

Role of Research and Development Institutions and AgTechs in the digital transformation of Agriculture in Brazil

O papel das Instituições de Ciência e Tecnologia e Agtechs na transformação digital da Agricultura no Brasil

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ABSTRACT - The Brazilian agribusiness sector has been witnessing increasing modernization, caused by the extensive adoption of technologies, with increase in productivity and reduction of risks. In addition, the use of digital technologies in farms has recently been increasing, engendering the emerging field of digital agriculture. In this context, this article presents a startup acceleration program, called TechStart Agro Digital, an initiative of Embrapa Agricultural Informatics and Venture Hub with the support of various stakeholders in the agricultural innovation ecosystem. Further, this article presents a methodology for technological and business acceleration focused on agribusinesses, which was proposed by the two institutions, and its application in the first cycle of the program in 2019. The results show that the 11 startups that graduated from the program demonstrated an improvement and growth six months after the acceleration program, and validate the potential of the program in facilitating the development of technologies that are more consolidated and focused on the real problems of agriculture. The post-program follow-up indicates that these agricultural technology startups and organizations (AgTechs) have helped rural producers effectively and efficiently, thereby adding value to Brazilian agriculture.

Key words: Digital agriculture. Agricultural innovation ecosystems. Open innovation. AgTechs. Startups.

RESUMO - O agronegócio brasileiro vem se modernizando pela intensa adoção de tecnologias, com aumento de produtividade e redução de riscos. Mais recentemente, observa-se um crescente aumento no uso das tecnologias digitais no campo, fazendo emergir a chamada Agricultura Digital. Neste contexto, este artigo apresenta o Programa de Aceleração de startups, denominado TechStart Agro Digital, uma iniciativa da Embrapa Informática Agropecuária e da aceleradora Venture Hub com o apoio de vários atores do ecossistema de inovação agrícola. Este trabalho apresenta a metodologia de aceleração tecnológica e de negócios com foco no agronegócio, proposta pelas duas instituições, ilustrando sua aplicação no primeiro ciclo do programa em 2019. Os resultados demonstram que as 11 startups graduadas no Programa demonstraram um aperfeiçoamento e crescimento após os 6 meses de aceleração, viabilizando a proposição de tecnologias mais consolidadas e focadas nos reais problemas da agricultura. O acompanhamento pós-programa indica que estas AgTechs têm auxiliado o produtor rural, efetiva e eficazmente, agregando valor à agricultura brasileira.

Palavras-chave: Agricultura digital. Ecossistema de inovação agrícola. Inovação aberta. AgTechs. Startups.

DOI: 10.5935/1806-6690.20200082

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INTRODUCTION

The Brazilian Digital Transformation Strategy (E-Digital) (BRASIL, 2018) is responsible for the coordination of several public policies that facilitate widespread appropriation of digital technologies in Brazil. Among these policies, we believe the following are highlights: a) stimulating interaction among universities, research and development institutions, and companies in research and development dealing with digital technologies; and b) improving and articulating governmental initiatives that support startups, including acceleration, fund raising, mentoring, and connection with investors, universities, and companies already established in the market. In the agricultural sector, the role of the Brazilian Agricultural Research Corporation, commonly referred to as Embrapa, as a key institution in the process of research, development, dissemination, and technological training, is highlighted by E-Digital, which strives to leverage the digital transformation of the economy.

The contributions of digital technologies in solving traditional problems, modifying operational processes, and improving the customer experience as well as enabling new business models (MASSRUHÁ *et al.*, 2020) have appreciably impacted world agriculture and more recently Brazilian agriculture. A nationwide (Brazil) survey conducted with 753 farmers, companies, AgTechs, and service providers in digital agriculture revealed that 84% of rural producers have already used at least one digital technology in their production process at different technological levels (BOLFE *et al.*, 2020). In this scenario, the so-called digital agriculture revolution is potentially a key technological driver towards the addressing of several challenges, by providing new opportunities in terms of the availability, access, and adoption of data-intensive and interconnected computing technologies (TRENDOV *et al.*, 2019). Currently, new disruptive technologies are responsible for the emergence of Agriculture 4.0, also called digital agriculture, which consists of the use of several new and advanced technologies (including sensors, communication networks, unmanned aviation systems, artificial intelligence, robotics, and other advanced machinery, and often drawing on the principles of the Internet of Things) integrated into one system, to enable farmers and other stakeholders within the agriculture value chain to improve food production (MASSRUHÁ *et al.*, 2020).

Over the years, the business world has used the concept of the ecosystem, initially proposed by Tansley (1935), to conceptualize the relationships between various actors in an environment that is simultaneously collaborative and competitive. Moore (1993) defines how companies interact to evolve their potential, satisfy

their customers, and seek innovation as a “business ecosystem.” In this sense, the involvement of actors, such as research institutions, companies, accelerators, incubators, and technology parks, has strengthened the growth of entrepreneurship in several regions that are referred to as “entrepreneurship ecosystems” (MALECKI, 2018). Increasingly, spaces that promote co-creation and collaboration; events that stimulate ideation and business roundtables; and actions that contribute to the development of innovative projects have been called “innovation ecosystems” (GOMES *et al.*, 2018). The interaction of claimants, suppliers, and collaborators often puts the concept of open innovation into practice. According to Chesbrough *et al.* (2006), “open innovation” assumes that research and development can occur in an open system, in which ideas can arise inside or outside corporations and organizations aiming to improve their products and services, increase efficiency, and accelerate the innovation generated by a company, expanding its market with the external use of its innovations. This paradigm presupposes new business models and commercialization paths to generate and capture value. These phenomena are captured in the agribusiness domain through “agricultural innovation ecosystems,” where the objective is the generation of new technologies and information to effect innovation in agriculture (PIGFORD *et al.*, 2018).

In this scenario, Embrapa has reinforced its role as a key institution in the process of research, development, dissemination, and technological training for the Brazilian agricultural sector, through its association in the innovation ecosystem for digital agriculture via open innovation programs: i) Creative Startups, which is a collaboration between Samsung, the National Association of Entities Promoting Advanced Technology Enterprises — Anprotec, and the South Korean Center for Creative Economy and Innovation (CCEI), with the support of the Brazilian Ministry of Science, Technology and Innovation (MCTI) and the support of the Brazilian Informatics Law (LEI No. 8,248/1991); ii) support for the pre-acceleration of startups, conducted by the Brazilian Micro and Small Business Support Service (SEBRAE-SP); iii) collaboration between Embrapa and the Eldorado Research Institute with Baita Aceleradora to participate in the IA2 MCTI Program supported by Softex, which focuses on developing artificial intelligence solutions; iv) Campo Digital, launched in 2020 by Facebook and Baita, focusing on the development of digital solutions for small and medium agricultural producers; v) TechStart Agro Digital (TSAD), an acceleration program created by Embrapa and Venture Hub, and supported by Anprotec, to help startups, large companies, and institutions to accelerate business and technologies, focusing especially on digital agriculture.

This article presents and discusses the first phase of the implementation of the TSAD, the methodology used in its execution, criteria for its implementation, the methodology adopted for its validation, and the results obtained. It also discusses the lessons learned and suggestions for changes to the proposed methodology. The results demonstrate that the convergence of efforts between science and technology institutions, companies, accelerators, innovation hubs, and other actors in the innovation ecosystem, with which Embrapa is associated, contributes effectively to the improvement and growth of these emerging companies. This enables the generation of more consolidated and focused technologies for real problems of rural producers, adding value and competitiveness to Brazilian agriculture.

MATERIAL AND METHODS

The methodology of the TSAD comprises the technological and business acceleration of AgTechs to boost the arrival of new technologies to the market, such that they offer solutions to real problems of agriculture, bring benefits to farmers, and aggregate more value to agricultural production. The program was structured to strengthen the agricultural innovation ecosystem, in addition to serving the interests of partner companies in the search for potential technologies to integrate their businesses with investment possibilities.

The program steps, briefly presented in Figure 1, comprise the processes of:

1) Screening: To identify TSAD candidates, a website was created with program information and a detailed registration form to collect information about the company, employees, cap-table, history, and technology. With a focus on digital agriculture, the first edition of the program sought startups with expertise in topics, such as: a) biotech, b) precision livestock, c) field automation and robotics, d) animal nutrition and health, e) identification and detection of pests and diseases, f) agricultural risk management, g) horticulture chain, and e) water, soil, and plant management and monitoring.

2) Selection: This step was conducted in two stages: i) analysis of the information provided in the registration form, and ii) interviews. In the first phase, certain criteria were used to define which of the applicants would be invited to the interview stage. Approximately 30 registered startups qualified for the personal or remote interview phase, which occurred both at Venture Hub and Embrapa. The interviews were based on previously defined criteria to assess the level of technological maturity and the alignment of the proposals presented

with the themes foreseen by the program. The questions dealt with the business and technological aspects of the candidate companies and, based on the voting scores of each appraiser, a group of candidates were invited to participate in the final stage of the selection process, which included a legal and accounting assessment. As shown in Figure 1, the selection process aimed at choosing eight to twelve startups for the program. This number was defined based on a previous analysis of the number of mentors, infrastructure, and staff, among others.

3) Acceleration: This stage occurred over a period of 21 weeks divided into five sessions, as illustrated in Figure 2: welcome, traction and finance, product and team development, product growth and delivery, and investment. During the face-to-face sessions, lectures were conducted by specialists in the areas of business, agriculture, people management, personal and team development, communication, and other relevant topics. The setting of the sessions in the acceleration step included workshops and group activities. One of the first meetings had the objective of identifying the expectations of startups in relation to the program. The answers provided were grouped into themes that revealed what the companies in general were looking for when participating in the process. The last step in the acceleration process is an event referred to as Demo Day or Graduation, when startups exhibit their results for strategic partners to better understand new solutions available in the market.

Various activities, such as technical and business mentoring were offered in addition to training during the acceleration process. The purpose of some of these activities was to aid in the validation of products and in the improvement of the business model, while other activities focused on the relationship with investors interested in leveraging new technologies.

The acceleration process also provides for the provision of infrastructure and access to information and specialists. In this context, startups that participate in the TSAD Program receive the benefit of accessing Embrapa's AgroAPI platform (<https://www.agroapi.cnptia.embrapa.br/portal/>) during the six months of acceleration. AgroAPI is an initiative by Embrapa to promote the creation of value in agriculture by offering data and services through Application Programming Interface (API), which are specifications that govern the interoperability between applications and services. AgroAPI facilitates the integration of information systems, enables the saving of computational resources and the sharing of data and services, facilitates the establishment of agreements between organizations, and enables greater reach of the results obtained by the company and its partners (VAZ *et al.*, 2017). APIs are

Figure 1 - Startup identification and selection process - TechStart AgroDigital Program



Figure 2 - TechStart Agro Digital Program 2019 session schedule overview

1. Onboarding	2. Traction, Finances & Product Roadmap	3. Team & Product Development	4. Growth & Product Delivery	5. Funding & Scale
1. Meet your peers, Q&A	2. Traction & Finances 3. Product Roadmap 4. Company Building 5. Company Building	7. Team & Culture 8. Product Development 9. Company Building 10. Company Building	12. Growth 13. Product Delivery 14. Company Building 15. Company Building	17. Funding 18. Scale 19. Company Building 20. Company Building
	6. Review #1	11. Review #2	16. Review #3	21. DEMO-DAY

fundamental in this scenario of digital transformation, which occurs rapidly in organizations and revitalizes their digital business models, changing the way they organize, create, and deliver value (BASOLE, 2016). A session focusses on this theme with a lecture presented by a leading company in the API platform segment, in addition to a workshop on the AgroAPI platform.

The schedule for each session (illustrated in Figure 2) was defined jointly by the organizing institutions. The lectures, workshops, and other activities were focused on the following: research or product development with Embrapa; validation, evaluation, and assistance in a product or startup improvement; access to partners, customers, and the innovation ecosystem in the agribusiness; business issues, such as improving the business model, scalability, reaching new markets,

growth strategies, and fundraising; other matters, such as interactions with other startups, association with the Embrapa brand, issues related to the team, and other more specific topics.

Lectures were conducted by speakers such as former presidents and heads of research centers of Embrapa, and important actors in the innovation ecosystems of Campinas and neighboring cities, where the program is conducted. The lectures covered agribusinesses, the theme of the program, and included technical workshops with methodologies, such as Technology Roadmap (TRM) and User Experience. From a business point of view, Venture Hub provided numerous lectures on various topics that are directly related to the startup's own development, enabling a broad assessment of its business model and assisting

in the validation of its initial hypotheses. Talks about teams, with specialists in human resources, and about communication and brand, with specialists in those areas, are examples of the stages of the program. In addition, the environment promotes interaction between startups.

Moreover, meetings with producers and investors were part of the activities, as well as the participation of the startups in regional events, in which they demonstrated their core business and technologies in stands organized by Embrapa and Venture Hub. Business-related topics, such as lectures and workshops on access to capital, sales, traction, and meeting with investors, were promoted by the accelerator.

In addition to workshops and lectures by the organization, pitches were frequently presented by startups and evaluated by different teams of specialists. The diverse profile of the evaluators provided for a collection of interesting feedback for the startup teams. The pitches also helped track the evolution of each company throughout the process.

In addition to face-to-face meetings, startups met with mentors from both Venture Hub and Embrapa two to three times a month to resolve specific issues, personally or remotely (e-mail, telephone, and virtual meetings). Google Classroom was also used as a support tool for the distribution of materials for face-to-face sessions, requests for deliveries to be made by startups, feedback, and general monitoring.

RESULTS AND DISCUSSION

After the initial selection phase, approximately 30 startups were invited to the second phase, where they participated in face-to-face or distance interviews. At the end of the selection process, 13 startups were invited to participate in the first cycle of TSAD - the acceleration process. At the beginning of 2020, 11 of these startups graduated from the acceleration program.

Table 1 summarizes the startups for the first cycle of TSAD, their core business, and their location.

During the 21 weeks of the program, startups were supported, guided, and accompanied by more than 80 mentors focused on helping them increase the efficiency of their technological and business development processes. In this manner, they were able to introduce new technologies to the market with a focus on real agricultural problems, with benefits to the farmer, and more value for agricultural production. The business models of these emerging companies were improved

through technical and business mentoring, fundraising, and connection with more than 15 investors or investment funds, universities, and companies already established in the market in digital agriculture. Complementarily, the startups participating in the program were encouraged to interact with institutions and companies in research and development activities in digital technologies for agriculture by approaching business incubators, technology parks, and innovation hubs.

To accomplish this, the program provided a digital tool for recording feedback regarding interaction and organization of content via Google Classroom. During the first cycle of TSAD, more than 450 instances of feedback and 770 assignments with a focus on strategy and growth were officially registered through Google Classroom. The program also included the participation of mentors in legal, intellectual property, accounting, and other fields to ensure the legality and sustainability of the business. As a result, the number of office hours between startups and the program staff was over 120 h during the six months of acceleration.

The startup teams also received mentoring in the area of communications, being encouraged, accompanied, and guided in technological fairs and innovation events. The presence of the startups at these events led to an increase in the dissemination of the program in various media, which attracted new participants and supporters for the 2020 edition of the program.

The infrastructure offered by the TSAD in 2019 included Venture Hub's Innovation Hub at Campinas for acceleration sessions, mentoring, training and meetings, the Embrapa infrastructure with access to experimental fields and laboratories, and access to the partner network and its available assets. In addition, considering that it is in informal work environments where people acquire 70% of the knowledge and skills necessary to perform well, face-to-face sessions were organized with workshops, lunches, and happy hours for interaction between participants from startups and mentors.

The main results of the TSAD Program in its first edition are as follows: i) increased proximity between startups and Embrapa; ii) celebrating six partnership agreements between startups and Embrapa Research Centers; iii) establishing more than 30 connections from startups with large companies during the program; iv) 300x increase in growth (in Ha) in the area covered by one startup at the end of the first cycle of the acceleration program; v) selection of two startups that participated in the TSAD in the IA² MCTI / Softex Program call, which aims to support research and development projects oriented towards the development of artificial intelligence solutions; vi) investment proposals for five startups during

Table 1 - Summary of the 11 startups that graduated from the acceleration program

Name	Core business	Locality
Aptah	Research and development of new pesticides and diagnostic kits for the agro-industrial market. Specialist in computational biology; has already received R \$ 1.3 million in funding.	Brasília, DF
BirdView	Development, manufacture, and operation of agricultural implements for the release of biological inputs on a large scale and at low cost.	Botucatu, SP
Brazsoft	Develop solutions for the organization of data to transform them into objective information on the financial and productive situation of the entire farm.	Cuiabá, MT
Dominus Soli	Pioneer in the development of solutions focused on the planning and monitoring of aerial application services for agrochemicals. The company enables increased control, productivity, and mitigation of socio-environmental risks through the traceability of operations.	São João da Boa Vista, SP
Gira	Fintech that aims to bring greater security to agricultural credit operations. The company operates in all Brazilian productive regions and has already managed more than R \$ 4 billion in securities and credit assignments, in more than one million hectares. It offers services to creditors as well as structure and risk taking in Agribusiness Receivables Certificates (CRA, in Portuguese) and Credit Receivables Investment Funds (FIDC, in Portuguese).	Uberlândia, MG
Inceres	Flexible agronomic digital platform capable of storing and processing structured and unstructured data to support business decisions. The company understands digital technology as a means to expand the human capacity to make the best decisions in agribusiness.	Piracicaba, SP
IZAgro	Free mobile and web platform that conveys information and alerts to over 50 thousand farmers across Brazil and helps them make better decisions, connecting them with consultants and input distributors to search for better information and business opportunities.	Franca, SP
Pasto sempre verde	Platform for intelligent management of pastures that enables the multiplication of meat production, without increasing the number of hectares.	Jaguariúna, SP
Pitaya Irrigation	Company offering digital and analog solutions based on soil moisture sensors patented by Embrapa and Tecnicer Tecnologia Cerâmica, to help farmers irrigate more efficiently, accurately, and sustainably to produce more while wasting less water.	São Carlos, SP
Precision Cane	Company focused on the development of technologies for the generation of standardized and high-quality cane blanks, seeking to make the planting of sugarcane sustainable.	Lençóis Paulista, SP
Verde Drone	Digital platform that connects drone pilots, agronomists, and companies closer to agricultural areas. In this way, it offers a network that speeds up the production of georeferenced maps and other services, all connected by an application, generating value in the agribusiness chain.	Belo Horizonte, MG

the acceleration process; vii) a bank acquired 80% of the business from one startup at the end of TSAD.

Complementarily to the results obtained, we also highlight the potential of the program to i) guide the formulation of public and private strategies for the strengthening of new lines of research, development, and innovation linked to the demands obtained from the productive sector and aimed at adding value to the Brazilian agricultural products; ii) support the various stakeholders of the innovation ecosystems to invest in capacity building and training considering the different technological, economic, and social levels in topics, such as: a) management and administration of rural property, b) purchase of agricultural inputs and marketing of production, c) land use planning, d) detection and control of diseases, water, or nutritional deficits, e) prediction of climatic risks, and f) certifications and traceability; iii) support the strategic decisions of stakeholders in innovation ecosystems for the development of disruptive innovations in digital agriculture on topics such as big data (WOLFERT *et al.*, 2017), machine and deep learning (LIAKOS *et al.*, 2018; KAMILARIS *et al.*, 2018), agricultural IoT (VERDOUW, 2019), remote sensing (KAYAD *et al.*, 2020), mobile applications (MICHELS *et al.*, 2020), connectivity (ZERVOPOULOS *et al.*, 2020), blockchain (CHEN *et al.*, 2020), artificial intelligence (ABRAHAM *et al.*, 2020), and quantum computing (MICROSOFT; IBM; DELL, 2020).

Digital agriculture offers new insights that enhance the ability to make decisions and subsequently implement them; further, digital agriculture exhibits the potential to make agriculture more productive and to use time and resources more efficiently. This brings critical advantages for farmers and enables organizations to share information across traditional industry boundaries to open up new disruptive opportunities. However, the approach is still new and certain costs are high (UNGC, 2017). To secure its widespread adoption will require collaboration of research and development institutions and AgTechs in the digital transformation of Brazilian agriculture, as brought about by the TechStart Agro Digital Program.

CONCLUSIONS

1. The main contribution of this article concerns the presentation of a startup acceleration program focused on agribusiness, especially on Agriculture 4.0 or digital agriculture. The results of this work provide evidence that joint efforts of RD&I institutions, companies, accelerating companies, innovation hubs, and other stakeholders in the ecosystem contribute

to the improvement and growth of startups. In this manner, these startups can bring more consolidated technologies to the market with a focus on real problems in agriculture, aiding rural producers, and adding value to Brazilian agriculture;

2. After the completion of the first cycle of the startup acceleration program, adaptations were made to the methodology to provide mechanisms to enable greater proximity between startups and technical mentors. The content and objectives of each day of the acceleration program were improved to define which additional technological tools must be added to monitor the development of the startups throughout the new cycles of the program, especially in the current pandemic scenario in which much of the program must be conducted digitally;
3. The TechStart Agro Digital Program leveraged the generation of disruptive digital solutions, which favored greater competitiveness and added value to Brazilian agriculture. Digital technologies increase the interaction between links in agricultural production chains and promote new approaches and applications in rural areas. The challenges to expanding digital transformation in agriculture include greater public and private investments in science, innovation, entrepreneurship, connectivity, communication, and professional training.

ACKNOWLEDGMENTS

We thank the staff responsible for organizing the first cycle of TechStart Agro Digital, as well as the mentors, speakers, and supporters who contributed towards the success of this initiative. We would also like to thank the directors of Embrapa and Venture Hub for their support and for the financial and non-financial resources that made the program feasible.

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