
Q-Bra and Quantum Technologies for Agricultural Innovation

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Abstract

Qubits Brasil, or Q-Bra, is a Brazilian startup that believes in and works towards the use of quantum technologies in agribusiness, aiming to revolutionise precision soil and crop monitoring, optimise resource use, and increase sustainability within 4 years. To establish this advantage for Brazilian agribusiness, it is necessary to overcome challenges related to costs and expertise in quantum technology through investments in research via strategic partnerships, in which Q-Bra has been actively engaged to achieve unprecedented results that justify these initiatives.

Keywords: Quantum technologies, quantum sensors, agribusiness, sustainability, startups and innovation.

1 Introduction

Brazilian agribusiness, a cornerstone of the national economy and a key player in the global food scenario, is closer than ever to a transformation driven by quantum physics. The introduction of quantum technologies that

utilise particle superposition and entanglement can promote unprecedented advances in agriculture.

2 Agribusiness

Agribusiness is the economic activity that encompasses the entire production chain in the rural sector, extending far beyond simple agriculture and livestock farming. It includes everything from input suppliers (such as seeds, fertilisers, and machinery) to on-farm production, industrial processing, distribution, transportation, and final product commercialisation.

In Brazil, this sector is a fundamental pillar of the economy, accounting for a significant share of Gross Domestic Product (GDP), exports, and job creation. It is characterised by its diversity, ranging from commodities such as soy, corn, and beef to fruit, coffee, and forestry crops, and it plays a crucial role in national and global food security.

3 Brazilian Agribusiness

Brazilian agribusiness is a complex and dynamic economic sector that is one of the nation's main foundations, accounting for about a quarter of GDP and a significant share of exports. It stands out for the production and export of agricultural commodities, such as soy, corn, coffee, and beef, positioning the country as one of the world's largest food suppliers.

This strength is driven by a combination of factors, including favourable climate, vast arable areas, cutting-edge research technology (such as that from Embrapa), and the entrepreneurship of rural producers. However, the sector also faces critical challenges, such as reconciling productive expansion with environmental sustainability and land regularisation, making it a field of constant innovation and debate about the future of national development. The summary of the fourth survey of the **2025/26 Grain Harvest (Conab)** presents valuable data on Brazil's total grain production, estimated at **353.1 million tons**, an increase of **0.3%** (+987.5 thousand tons) compared to the previous harvest, cultivated in an area of **83.9 million hectares** (+2.6%). The Central-West Region leads, responsible for **49.4%** of national production. Highlights by crop:

- **Soybeans:** Production of 176.1 million tons (+2.7%). Planted area of 48.7 million hectares (+2.8%). Stable productivity with a slight decrease of 0.1%.

- **Corn (3 harvests):** Production of 138.9 million tons (−1.5%). Planted area of 22.8 million hectares (+4%). Productivity of 6,114 kg/ha (−5.3%).
- **Sorghum:** Production of ~6.7 million tons (+9.2%). Area of 1.8 million hectares (+11.3%). Productivity of 3,670 kg/ha (−1.9%).
- **Cotton (lint):** Estimated production of 3.8 million tons. Cultivated area of 2 million hectares (−2.8%).
- **Rice:** Production of 11.1 million tons (−13.3%). Sown area of 1.6 million hectares (−9.9%).
- **Beans (3 harvests):** Total production of 3 million tons (−0.5%).
- **Sunflower:** Production of 101.9 thousand tons (+1.5%). Area of 63.8 thousand hectares (+3.1%). Productivity of 1,598 kg/ha (−1.5%).
- **Castor bean:** Production of 147.4 thousand tons (+47.4%). Area of 76.1 thousand hectares (+9.3%). Productivity of 1,938 kg/ha (+34.8%).
- **Wheat (2025 harvest):** Production of 7.9 million tons (similar to 2024), with a 20% smaller area.

For the market, soybean exports are projected at **41.5 million tons**, and domestic corn consumption at **90.56 million tons (+7.8%)**, driven by ethanol production. Agribusiness exports reached about **US\$ 169.2 billion** in 2025, according to the Brazilian Ministry of Agriculture and Livestock, a **3.0% increase** from 2024. The sector accounted for **48.5%** of the country's exports. The result was sustained by a 3.6% increase in volume, offsetting a **0.6% drop** in prices. The sector's trade surplus was **US\$ 149.07 billion**.

Table 1 highlights the strong concentration of exports among the main trading partners, with China standing out as the leading destination both in export value and share of the total, while also maintaining significant growth. The European Union also shows consistent expansion, reinforcing its importance as a strategic market. In contrast, exports to the United States declined, whereas markets such as Pakistan, Argentina, and the Philippines recorded high growth rates, despite the absence of detailed export values, indicating potential for diversification and future expansion.

Table 1 Main export destinations

Destination	Export Value (US\$ Billion)	Growth Rate	Share of Total (%)
China	55.3	+11%	32.7%
European Union	25.2	+8.6%	14.9%
United States	11.4	−5.6%	6.7%
Pakistan	—	+122%	—
Argentina	—	+29%	—
Philippines	—	+9.18%	—

Performance by Product (Highlights):

- **Soybeans (grain):** US\$ 43.5 billion (+1.4%), with a record volume of 108.2 million tons (+9.5%).
- **Beef:** US\$ 17.9 billion (+39.9%), with volume +20.4%.
- **Coffee:** US\$ 16 billion (+30.3%), driven by record prices.
- **Pork:** Value +19.6% and volume +12.5%, making Brazil the 3rd largest global exporter.

The performance by product highlights the strength and competitiveness of the agricultural export sector, with soybeans standing out for maintaining a high share in export value and reaching a record volume, reinforcing their strategic position in the export basket. The significant expansion in beef exports reflects strong growth in international demand, while the increase in coffee exports, driven by record prices, indicates substantial gains in terms of added value. Meanwhile, the growth in pork exports, both in value and volume, consolidating the country as the world's third-largest exporter, signals structural strengthening and deeper integration into global markets. Overall, these results reveal a balanced performance between price gains and volume expansion, supporting the continued growth of the sector's exports.

Table 2 highlights products that recorded significant growth in exports, both in value and volume, underscoring the dynamism of specific segments within the export portfolio. Items such as peanuts and black pepper posted substantial increases in export value, while beans and fruits combined growth in both value and volume, indicating stronger external demand and enhanced competitiveness. The performance of sesame exports to China also points to opportunities in strategic markets. Overall, the results demonstrate strengthened productive diversification and the consolidation of niche markets with high expansion potential, helping to sustain export growth on a broader and more resilient basis.

The diversification strategy has led to the opening of 525 new markets since 2023, with approximately 15% growth in non-traditional product exports.

Table 2 Products with significant export growth

Product	Export Value (US\$ Million)	Value Growth	Volume Growth
Piper pepper	517.81	+81.1%	–
Peanut oil	264.6	+147.4%	–
Beans	443	+32%	+55.5%
Sesame (to China)	195.1	–	–
Fruits	–	+12.8%	+19.7%

4 Sensors

The word “sensor” derives from the Latin *sensus* (perception, feeling) and *sentire* (to feel, to perceive), and it refers to devices designed to detect and respond to stimuli. Its technical formation comes from the Latin *sensu* + *or* (agent), reflecting its function of identifying environmental changes, similar to biological sensation. Sensors are fundamental for advanced technologies, characterised by edge intelligence, IoT connectivity, and multifunctionality. Notable examples include solid-state LiDARs and 4D radars in autonomous vehicles, which create detailed environmental maps. In healthcare, non-invasive sensors such as continuous glucose monitors and optical blood pressure meters in wearables are proliferating. Privacy concerns drive the adoption of sensors such as millimetre-wave (mmWave) radar for presence detection in smart homes, while multi-gas sensors monitor air quality with precision.

In Industry 4.0, 3D vision and condition sensors (vibration, ultrasound) enable quality inspection and predictive maintenance. Precision agriculture uses multispectral drone sensors and IoT soil moisture sensors to optimise resource use. The dominant trend is sensor fusion, which combines data from multiple sources (camera, radar, LiDAR) to generate a more robust and reliable contextual perception, enabling systems to be more autonomous and efficient.

Quantum sensing is a technology that uses the principles of quantum mechanics, such as the superposition and entanglement of states, to perform physical measurements with extremely high precision, surpassing the limits of traditional sensors. It allows measuring magnetic and electric fields, temperature, pressure, and other quantities with unprecedented sensitivity. Practical quantum sensors, such as atomic clocks, atomic magnetometers, and atomic interference gravimeters, are already a reality. The technology is advancing in promising directions, such as the use of diamond NV colour centres and Rydberg atoms. The technology is divided into three main approaches: using quantum objects with discrete energy levels as sensors; employing quantum coherence (superposition states) for measurements; and exploring resources such as entanglement and noise squeezing to surpass the statistical limits of classical metrology.

The British Royal Air Force (RAF) is testing quantum sensors, focusing mainly on quantum inertial navigation (Q-INP). This technology, developed with companies like Infleqtion, uses cold atoms to create an ultra-precise, interference-proof navigation system that does not depend on GPS and has

already undergone flight tests. Another research area is quantum gravimeters, which measure minimal variations in gravity to detect submerged or underground objects, a project led by the Ministry of Defence. The future goal is to integrate these sensors into next-generation platforms, such as the Tempest fighter. However, major challenges in miniaturisation, robustness, and cost need to be overcome before widespread operational deployment. In summary, the RAF is actively exploring quantum potential, but the technology is still in the prototype stage.

In the context of Brazilian agriculture, with its extensive properties, logistical challenges, and fertility variation within the same crop, this extreme sensitivity of quantum sensors is a sought-after outcome and could be revolutionary. These sensors will allow mapping nutrient availability, the presence of incipient pests, or plant water stress levels with atomic resolution, even before any visible signs appear. This paves the way for personalised, proactive resource management, enhancing the efficiency and resource use of companies and producers in the agribusiness context.

The practical application of these sensors materialises in integrated quantum precision agriculture systems. Imagine drones or fixed stations equipped with quantum magnetometers, mapping subsurface structure and locating aquifers with centimetre accuracy. Or even quantum-based spectrometers analysing, in real time and from minimal samples, the molecular signature of a leaf, diagnosing specific nutritional deficiencies or the presence of fungal toxins. For livestock, miniaturised quantum sensors could monitor animal health indicators by analysing molecular-level chemical markers in breath or secretions. This continuous flow of ultra-precise data will feed AI systems that generate agronomic prescriptions with near-zero margin of error. The direct result is the absolute optimisation of inputs: water, fertilisers, and pesticides applied in the exact dose, at the exact location, and at the exact time, enhancing environmental sustainability and profitability.

5 Conclusions

The adoption of this technological frontier, however, is not free from significant challenges for Brazil. The development and production of quantum sensors still involve high costs and require specialised infrastructure, with controlled environments and highly qualified personnel for operation and maintenance. This imposes the need for massive investments in research and development, preferably through strategic partnerships between universities, technology institutes, deeptech startups, and agribusiness groups themselves.

Once these initial barriers are overcome, the potential for consolidating Brazilian agribusiness's global leadership in the coming years is immense.

By integrating the forefront of quantum physics with its agricultural power, Brazil can not only increase productivity but also certify the quality and traceability of its products with a new level of scientific confidence, creating a model of advanced tropical agriculture that harmonises productivity, sustainability, and cutting-edge innovation.

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Biography



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