorised use, but added a comment to the effect that “I’m not aware of any [unauthorised use] but there would’ve been”, or remarked “how would I even know?” or that “it is very difficult to know when infringement occurs, or who specifically is doing it”. A smaller additional group of respondents indicated that although they were not aware of unauthorised use to date, they are anticipating it will happen in the future.

Table 17: Percentage of known/suspected unauthorised use and count of affected varieties, by sector and PBR status

Sector	Some PBR protection	N	PBR refused, withdrawn*	N	PBR never applied	N	Total	N
	Broadacre crops	40.9	22	0.0	6	28.6	7	31.4
Forage crops	35.7	14	50.0	4	40.0	5	39.1	23
Fruit and nuts	8.7	23	11.1	9	40.0	5	13.5	37
Nurseries	21.1	57	8.3	24	21.2	33	18.4	114
Vegetables†	25.0	4	100.0	1	0.0	1	33.3	6
All sectors	24.2	120	13.6	44	25.5	51	22.3	215

Note: There were 218 varieties surveyed but mean years for commercial life was only given for 215 varieties.

† Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

Knowledge or suspicion of unauthorised use was lowest for varieties that had been the subject of an unsuccessful or withdrawn PBR application. There was no statistically significant difference in reported rates of unauthorised use between varieties with full or provisional protection PBR and those which had never been the subject of an application.

This reported rate of “unauthorised use” – covered not only PBR use but also the unauthorised use of a trade mark, a license agreement, or a grower contract. Other situations which were reported as unauthorised use include the transport of varieties to overseas markets without authorisation, and the late payment of licencing fees (through PBR or other end-point royalty systems). For plants without formal

protection, several respondents also noted that whereas there may be no formal mechanism to stop others propagating the material, and therefore no technically “unauthorised” use, they had experienced use of their varieties as an unwanted behaviour.

Respondent’s comments around unauthorised use and enforcement varied widely, including within the same sector. Some organisations described an experience of strong community links and a culture of mutual good practice. Others described unauthorised use as rife within their subsectors, and having an expectation that infringement would occur. Amongst those who had experienced unauthorised use, or perceived it to be widespread,

many respondents reported a pessimistic view of their ability to enforce their rights. A perceived lack of “teeth” in the PBR system, and the cost and difficulty of pursuing redress were frequently mentioned.

Use of alternative protection mechanisms

Respondents were asked to indicate which strategies – additional or alternative to PBR – they used to protect the 218 varieties which they were specifically surveyed about. Overall, two thirds of all varieties we canvassed used some form of non-PBR protection. Eleven per cent had no strategy and 25 per cent relied on PBR only.

A disaggregation of additional protection is shown in Table 18. The most frequently reported non-PBR protection mechanism (49 per cent) was contracts or use agreements – such as grower contracts,

licensing agreements, etc. This was highest for broadacre crops and fruits and nuts. The next most used form of protection was trade marks (14 per cent) and this was most popular with the nurseries sector. F1 hybrid as protection was only seen as relevant in 2 per cent but most used by the broadacre crop sector (9 per cent).

Sixteen per cent of varieties used other forms of control which were mainly a) controlling access to the plants or propagating material (e.g., keeping all germplasm on-site); or b) the plant in question being especially difficult to grow or propagate. A few respondents indicated that word of mouth networks, such as community or social media groups, help each other monitor for and address unauthorised use.

Table 18: Percentage distribution of strategies to protect variety, by sector

Sector	None	Only some PBR protection	Contracts or use agreements	Variety is F1 hybrid	Trade marks	Other form of control	Total
Broadacre crops	0	23	74	9	9	3	100
Forage crops	17	35	43	4	13	13	100
Fruit and nuts	3	22	69	3	6	8	100
Nurseries	16	24	38	0	19	22	100
Vegetables [†]	17	33	17	0	17	17	100
All sectors	11	25	49	2	14	16	100

Note: There were 218 varieties surveyed but strategies only given for 212 varieties.

[†] Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

Two of the most frequent comments were (to paraphrase) “all the enforcement effort falls on the PBR holder” and “the PBR office doesn’t help you at all with enforcement” and calls for change in these respects.

Although there was no significant difference in unauthorised use between varieties with some PBR protection and those which had never been the subject of an application, varieties with alternative forms of protection were more likely to be the subject of perceived unauthorised use. It is possible that the perception of potential unauthorised use leads variety owners to take out more forms of protection, or that these varieties are more valuable and hence greater targets of unauthorised use.

Experiences of enforcement

Respondents who indicated that they knew of or suspected unauthorised use of their varieties were asked about their subsequent enforcement activity, if any. Of those respondents who had knowledge or

suspensions of unauthorised copying, 60 per cent did nothing. Only 5 per cent pursued a court case, while the remaining 35 per cent communicated with the infringing party or took other actions. We did not ask directly why people did not take action, but it may be related to the estimated loss of unauthorised use. The mean estimate of lost revenues was \$181,000 for respondents who took no action; \$203,000 from respondents who communicated with the user; and \$1,000,000 from respondents who took court action. We note however the small numbers involved in these estimates (N=21).

Of those who took action, 44 per cent believe that the unauthorised use stopped. The costs of the action varied from nothing to \$400,000. These rates of suspicion of copying and lack of action are comparable with patentees’ views on copying (Weatherall and Webster 2010).

A number of respondents reported finding it ineffective or frustrating that PBR enforcement falls entirely on the individual organisation, without any

centralised support. Several provided ideas of their own for discouraging infringement (such as education campaigns) or enhancing enforcement (for example by implementing industry-based or industry-advised arbitration services as an alternative to the courts; and/or an increased role for genetic fingerprinting).

Reported reinvestment into plant breeding

Despite reporting rates of infringement, and some reported pessimism about a PBR holder's ability to enforce their rights, we note that 38 per cent of reporting respondents indicate that they are able to

support their plant breeding activities by reinvesting funds produced by their breeding program – such as end-point royalties, as shown in Table 19. A further 43 per cent indicated their plant breeding is largely funded by other operational revenue.

Almost all funds – 81 per cent – for breeding activities is from past breeding revenues and other retained earnings and this holds for all types of varieties. Governments and industry bodies only supplied 12 per cent together and there were minimal funds from other sources.

Table 19: Largest source of funding for breeding activities and number per variety, by sector

Sector	Reinvest	Other	Government	Industry	Dom.	Inter.	Other	Total
	breed	business						
	\$	\$		body	business	business		
Broadacre crops	7	3	4	3	0	0	0	17
Forage crops	6	6	2	1	0	0	1	16
Fruit and nuts	0	2	0	0	0	0	0	2
Nurseries	4	4	1	1	0	0	0	10
Vegetables [†]	19	26	0	0	1	1	4	50
Total	36	41	7	5	1	1	4	95
%	38	43	7	5	1	1	4	100

Note: There were 130 respondents surveyed but 95 respondents answered this question.

[†] Small sample size indicates the value may not be representative of the sector. There were 35 unsuccessful vegetable applications and an unknown number of varieties which were never subject to a PBR application between 1988 and 2021.

Although a high risk (or perceived risk) of infringement may encourage the uptake of formal protections such as PBR, a perception that such protections are not effectively enforceable is likely to act as a counterpoint. Overall, it is not clear how this interplay affects the incentive to pursue PBR – and ultimately, the incentive to invest in plant breeding.



V: CONCLUSION

This report has presented the results of the first comprehensive user-level survey on the economic impact of PBR and the cost-benefit proposition offered by the PBR system in Australia. The evidence presents a mixed review of the impact of PBR at the user level.

Tables 20 and 21 show a summary of the mean and median cost of breeding and developing a new variety (\$507,000 and \$30,000, respectively) and the mean and median revenue (\$563,000 and \$10,000, respectively). This comparison needs to be tempered

as revenues may not conclude all lifetime earnings as some varieties will still be in the marketplace.

Strictly, we are not comparing like with like as the revenues refer to a named variety and the costs refer to the organisation's costs per variety in general. Nonetheless, it is striking. This pattern of low revenues to high development costs is found in all sectors – and in forage crops the estimated cost of development is twice that of the revenues as shown in Tables 20 and 21.

Table 20: Mean (all years) revenue (\$) and development cost per variety, by sector

Sector	Mean (all years) revenue per variety (\$)	Typical cost incurred to develop a new variety (\$)
Broadacre crops	1,517,368	1,254,167
Forage crops	281,250	922,964
Fruit and nuts	878,346	1,010,000
Nurseries	194,487	103,593
Vegetables [†]	1,302,500	300,000
All sectors	563,862	507,478

[†] Small sample size indicates the value may not be representative of the sector.

Table 21: Median (all years) revenue (\$) and development cost per variety, by sector

Sector	Median (all years) revenue per variety (\$)	Median cost incurred to develop a new variety (\$)
Broadacre crops	20,000	450,000
Forage crops	7,500	40,000
Fruit and nuts	11,000	100,000
Nurseries	7,500	12,000
Vegetables [†]	90,000	90,000
All sectors	10,000	30,000

[†] Small sample size indicates the value may not be representative of the sector.

We found different experiences across different sectors. Larger and cropping-based respondents report greater returns and higher likelihood to use the PBR system for a new variety, as well as being more likely to comment that the PBR system is working for them. Smaller respondents and nursery, cut flower, or cultivated turf respondents report lower returns – both on an absolute and proportional basis – and lower likelihood to use the system. This group

was also more likely to comment unfavourably on the cost of the PBR system.

The greatest concern appears to be around unauthorised use. Varieties experiencing the greatest rates of unauthorised use, are also the heaviest users of alternative forms of protection such as contracts and trade marks. Use of alternative protections may be a response to the fear of infringement.

APPENDIX A: PLANT BREEDER'S RIGHTS USER SURVEY

Survey design

We elected to conduct the survey of Australian PBR-using organisations via telephone because:

- Telephone surveys yield a higher response rate than email surveys;
- Telephone numbers are readily available for our target population. Applications on the PBR register frequently list a telephone contact; where this is not available, a contact number may be available in the Australian Business Register or on public websites; and⁹
- Direct conversation with respondents allows for some discussion, potentially yielding deeper insights into responses.

Survey questions were developed in close consultation with IP Australia, targeting the three research questions outlined in the introduction. These questions are provided in full in Appendix B.

The survey was divided into two sections. The first section asked standalone questions pertaining to the respondent's overall experience in plant breeding, and with PBR. The second section contained questions about specific plant varieties with which the respondent had been involved.¹⁰ For each respondent, the same set of variety-specific questions was repeated up to three times, for plant(s) in as many as possible of the following three scenarios:

1. A variety with PBR currently granted, terminated, or expired (i.e., which was at least at some stage under full PBR protection) or accepted (i.e., currently with provisional PBR protection)
2. A variety with PBR currently withdrawn, rejected, or refused (i.e., a variety which never had full PBR protection, and does not currently have PBR protection)
3. A variety which the respondent took to market but for which no PBR application was ever made.

This approach was designed to enable a comparative analysis of outcomes across a spectrum of scenarios: from the full presence to the full absence of PBR protection. For scenarios 1 and 2, pertaining to plants which have been the subject of a PBR application, a semi-random choice of variety was made from the respondent's PBR application history.¹¹ This variety preselection was aimed to ensure that data was gathered for a broad cross-section of varieties – and avoided respondents simply reporting on their most recent or most commercially notable varieties. Respondents were asked to self-report whether they had any varieties fitting scenario 3; and, if so, asked to think about the most recent such variety.

Survey population

To assess the economic impact of PBR in Australia, we considered the appropriate survey target population to be the population of Australian organisations (excluding individual applicants) recorded as using PBR.¹²

Phase I of this research identified and disambiguated 439 such targets in the PBR register: ABN-identified Australian organisations recorded as PBR applicants.¹³ To these, we added all other PBR applicants identified in IPGOD as being Australian organisations. In total, 542 past applicants were identified as suitable potential respondents.

⁹ Contact details in the ABR are available to Swinburne as an Authorised Agency for research purposes.

¹⁰ i.e., for varieties from the PBR register, where they are recorded as variety applicant or agent.

¹¹ Appendix B contains further details on variety selection.

¹² We did not consider overseas applicants, which are identified using IPGODs 'country_code'; these PBR users operate in different economic landscapes than the Australian context we consider. Further, contacting them poses a range of additional challenges. We also did not consider private individual applicants: previous analysis has shown individuals to be less prolific users of the PBR system; personal contact details can be challenging to obtain; and many of the relevant individuals will be contacted in their roles as representatives of a PBR-using organisation.

¹³ Throughout, "applicant" is used synonymously with "title holder"

Recognising that the agent on a PBR application can often play a significant role in the development and commercialisation of a new variety, we also sought to include suitable PBR agents in the survey population. We also removed private individuals, and the names of legal offices, as being outside the target population. After removal of these entities, a total of 300 listed agents met our criteria for potential survey respondents. Adding to the pool of targeted applicants, this yielded 842 potential respondents – comprising a full historical sample of Australian PBR-using organisations, as identified in the PBR register.

As of 31 December 2021, the number of PBR applications filed with IP Australia since 1988 was 10,057, including 2,477 individual applicants and 7,580 organisation applicants, as shown in Table A1.

Table A1: Total number of PBR applications to IP Australia, 1988 to 2021

Applicant type	Country code	N
Individual	non-AU	1,270
	AU	1,207
Total individuals		2,477
Organisation	non-AU	4,297
	AU	3,283
Total organisations		7,580
TOTAL		10,057

Survey implementation

Telephone contacts for this potential survey population were drawn from the PBR register wherever available, or alternatively from the ABR or via internet research. Extensive effort was made to track down a suitable, active contact number for all potential respondents; where listed numbers were disconnected or consistently not answered, all efforts were made to locate alternative contact mechanisms. We are confident that these efforts were as comprehensive as possible and tested any publicly available or ABR-recorded contact details.¹⁴

Repeated attempts were made to contact each potential respondent:

- For PBR applicants – most likely to be plant breeders, and so the highest-priority respondents - up to five call attempts were made (if no survey response or refusal was received first). Where applicable, voicemail messages were left at the third and fifth call attempt, with survey details and a call-back phone number.
- For PBR agents, up to three call attempts were made (if no survey response or refusal was received first). Voicemail messages were left at the first and third call attempt.
- Many potential respondents requested we email a digital version of the survey – to assist in directing it to the correct person, or to complete at their convenience. In these cases, an initial email contact and up to two follow-up emails were sent, in addition to follow-up phone calls where appropriate.

Survey calls were conducted on weekdays during time zone-appropriate business hours, during the period from October 2022 – February 2023. Respondents were invited to nominate suitable time(s) for a call-back appointment if we reached them at an unsuitable time.

¹⁴ Organisations for which we were unable to reach a representative may no longer be in operation. We note that about 40 per cent of these organisations have any active (i.e., accepted or granted) PBR holdings, a figure lower than the approximate 60 per cent of all IPGOD's PBR-holding Australian organisations with an active PBR.

Survey call outcomes

Our research team contacted, or attempted to contact, each of the 842 potential respondents in the original target population and received responses from 130 organisations. This represents the first comprehensive effort to reach all of Australia's historically PBR-using organisations. The overall outcomes for the initially identified survey population are summarised in Figure A1.

As Figure A1 shows, our contact efforts suggest that the current user base for PBR is a more compact one than originally thought. Although our initial estimate of the potential respondent pool was >800, only ~350 organisations were able to be reached on an active phone line or had other definite indications of being active. For a further 78 organisations, we were able to locate a phone contact listing which still rang, but we were never answered despite repeated call attempts. The activity status of these organisations is not clear.

The drop from our initial population estimate is largely accounted for by what were at first considered potential respondents being removed from consideration as the survey progressed. Once we began researching and contacting organisations, it became clear that in some cases the same entity had inadvertently appeared twice in our list of supposed unique respondents: for example, where a name or spelling change had occurred, and both the current and previous names were recorded; or where both an official and a trading name were recorded.

Similarly, on speaking with potential respondents, we identified several cases where more than one (typically small) organisation was operated by the same proprietor. In these cases, we only sought a survey on behalf of one of the relevant organisations, to avoid demanding too much time of the proprietor. In this instance we chose the most prolific and/or most recently active of the relevant organisations - at our discretion or in consultation with the respondent.

As Figure A1 shows, once these "duplicate" organisations and other unsuitable entities (per Table A2) were removed, we were able to locate connected phone numbers for 429 (70 per cent) of the remaining organisations. The still-remaining 182 (30 per cent) we consider likely to be inactive: since our sample includes applicants and agents for all historical PBR records to the inception of the scheme in 1988, it is likely that it includes many defunct entities, for whom no contact is likely to be found.

For 78 (18 per cent) of these 429 callable organisations, no representative was ever reached; the phone number(s) either going consistently to voicemail or ringing out. The status of this group is not clear. Some are likely to be active organisations with poorly monitored phone lines, and who either do not have a voicemail box or were uninterested in responding to our voicemail. Others are likely to be defunct or dormant organisations, where the phone number is unmonitored. Still others may be wrong numbers, despite all efforts to locate the best possible contact number for each potential respondent – undetected due to a missing or insufficiently identifying voicemail message.

Of most interest; however, are the 351 organisations for which we did reach a representative on at least one call or have another definite reason to believe they are currently active. Of these, 130 (37 per cent) completed the survey, while 51 (15 per cent) were unwilling to take part. A further 21 (5 per cent) were willing but unable to take part (e.g., due to very poor English), or not invited to take part (e.g., due to hostility).

For the remaining 149 (42 per cent) organisations, although we spoke to a representative on at least one occasion, no survey response or refusal was given within the allocated call attempt limit. This group includes those who repeatedly requested call-backs but proved unavailable again at the appointed call-back time; as well as those who requested and were emailed a digital version of the survey, but never provided a response despite follow-up calls and/or emails.

We conclude that these 351 organisations are likely to provide a reasonable guide to the size and nature of the current landscape. Based on the high response rates and low refusal rates – and on overwhelmingly positive and enthusiastic interactions with the community – we suggest this user base is also highly engaged. We also note that we observed significant personnel overlap between organisations, both big and small, meaning that efforts to engage with key figures in the community are likely to have a broad reach.

Figure A1: Flowchart of survey outcome categories, for PBR-using organisations and agents

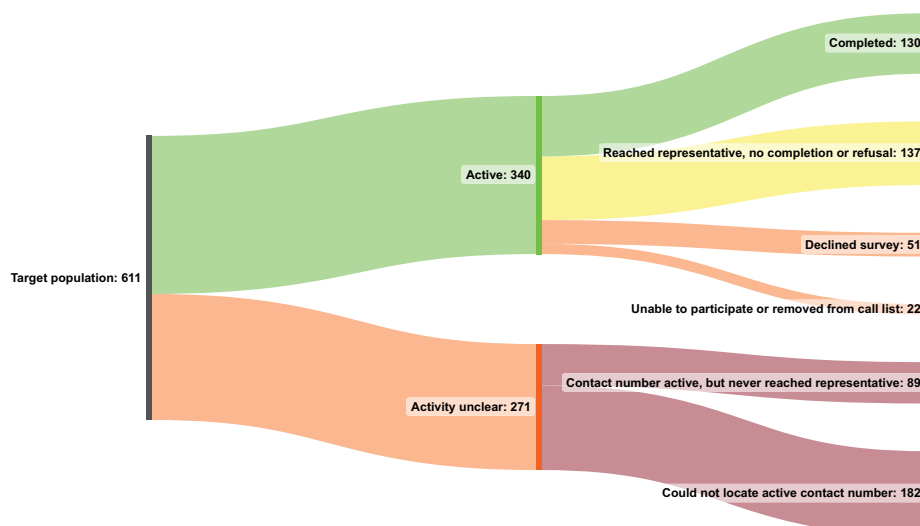


Table A2: Summary of survey outcome categories

Status	Description
Completed	Completed survey
Reached representative, no completion or refusal	For applicants, our original survey population, 5 contact attempts were made. For agents, targeted later to augment responses from applicants, 3 contact attempts were made. If any of these attempts was successful in reaching a representative of the correct organisation, we consider that the organisation is active. However, not all conversations with a representative resulted in either a survey response or a refusal: many (for example) requested a call back at a later date; took our contact details and said they would call us back later; or requested an emailed survey instead. In such cases, we continued to pursue the organisation for a response up to a limit of 5 phone call attempts and 3 email attempts. When this limit was reached, however, the organisation was not pursued further.
Declined survey	Unwilling to take part in survey.
Unable to participate or removed from call list	Indicates where a respondent was not unwilling to take part, but simply unable to take part (e.g., where English was too poor; relevant contact was deceased or on long-term holiday and so organisation could not assist despite interest; or where representative was hostile).
Contact number active but never reached representative	Indicates where one or more contact numbers was located and considered possibly suitable, but no representative was ever reached before call-back attempt limits were hit. Includes instances where only a voicemail was ever reached, or where no voicemail was present, and no answer ever received. We note that for this subsample, alternate contact numbers have been extensively sought, and called wherever available.
Unlocatable	Indicates where no contact number could be found for an organisation, or where the only contact number(s) found were disconnected or invalid.

Respondents' organisation type

Respondents' organisation type is based on our conversations with each respondent, knowledge of their work, and publicly available information, and aggregated to preserve respondent privacy. According to Table A3, most respondents were from a small or medium-sized nursery or fruit or nut company.

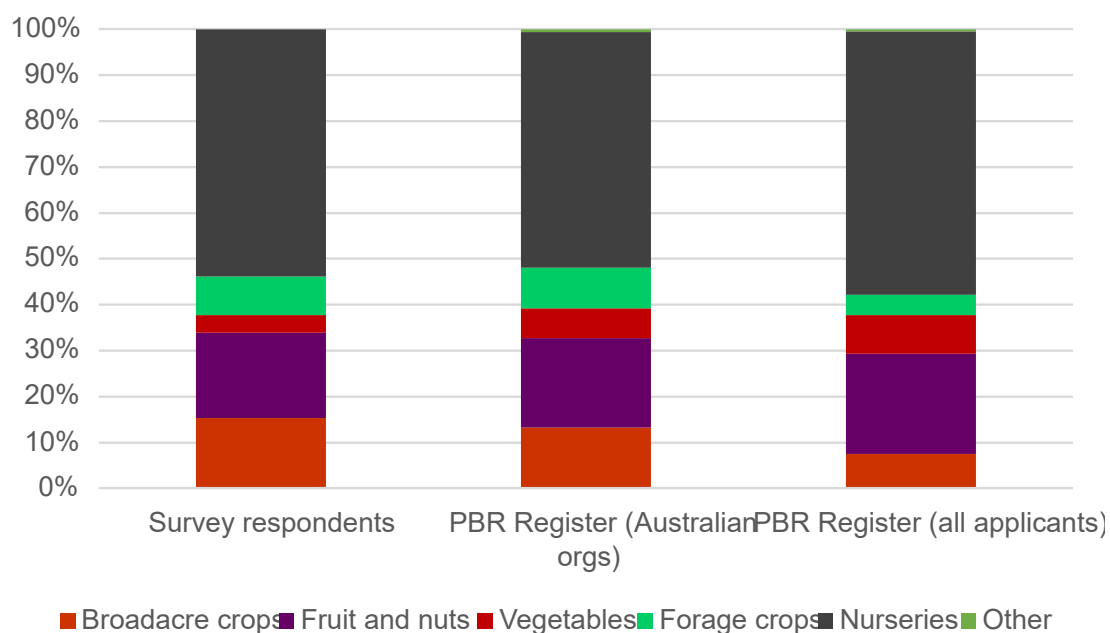
Table A3: Respondents by category

Respondent category	N
Small nursery	26
Medium nursery	12
Small fruit or nut company	10
Large nursery	9
Medium seed company	7
Industry body	6
Large seed company	6
Small seed company	6
Consultancy	6
Government department or agency	6
Large fruit or nut company	5
University or Not-For-Profit	5
Other	4
Small turf company	4
Botanic garden	4
Medium or large turf company	4
Medium fruit or nut company	4
Cut flower company	3
Vegetable company	3
Total	130

Respondent distribution by sector

Figure A2 shows the distribution of our survey respondents by sector, compared with the distribution by sector of all Australian organisations on the PBR register, and of all historical applicants on the PBR register, regardless of type or location. An applicant's sector is calculated using a mapping between plant genus/species and the category of agricultural, horticultural, or other commodity in which that plant type is most typically used.¹⁵ The sector categories used are given in our previous report. The sector in which an organisation most frequently applies for PBR protection is presumed to be their major operating industry.

Figure A2: Percentage distribution of responding organisations, all Australian organisations, full PBR register (organisations and individuals), by most common sector of PBR activity



This breakdown indicates that our survey respondents are representatively distributed across sectors relative to the full sample of Australian organisations.¹⁶ We note that the differing distribution in the full PBR register is attributable to the presence of international and individual applicants. These PBR users were not targeted in this survey.¹⁷

Distribution by degree of breeding activity

To contextualise their survey answers, respondents were asked to indicate how much of their organisation's activity was devoted to plant breeding. This was a multi-choice question, with the presented options being: "all"; "most"; "about half"; "a minority"; or "none".

Only 10 per cent of respondents reported that their organisation committed all of their business activity to plant breeding (see Figure A3). This percentage was highest for respondents in the broadacre crop sector, and lowest for those in the vegetable sector, though we note the low respondent count in this category.

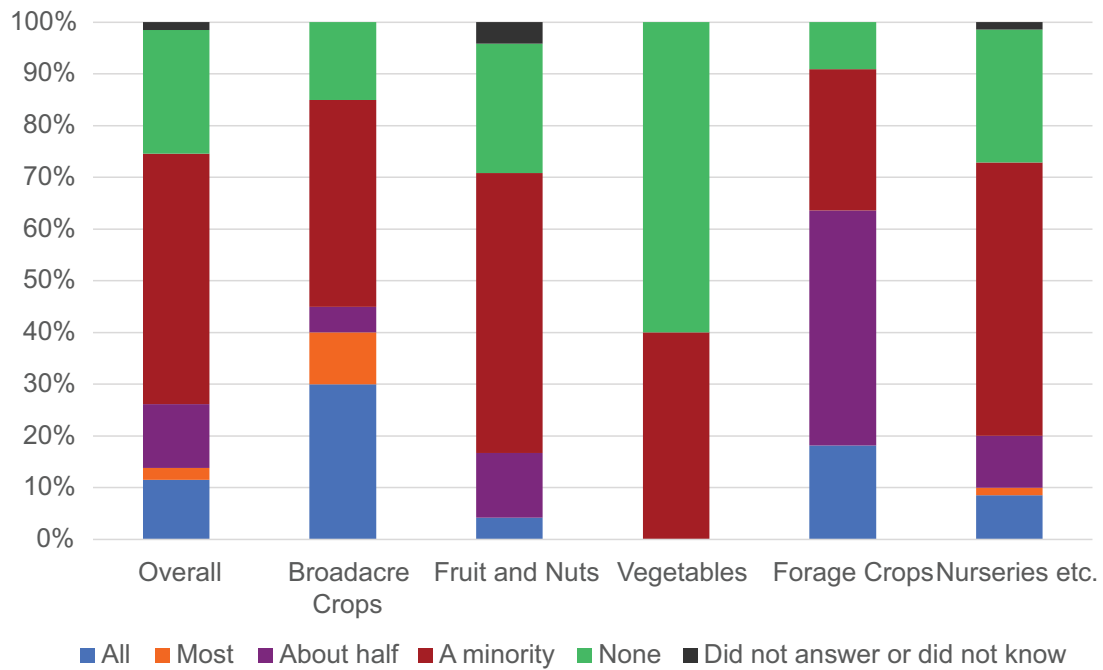
Overall, half of respondents indicated that breeding was a minority activity (i.e., about half of their business, or less). This speaks to a broad relevance for PBR, which is not necessarily concentrated only in breeding-intensive organisations.

¹⁵ We refer the reader to the full discussion in Hegarty et al. (2022) for details of this mapping and its limitations.

¹⁶ Similar comparisons assessing the end-use sector of applications from these respondents against all PBR applications show their distribution is similarly representative of the underlying population.

¹⁷ See Appendix A for further discussion

Figure A3: Degree of business activity reported to be devoted to plant breeding, by sector



In summary, we are satisfied that the 130 respondents to our survey provide a sufficiently deep sampling of PBR experience for Australian organisations, as they represent approximately 37 per cent of the relevant population and are responsible for a majority of historical PBR applications from Australian organisations.

We are also satisfied that we have received survey responses across a representative cross-section of PBR-using organisations in Australia. Respondents give a proportionally representative sample across Australia's PBR-using industries, as well as a broad sampling of organisations of varying types, sizes, and breeding-intensiveness.

APPENDIX B: SURVEY QUESTIONS

Section 1 – Questions about overall organisational plant breeding and PBR experience

Q1: In the last 5 years, or in the last five years you were active in the plant breeding sector, how much of your business activity was devoted to plant breeding?

- a. All
- b. Most
- c. About half
- d. A minority
- e. None

If Q1 not (e.) – that is, if some breeding activity is reported

Questions about breeding activities, if any

Q1-1: In a typical year over that 5-year period, how many full-time equivalent employees worked as part of your plant breeding program?

Q1-2: Over that same 5-year period, what has been the #1 funding source for your breeding program?

- a. Reinvested revenue from your plant breeding activities
- b. Other business revenue
- c. Government
- d. Industry body funding
- e. Domestic commercial partner
- f. International commercial partner
- g. Other

Q1-3: In a typical year, what percentage of your breeding program funding was provided by that source?

Q2: Over that same 5-year period, how many varieties in total did you release commercially?

Q3: For how many of those varieties did you apply for PBR protection?

Q4: Over that same 5-year period, did you develop any varieties to the point of being “commercial ready”, and seriously considered for commercial release, that were ultimately not brought to market?

If Q4 = “Yes” – that is, if some commercial-ready variety/ies not brought to market

Questions about commercial-ready varieties not brought to market

Q4-1: How many varieties, do you estimate? N

Q4-2: For what percentage of those did you apply for PBR protection? N

Q4-3: What is the main reason these were not released commercially? Choose all that apply

- a. Market too small
- b. Not PBR-eligible
- c. Variety was not competitive (no better than existing varieties)
- d. Other (write in)

Questions about plant development experience

Q5: In years, how long does it typically take you to develop a new variety? Try to think from the very start of the development process until the variety is commercial-ready.

Q6: In total, how much does it typically cost you to develop a new variety? Again, try to think from the very start of the development process until the variety is commercial-ready - and remember to include employee wages and overheads.

Questions about PBR costs

Q7: In dollars, what would you estimate as the typical cost of pursuing a PBR application? As well as the IP Australia fees, think about what you spend on growing trials, employee wages, legal or Qualified Person costs, overheads and other costs.

Q8: In dollars, which aspect of the PBR application and examination project is typically the most costly to your business?

- a. IP Australia's standard application and examination fees
- b. Cost of growing trials
- c. Qualified Person fees / costs
- d. Legal advisory
- e. Other _____

Section 2 – Variety-specific questions

Respondents were typically asked about a single plant variety in each of the three PBR status categories outlined above: a variety with some PBR protection; a variety for which a PBR application was submitted but subsequently unsuccessful or withdrawn; and a variety which had never been the subject of a PBR application.

The questions in Section 2 were repeated for each relevant variety.

Introductory remarks for Section 2, by case

For any variety which has been the subject of a PBR application

We'd now like to ask a few more questions which are specific to a particular variety. From your PBR application history, we have selected for you to think about.

The first variety we're interested in is the [*common name*] with variety name [*variety name*] (a [*genus*] [*species*]). Records show you submitted a PBR application for the [*variety name*] on [*date application received*], which was ultimately [*PBR status*] on [*date status updated*]. The [*variety name*] has PBR application number [*application number*]. You may also know it by: Breeders Code [*breeder's code*]; Trade Name [*trade name*]; or Other Name [*other name*].

Do you feel able to answer some questions about this variety?¹⁸

To identify any variety which has not been the subject of a PBR application

Finally, we would like to ask you a few questions about a variety which you commercialized but for which you never applied for PBR protection. Can you think of any such variety?

[Respondents answering "yes" at this point were instructed to "think about the most recent such variety you can". For respondents answering "no", the survey concluded at this point]

¹⁸ Wherever possible, we selected a "first-choice" and a "fallback" application in each PBR status category. A respondent who was unable to speak to the first-choice selection (for example, if they had not been personally involved in its development), would be offered the alternative of speaking about the fallback selection instead. This approach increased the chance of obtaining a variety-specific response in each category from each respondent.

Additional introductory questions for varieties without current PBR protection

If variety was the subject of an unsuccessful or withdrawn PBR application

Why was the PBR application for this variety withdrawn, refused, or rejected?

- a. It was not, or was not likely to be, approved
- b. You decided not to commercialise the variety
- c. PBR protection wouldn't add enough value to justify investment
- d. Other (please write)

If variety was never the subject of a PBR application

Why did you decide not to pursue PBR protection for that variety?

- a. It was not, or was not likely to be, eligible for PBR
- b. It was already in the market for more than the allowable time window
- c. Already released overseas outside allowable time window
- d. PBR is too costly
- e. You were not worried about infringement
- f. You didn't feel PBR would help protect against infringement
- g. The variety's commercial life was too short to make PBR worthwhile
- g. Other (please write)

Section 2 questions for all varieties

Questions about development of this variety

Q12: What best describes your relationship to this variety?

- a. We bred it ourselves
- b. We collaborated on breeding it
- c. We sponsored its breeding
- d. We licensed it or bought the IP
- e. Other (please write)

If respondent not involved in breeding variety

Questions about variety bred elsewhere

Q12-1: Where did the variety come from?

- a. A commercial partner
- b. A government, university, or non-profit partner
- c. Discovered in the wild / as a sport or spontaneous vegetative mutation
- d. Other (please write)

If variety bred by another party

Q12-2: Was that partner here in Australia, or overseas?

- a. Inside Australia
- b. Outside Australia

Q13: How many years did it take to develop this variety? Try to think from the very start of the development process until the variety was commercial-ready.

Q14: Where did the germplasm for this variety come from? You may choose more than one

- a. From within your own breeding program
- b. From varieties that were already in the market and PBR registered
- c. From varieties that were already in the market but not PBR registered
- d. Pre-commercial line from a government, university or not for profit
- e. Pre-commercial line from another company
- f. Other (please write)

Questions about commercialisation of this variety

Q15: Did you ever take this variety to market? (Alternative wording: did you ever commercialise this variety?)

If variety commercialised

Q9-1: We would like to know a little about this variety's Australian "market segment" - the commercial context where this variety might be grown in practice, considering the specific region, climate, or product class it is intended for. This might be something like "ornamental fruit trees", "prime hard wheat", "indoor plants" or "cool climate table grapes".

Q9-2: Now, irrespective of how well this variety actually sold, what would you say is the annual dollar value of its market segment?

Q10: With that market segment in mind, I'll ask how you would describe the quality or performance of this variety, compared to its competitors in the market at the same time. Use a scale of 1 to 10, where 1 means this variety was much worse than competing varieties in that market at the same time as it, 10 means it was much better than its competing varieties, and 5 means it was about the same as its competition.

Q16: If you are happy to disclose, approximately how much revenue has this variety brought in, in total?

Q17: How many years after its release was this variety most widely grown?

Q18: In that most successful year, how widely cultivated was the variety, as a percentage of the total relevant market segment?

Q19: In years, how long would you estimate the commercial life of the variety was, or will be? (Alternative wording: how many years do you think it was or will be before this variety will no longer be grown by users?)

Q11: Did you commercialise this variety in any international markets?

If variety commercialised internationally

Questions about international IP protection attempts

Q11-1: Did you apply for PBR or PVP protection in the international markets where you commercialised this variety?

If variety subject of international IP protection application

Q11-2: What percentage of your international IP applications were successful?

Q20: Compared to other varieties you have commercialised, how much did you spend on marketing this variety?

- a. More
- b. Less
- c. About the same

Questions regarding infringement and enforcement

Q21: Which strategies did you use to prevent others from using this variety without authorisation? You may choose more than one

- a. PBR only
- b. Contracts or use agreements
- c. Patents
- d. Trade marks
- e. Variety is an F1 hybrid
- f. Other: _____

Q22: Are you aware of any instances where this variety has been used without authorisation?

- a. Yes
- b. No
- c. Suspicions but unconfirmed

If unauthorised use known or suspected

Q22-1: Could you estimate the loss of revenue as a result of the unauthorised use?

Q22-2: What action did you take in response?

- a. Nothing
- b. Communication with infringing party (e.g. cease and desist letter)
- c. Pursued court case
- d. Other (please write)

Questions about enforcement actions taken

Q22-3: Did the unauthorised use end as a result of your action?

- a. Yes
- b. No
- c. Don't know

Q22-4: Approximately how much, in total, did it cost you to take that action?

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