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National register of cultivars of Brazil: 25-year overview for crops of economic and social importance

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National register of cultivars of Brazil: 25-year overview for crops of economic and social importance

ABSTRACT

Plant genetic improvement programs are conducted by public and private companies that differ in the crops they focus on and their investment capacities. This study analyzed the number of registered cultivars of cassava, cowpea, common bean, corn, cotton, rice, sorghum, soybean, sugarcane and wheat, as well as the contribution of public and private companies to the registration of cultivars of these species from 1998 to 2022. Data were obtained from the National Cultivar Registry Service database. A total of 6,995 cultivars were registered, with significant variation in the number and distribution of registrations. Corn and soybean were particularly prominent, accounting for 74% of registrations — at least five times the number of registrations compared to crops such as rice and common bean. Over 80% of the registrations were made by private companies. Partnerships contributed modestly (7%). Private companies outpaced public institutions in registering corn, sorghum, soybean, sugarcane, cotton, common bean, rice and wheat. Public institutions prevailed in the registration of cassava and cowpea, which had the fewest registrations. The results highlight disparities in cultivar development and raise questions about public investment in staple food crops and the availability of cultivars for different production chains.

Keywords: Plant breeding. Food security. Agribusiness.

Registro nacional de cultivares no Brasil: panorama de 25 anos para culturas de importância econômica e social

RESUMO

Os programas de melhoramento genético de plantas são conduzidos por empresas públicas e privadas que diferem quanto à cultura de interesse e à capacidade de investimento. Este estudo analisou a quantidade de cultivares registradas de mandioca, feijão-caupi, feijão-comum, milho, algodão, arroz, sorgo, soja, cana-de-açúcar e trigo, bem como a contribuição de empresas públicas e privadas para o registro de cultivares dessas espécies, no período de 1998 a 2022. Os dados foram obtidos no banco de dados do Serviço Nacional de Registro de Cultivares. Um total de 6.995 cultivares foram registradas, com grande variação no número e na distribuição dos registros. O milho e a soja se destacam com 74% dos registros, superando em pelo menos cinco vezes culturas como arroz e feijão-comum. Mais de 80% dos registros foram realizados por empresas privadas. As parcerias contribuíram modestamente (7%). As empresas privadas superam as instituições públicas no registro de milho, sorgo, soja, cana-de-açúcar, algodão, feijão-comum, arroz e trigo. As instituições públicas prevalecem nos registros de mandioca e feijão-caupi, as quais apresentam os menores números de registros. Os resultados evidenciam disparidades no desenvolvimento de cultivares e suscitam análise do investimento público em culturas alimentares básicas e disponibilidade de cultivares para diferentes cadeias produtivas.

Palavras-chave: Melhoramento de plantas. Segurança alimentar. Agronegócio.

INTRODUCTION

In fifty years, Brazil evolved from a net food importer to a global agricultural leader, now ranking as the fourth largest grain producer (after the U.S., China and India) and top net exporter (USDA, 2024). The country holds 50% of the global soy market and ranks second in corn exports. Brazil is among the top five producers of 34 commodities, exporting to 222 markets (VALDES, 2022).

From 2011 to 2020, Brazil's grain production grew at 5.33% annually versus 2.03% globally (CONTINI; MARTHA, 2021). Agricultural output increased 385% with only 32% more farmland, under 10% of Brazil's territory (VALDES, 2022). This growth propelled agricultural exports from 20.6 to 100 billion dollars in a decade, led by soybean, corn, cotton and meat. While global grain production rose by 60% from 2000 to 2020, Brazil's production surged by 210% during the same period, making it the second largest grain exporter (CONTINI; MARTHA, 2021; VALDES, 2022; USDA, 2024).

Brazil's agricultural transformation was propelled by four interrelated factors: (1) yield gains from agricultural research, (2) expansion of arable land, (3) investments in production technologies and (4) increasing global demand for food and feed commodities. Genetic improvement emerged as particularly critical, enabling crop adaptation to Brazil's diverse agroecological zones characterized by varying climates, soils and production systems (RAMALHO; ARAÚJO, 2011).

The foundation for modern plant breeding was established in the 1930s-1940s with early cultivar development programs for rice (*Oryza sativa*), coffee (*Coffea arabica*), sugarcane (*Saccharum* spp.) and other staples (GERALDI, 2012). Subsequent decades sheltered transformative innovations, including photoperiod-insensitive soybean (*Glycine max*) cultivars developed by the Instituto Agronômico de Campinas and Universidade Federal de Viçosa during the 1960s-1970s, which facilitated agricultural expansion into the Cerrado biome (SEDIYAMA *et al*., 2012). Between 1980-2000, EMBRAPA's improved cultivars of soybean, maize (*Zea mays*) and cotton (*Gossypium hirsutum*) increased productivity in this region by 40-60% (LOPES *et al*., 2012).

Notable cultivar releases included the vitamin A-rich cassava (*Manihot esculenta*) variety IAC 576-70, which achieved near-total market insertion by the late 1990s due to its disease resistance and nutritional quality (CARBONELL *et al*., 2012). In the sugarcane sector, cultivars developed by RIDESA accounted for 58.9% of Brazil's cultivated area by 2011 (BARBOSA *et al*., 2012). These innovations collectively enabled Brazil to triple agricultural output while increasing cropland area by only 32% during 1990-2020 (VALDES, 2022).

Research demonstrates that improved cultivars have played a fundamental role in modern agriculture, providing measurable benefits across multiple dimensions (CARBONELL *et al*., 2012). Plant genetic improvement has significantly increased productivity for major cultivated species, while enabling crop adaptation to diverse geographic regions and production systems. Documented benefits include enhanced resistance to biotic and abiotic stresses, reduced need for new areas for cultivation, improved nutritional value and functional characteristics of foods, decreased pesticide dependence, greater input efficiency and improved technological quality - all contributing to enhanced food security (RAMALHO; ARAÚJO, 2011; CARBONELL *et al*., 2012; FEDERIZZI *et al*., 2012; LOPES *et al*., 2012; SANTOS *et al*., 2012; ALVES; PAIXÃO, 2018).

The National Cultivar Registry (RNC) was established under Ordinance No. 527 (December 30, 1997) to regulate cultivar production and commercialization in Brazil.

Governed by the Seeds and Seedlings Law (No. 10,711/2003; BRASIL, 2003) and currently regulated by Decree No. 10,586/2020, the RNC serves three primary functions: (1) maintaining cultivar identity and quality standards, (2) systematizing authorized cultivar information and (3) protecting improved cultivars from genetic degradation (BRASIL, 2003; CARVALHO *et al*., 2009). The registry specifically protects against cultivar deterioration through mechanical mixtures, crossbreeding or improper naming practices (CARVALHO *et al*., 2009).

Plant breeding programs exhibit distinct patterns between public and private sectors, motivated primarily by economic considerations. Private companies focus on high-value crops with strong commercial potential, such as soybeans, where cultivar development offers substantial returns through royalties and technology licensing (RAMALHO; ARAÚJO, 2011). In contrast, public institutions dominate breeding efforts for less profitable crops like beans. This division reflects several key factors: (1) the crop's reproductive system, (2) seed market dynamics, (3) potential for value-added traits and (4) expected financial returns. The resulting imbalance is particularly evident in fruit and vegetable species, where private sector investment in cultivar development and protection significantly outweighs public efforts (GOMES *et al*., 2015; GOMES *et al*., 2016; NUNES; ABUD, 2022).

In light of the above, it is evident that plant breeding efforts in Brazil may vary regarding the availability of registered cultivars and the nature of the companies involved in improving agricultural species of economic and social importance. This variation can impact production chains or systems and jeopardize Brazilian agriculture and national food security. Therefore, one needs to survey the current scenario of cultivar development for agricultural species of economic and social relevance. Thus, this study aims to assess the number of registered cultivars for cassava, cowpea, common beans, corn, cotton, rice, sorghum, soybeans, sugarcane and wheat in Brazil from 1998 to 2022, as well as the contribution of public and private institutions to the genetic improvement of these species.

MATERIALS AND METHODS

The study utilized cultivar registration data obtained from the National Cultivar Registry (RNC) database, maintained by the Ministry of Agriculture and Livestock (MAPA) and accessed through the CultivarWeb portal on September 1, 2023. The dataset encompassed registrations covering the period from 1998 through December 31, 2022. Following data acquisition, we organized the information on Excel® spreadsheets and ran descriptive statistical analyses using R software (R CORE TEAM, 2024).

In accordance with Brazil's National Seed and Seedling System (Law No. 10,711/2003), we employed two fundamental definitions. First, a maintainer refers to an individual or legal entity responsible for preserving and providing propagation material of registered cultivars while maintaining their genetic identity and varietal purity. Second, a cultivar represents a distinct plant variety characterized by unique descriptors and denomination that clearly differentiates it from other known cultivars.

The RNC database uses two primary classification systems for plant materials. The first system organizes species into eight crop categories: forage, forestry, fruit trees, major crops, medicinal and aromatic plants, ornamentals, vegetables and others. The second system categorizes registered materials into five types: cultivars, export-only materials, single hybrid parents, parental lines and parental varieties. The study analyzed only cultivar registrations, excluding other types of registration (e.g., parental lines or export materials).

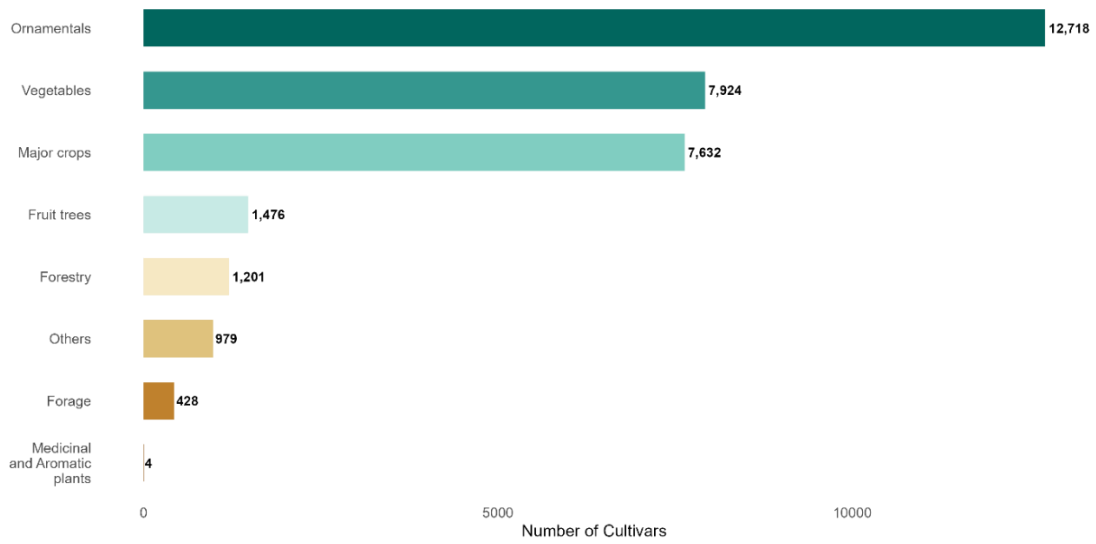
The analysis focused on ten crops selected for their socioeconomic importance, with scientific names as registered in RNC: i) cassava (*Manihot esculenta* Crantz); ii) cowpea (*Vigna unguiculata* L. Walp); iii) common bean (*Phaseolus vulgaris* L.); iv) corn (*Zea mays* L., *Zea mays* L. var. saccharina, *Zea mays* L. var. everta (Sturtev.) L. H. Bailey and *Zea mays* L. saccharata Koern.); v) cotton (*Gossypium hirsutum* L., *Gossypium hirsutum* L. var. latifolium Hutch, Gossypium L. and *Gossypium hirsutum* L. var. marie galante (Watt) Hutch); vi) rice (*Oryza sativa* L.); vii) sorghum (*Sorghum bicolor* (L.) Moench, *S. bicolor* (L.) Moench x *Sorghum sudanense* (Piper) Stapf, *Sorghum caudatum* (Hack) Stapf, *Sorghum* spp. and *Sorghum guinea* Kafir.); viii) soybean (*Glycine max* (L.) Merr.); ix) sugarcane (*Saccharum* L. and *Saccharum officinarum* L.) and x) wheat (*Triticum aestivum* L. and *Triticum durum* Desf.). Accordingly, herein corn records include popcorn and sweetcorn.

For each target crop, four categories of information were systematically collected: the total number of registered cultivars, the annual cultivar registration rates, the count and legal status of maintainer institutions and the institutional distribution of cultivar maintenance. The maintainers were classified according to their legal status into three groups: public institutions (governmental organizations or research institutes), private entities (companies or individual breeders) and public-private partnerships. For analytical purposes, the following classification rule was used: individual maintainers were classified as private entities. Collaborative efforts between multiple public institutions were considered as public partnerships, while collaborations between private companies and/or individual breeders were classified as private partnerships. Collaborations involving at least one public institution and one private entity were designated as public-private partnerships. Registrations with unidentified maintainers were excluded from subsequent analyses.

RESULTS AND DISCUSSION

The study recorded 32,362 cultivar registrations from 1998 to 2022. The most frequently registered groups were ornamentals (12,718), vegetables (7,924) and major crops (7,632) (Figure 1).

Figure 1. Distribution of cultivar registrations by designated groups (SRNC/MAPA, 1998–2022).



The ten focus species accounted for 6,995 registrations (21.6% of total), highlighting their agricultural significance. Corn dominated with 2,910 registrations (including 141 popcorn and 68 sweetcorn cultivars), followed by soybean (2,177) and sorghum (400) (Figure 2). Together, corn and soybean represented 73% of registrations for these ten crops. Common bean, rice, wheat, cotton, sugarcane, cassava and cowpea showed a progressively decreasing number of registrations.

The introduction of mandatory cultivar registration in Brazil in 1998 led to a sharp peak in the number of registered cultivars that year, exceeding 600 entries (Figure 3). This reflects the formal documentation of cultivars already in use prior to the regulation. From 1999 to 2005, the number of registrations declined and stabilized at lower levels, indicating a transition to routine registration of newly developed cultivars.

A steady increase was observed from 2006, peaking in 2013–2014, likely driven by greater investment in plant breeding, expansion of biotechnology and increased private sector participation. From 2015 onwards, registrations fluctuated but stayed at high levels, with additional peaks in 2020 and 2021, possibly influenced by food security policies and streamlined digital procedures.

Figure 2. Number of cultivar registrations (1998–2022) for 10 selected crops in the National Cultivar Registry (RNC).

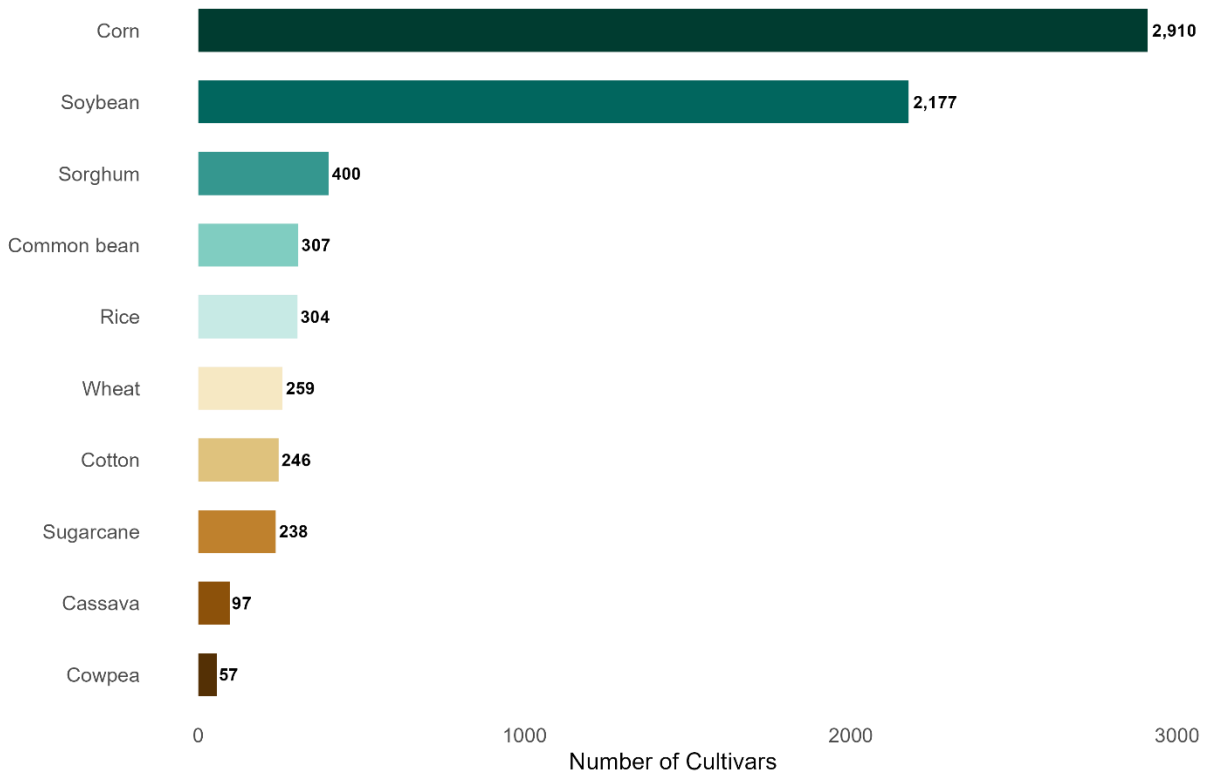
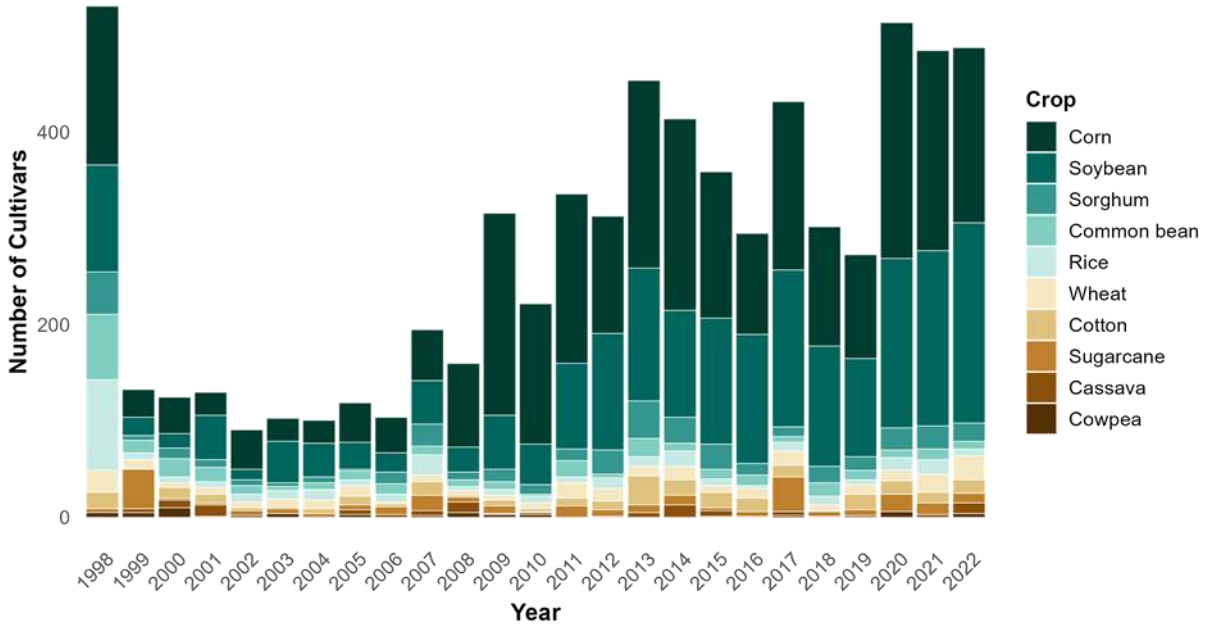


Figure 3. Total number of cultivar registrations per year for 10 crops selected from the National Cultivar Registry (RNC) database, for the period from 1998 to December 31, 2022.



Corn and soybean accounted for the majority of registrations, particularly after 2010, reflecting their economic importance and the rapid turnover of hybrid and transgenic materials. Other crops such as common bean, rice, sorghum and wheat showed lower levels of registration activity, but remained consistent. Crops like cassava and cowpea had minimal representation, indicating a lower interest in commercial breeding or a stronger reliance on traditional varieties. These trends highlight the long-term impact of the 1998 regulatory framework and the dynamic evolution of the Brazilian cultivar registration system in response to technological, economic and institutional drivers.

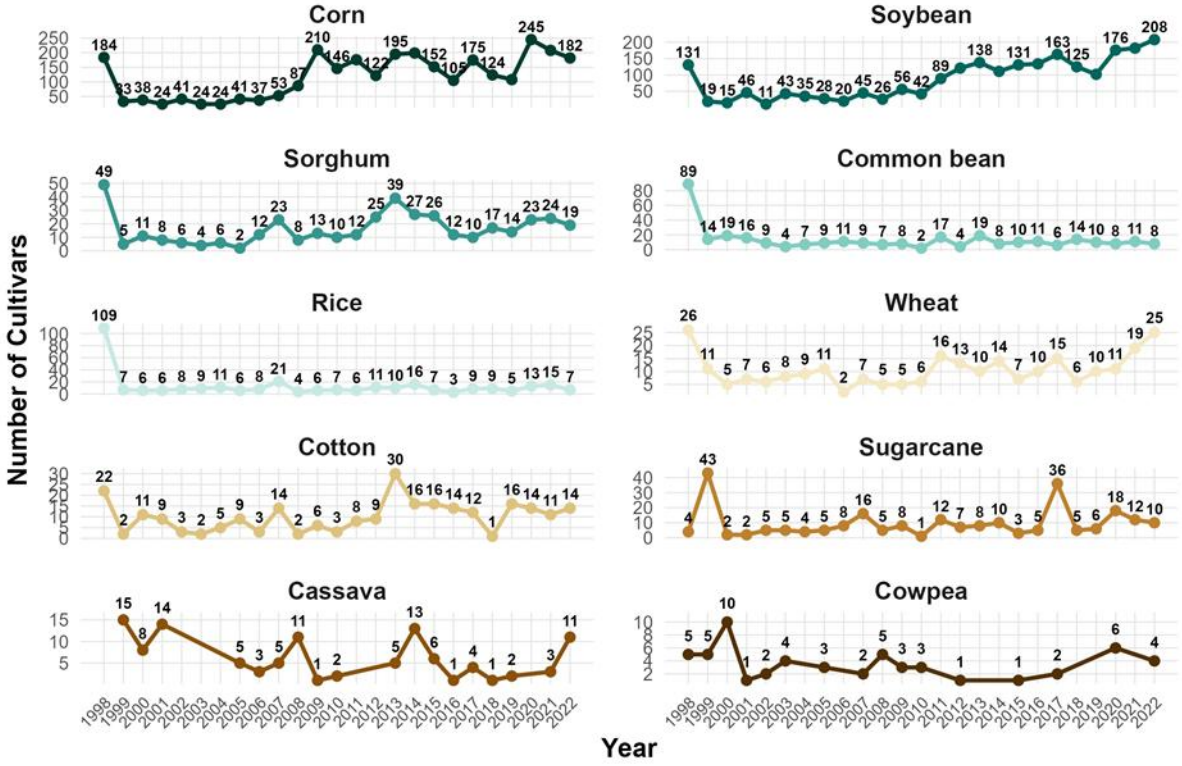
The numerical superiority of registered cultivars for corn and soybean may stem from the attractiveness of the seed market, which generates higher financial returns with the release of superior cultivars, as reported by Marinho *et al*. (2011). Data from the Brazilian Seed and Seedling Association (ABRASEM, 2024) show that in the 2020/2021 growing season, the area planted with soybeans was 38,532,100 hectares, with a seed utilization rate of 67%. For corn, the seed utilization rate was 91%, across 19,867,700 hectares cultivated. Comparatively, for some crops, the cultivated area is less significant (1,677,100 hectares for rice) or the seed utilization rate is very low (18% for common beans). For both corn and sorghum, hybrid-type cultivars also increase market attractiveness for these crops, as the genetic structure of these cultivars discourages the use of grains from previous harvests for the establishment of new production areas.

Figure 4 details the annual number of cultivar registrations by crop. Registration intensity varied widely across crops and appears influenced by market demand, breeding system complexity and institutional engagement. As expected, a surge in registrations occurred in the years immediately following the implementation of mandatory registration. For common bean, rice, wheat, soybean, sugarcane and cassava, the highest numbers were recorded during this initial phase. Over time, most crops showed fluctuations, with the exception of corn, sorghum, and soybean, which revealed upward trends.

The highest annual registration numbers for each crop are as follows: corn (245 in 2020), soybean (208 in 2022), sorghum (44 in 1998), common bean (68 in 1998), rice (94 in 1998), wheat (23 in 1998), cotton (30 in 2013), sugarcane (41 in 1999), cassava (13 in 2014), cowpea (10 in 2000).

In the case of cassava and cowpea, several years had no new registrations, indicating their lower integration in formal breeding systems. Corn and soybean consistently led in registrations, especially after 2010. Corn peaked in 2009, 2013 and 2020, reflecting rapid hybrid turnover. Soybean registrations increased steadily, reaching their maximum in 2022, likely due to sustained private sector investment and the crop's economic relevance. Sorghum showed moderate variability, with peak in 2013. Common bean and rice declined sharply after 1998 and then stabilized at lower levels, suggesting limited cultivar renewal or predominance of public breeding programs. Wheat remained stable, with a slight recent increase. Cotton had sporadic peaks, notably in 2013, possibly related to biotech adoption or market shifts. Sugarcane entries were low but variable, with peaks in 1999 and 2017, reflecting clonal breeding cycles and varietal protection practices. Cassava and cowpea had the lowest registration levels throughout the period. Their limited presence in the formal system may be due to their traditional cultivation, limited interest in commercial breeding and dominance of informal seed systems.

Figure 4. Total number of cultivar registrations per year for ten selected crops from the National Cultivar Registry (RNC) database, covering the period from 1998 to December 31, 2022.



The notably low number of registered cultivars for cassava and cowpea — which is also observed for common bean, rice and wheat — raises concerns about breeding efforts for staple crops in the Brazilian diet. According to the National Food Surveys (INA) of 2008–2009 and 2017–2018, rice, beans, coffee and bread are the most consumed foods in Brazil

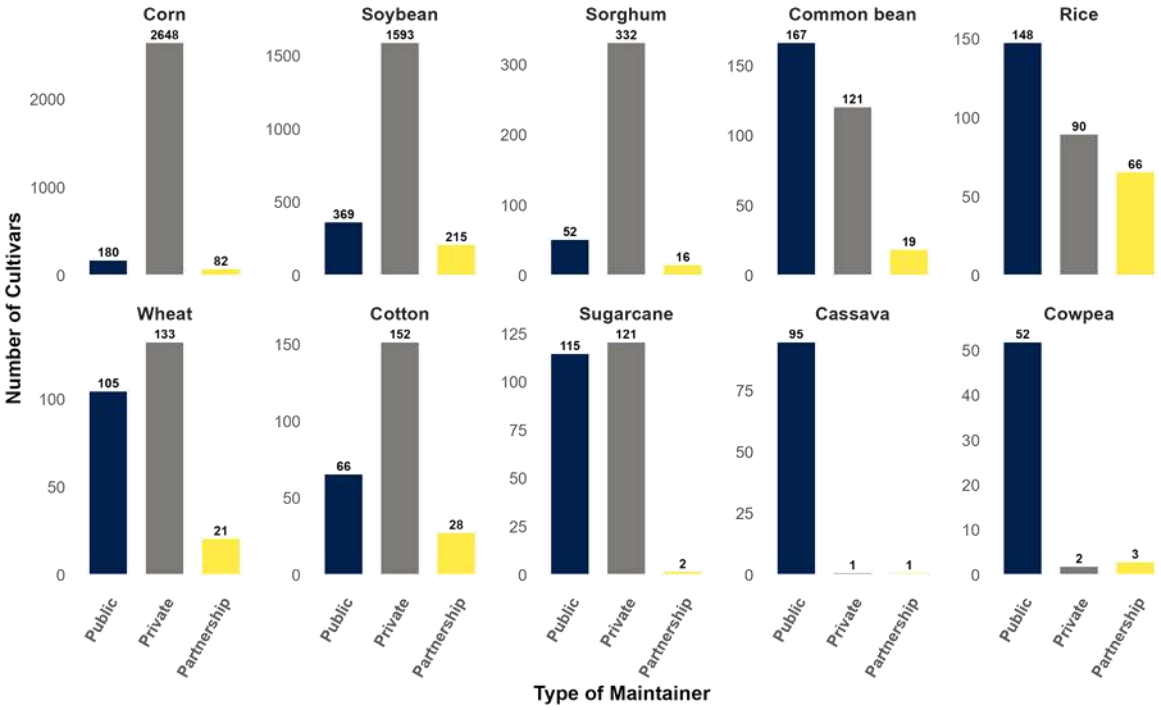
(RODRIGUES *et al*., 2021). Average daily intake includes 142.2 g of beans, 131.4 g of rice, over 8 g of cassava and cassava flour, and 8.8 g of cowpea (IBGE, 2020).

Cowpea cultivation alone supports more than 1.1 million jobs annually, feeds over 28 million people and generates over R$ 684 million in grain sales (FREIRE FILHO *et al*., 2011). Despite this socio-economic relevance, the number of cultivars currently available is insufficient to meet the diverse needs of regions, farming systems and market demands. Many cultivars are outdated and no longer used by producers, as noted for cowpea by Freire Filho *et al*. (2011).

Marinho *et al*. (2011) emphasize that crops of national importance should be prioritized in public policy agendas. Ramalho *et al*. (2012) further highlight that species predominantly grown by family farmers, such as rice and beans, have benefited from public breeding programs, ensuring greater cultivar availability and domestic supply.

Figure 5 illustrates the distribution of cultivar registrations by type of maintainer. Of the 6,995 total registrations, 5,193 (74%) came from private institutions, 1,349 (19%) from public ones and 453 (7%) from partnerships. Private entities were responsible for 91%, 83% and 73% of corn, sorghum and soybean cultivars, respectively. These crops are the primary targets of commercial breeding programs due to their economic return and technological innovation, including hybrids and GM traits.

Figure 5. Percentage of total cultivar registrations by crop and type of maintainer, for ten crops selected from the National Cultivar Registry (RNC) database, for the period from 1998 to December 31, 2022.



Conversely, public institutions dominated cassava (98%) and cowpea (91%) registrations. They also played a significant role in rice, common bean and wheat, which are strongly linked to food security and family farming. The predominance of the private sector in cultivar registration has also been observed for fruit (GOMES *et al*., 2015) and vegetable crops (GOMES *et al*., 2016).

The limited participation of public institutions is frequently attributed to underfunding and structural limitations. In academic breeding programs, professors balance their research duties with teaching and supervision responsibilities (SEDIYAMA *et al*., 2012). In spite of that, initiatives like RIDESA have effectively developed sugarcane cultivars while also training skilled professionals for both public and private sectors (BARBOSA *et al*., 2012). As noted by Geraldi (2012), a key outcome of university breeding programs is the training of future breeders, which contributes indirectly to cultivar development across various institutions. These results underscore the contrast between market-driven and food-security-driven breeding systems in Brazil. Strengthening public investment and fostering collaborative models are essential to ensure cultivar availability for strategic, though often neglected, crops.

Partnerships accounted for a small share of total registrations, which ranged from 1% for cassava and sugarcane to 22% for rice. Among them, 65% were between private companies, 31% between public institutions and only 4% were public-private collaborations. This limited contribution of public-private partnerships aligns with earlier findings for fruit (GOMES *et al*., 2015) and vegetable crops (GOMES *et al*., 2016).

Public-private partnerships are considered beneficial, as they combine the infrastructure, germplasm resources and technical expertise of public institutions with the agility and financial resources of private companies (GOMES *et al*., 2016). In this study, the top ten partnerships accounted for 113 cultivars (80%) of all partnership-based registrations. Notably, two public-public partnerships led by EMBRAPA, EMBRAPA/EPAMIG and EMBRAPA/EMATER-GO were responsible for 38 and 18 cultivars, respectively.

The enactment of the Plant Variety Protection Act in 1997 and agricultural expansion into new regions prompted EMBRAPA to restructure its collaborative model, initially with state research institutions and subsequently with private producer associations (ATRASAS *et al*., 2012). EMBRAPA partners with over 100 institutions in its breeding programs, including universities, national and international research centers, and private companies (LOPES *et al*., 2012). However, as Sediyama *et al*. (2012) point out, such collaborations remain rare in Brazil. Minas Gerais serves as an exception, where coordinated efforts between UFV, UFLA, EPAMIG and EMBRAPA have been successful in developing and recommending bean cultivars for the state. These findings reinforce the importance of public institutions in maintaining genetic improvement for food crops and highlight the potential of partnerships, especially public-private ones, to bridge gaps in funding, regional adaptation and cultivar delivery for strategic crops.

CONCLUSIONS

Over the first 25 years of the National Cultivar Registry (RNC), significant variation was noted in the number and distribution of cultivar registrations across major agricultural crops. Corn and soybean were dominant, which accounted for nearly three-quarters of all registrations among the ten target species, and far exceeding crops such as rice, common bean and wheat.

The private sector was responsible for over 80% of registrations, particularly in commercially valuable crops such as corn, soybean and sorghum. Public institutions played a relatively smaller role, with cassava and cowpea being the only crops where public maintainers predominated. These two crops also had the fewest registrations and the highest number of years without new cultivar entries, despite their nutritional and socioeconomic relevance in the Brazilian diet.

These findings highlight a structural imbalance in breeding efforts, favoring crops with high seed market value and hybrid potential. Strengthening public breeding programs and expanding collaborative models (especially public-public and public-private partnerships) are essential to address gaps in cultivar availability for food security crops and ensure broader adaptation to regional production systems.

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