*sustainability*

MDPI

*Article*

# Training Sources and Preferences for Agricultural Producers and Professionals in Middle-North Mato Grosso, Brazil

**Jordane Aparecida Vieira dos Reis [1], Aaron Kinyu Hoshide [1,2,*], John Robert Vreyens [3], André Soares de Oliveira [4], Vanessa Aparecida Moreira de Barros [1], Wininton Mendes da Silva [5], Luana Molossi [1], Jessica Lima Viana [1], Daniel Carneiro de Abreu [1,4] and Ronaldo Alves de Oliveira [1]**

1 AgriSciences, Universidade Federal de Mato Grosso, Caixa Postal 729, Sinop 78550-970, MT, Brazil
2 College of Natural Sciences, Forestry and Agriculture, The University of Maine, Orono, ME 04469, USA
3 College of Food, Agricultural and Natural Resource Sciences, University of Minnesota Extension, Saint Paul, MN 55108, USA
4 Instituto de Ciências Agrárias e Ambientais (ICAA), Universidade Federal do Mato Grosso, Campus Universitário de Sinop, Avenida Alexandre Ferronato, 1200, Sinop 78550-728, MT, Brazil
5 Empresa Mato-Grossense de Pesquisa, Assistência e Extensão Rural (EMPAER-MT), Centro Político Administrativo, Cuiabá 78049-903, MT, Brazil
* Correspondence: aaron.hoshide@maine.edu; Tel.: +1-207-659-4808

**Abstract:** Brazil's midwest has rapidly expanded large-scale commodity crops such as soybeans and maize. We surveyed both agricultural producers and agricultural professionals in the middle-north region of Mato Grosso state, Brazil. Agricultural professionals provide technical support to agricultural producers and both are served by Assistência Técnica e Extensão Rural (ATER) with nationally and internationally recognized extension outreach. Our objectives were to define and contrast agricultural producer and professional characteristics, especially source(s) relied upon for agricultural training. There were 94 agricultural producers and 89 agricultural professionals that responded to our surveys, which were summarized and contrasted using statistical software. There was a predominance of male farmers, married with a broad age range. Agricultural professionals who advise producers had a high educational level. Producers and professionals were most reliant on private sector agricultural companies and business support organizations for agricultural training, versus public institutions such as universities and state/federal agencies. In the state of Mato Grosso, extension outreach can involve joint efforts by public and private sector entities. However, more targeted efforts are needed to ensure that public sector research is more equally used by agricultural producers and professionals in the region, especially during field days and face-to-face technical lectures during the off-season.

**Keywords:** agricultural education; agricultural producers; agricultural professionals; education and learning processes; questionnaires; rural extension



**Citation:** Reis, J.A.V.d.; Hoshide, A.K.; Vreyens, J.R.; Oliveira, A.S.d.; Barros, V.A.M.d.; Silva, W.M.d.; Molossi, L.; Viana, J.L.; Abreu, D.C.d.; Oliveira, R.A.d. Training Sources and Preferences for Agricultural Producers and Professionals in Middle-North Mato Grosso, Brazil. *Sustainability* **2023**, *15*, 4712. https://doi.org/10.3390/su15064712

Academic Editor: Emanuele Radicetti

Received: 24 January 2023
Revised: 26 February 2023
Accepted: 3 March 2023
Published: 7 March 2023



## 1. Introduction

The Cerrado–Amazon ecotone is a macro-region composed of sixteen municipalities with relief, soil, and climate conditions that are favorable to the cultivation of annual crops. According to the Instituto Mato-Grossense de Economia Agropecuária (IMEA) in 2017 [1], this is an important region for grain production and distribution in the state of Mato Grosso and for the Brazilian economy. Technological innovations in Mato Grosso have quadrupled agricultural production from 1990 to 2020, while land area used to grow grain has only increased by 68% in the same period [2]. Brazilian agribusiness development, especially in the state of Mato Grosso, has seen increased demand for qualified labor and professional skills and competencies. Brazil's federal government has stimulated agricultural development in middle-north Mato Grosso state since the 1970s and 1980s.

Migrants from southern Brazil (e.g., Parana state) were encouraged to occupy the Cerrado (i.e., savannah) and Amazon, expanding cattle ranching and crop production [3,4].

Mato Grosso is a state located in the midwest region of Brazil spanning 903,207 $km^2$. In 2021, it had 3,567,234 people with a population density of 3.94 inhabitants/$km^2$ [5]. The state of Mato Grosso has the largest cattle herd in the country, with 32,424,958 heads. In 2017, Mato Grosso state had 118,679 rural properties totaling 54,922,850 hectares intended for agricultural production [6]. Mato Grosso is the largest Brazilian soybean-producing state, having 10,909,400 hectares planted producing 39,961,100 metric tons (t), with a productivity of 3.663 t/ha in 2022. For maize in the year 2022, the state of Mato Grosso had a planted area of 6,547,400 hectares producing 41,620,100 t with a productivity of 6.357 t/ha [7].

To increase productivity gains in agricultural regions, independent extension projects such as those developed by universities are very important [8]. However, despite the potential for agricultural technological innovation in the region and access to the Universidade Federal de Mato Grosso (UFMT) and its partners, there has been low participation in extension programs (innovation programs, technical lectures, and workshops) offered by these institutions. AgriSciences at UFMT is a program responsible for applied research and rural extension programming (Table 1) focused on sustainable agriculture established in 2016 [9]. Through public/private partnerships, AgriSciences develops extension actions focusing on producers, technical professionals, and rural youth. From 2019 to 2022, more than 3600 people were directly reached through extension activities (Table 1).

There are numerous challenges to establishing successful agricultural training programs even with a lot of extension agents per capita [10]. It can be difficult for rural agricultural extension to customize education to different types of producers (e.g., row crop, cattle ranchers, subsistence farming) with different socio-economic backgrounds [11]. Previous studies in developing nations suggest more limited participation in agricultural training for older, less educated farmers living further away from extension services [12,13]. Agricultural producers also have limited time and resources to devote to agricultural training. A previous study [14] surveyed 355 farmers in northern Greece where 47.6% could attend less than 2 days of Agricultural Education Programs annually. On-farm demonstrations require extensive and multi-faceted planning [15]. More modern methods of rural extension can be novelties, both for agricultural producers and professionals and institutions in Brazil [16].

While production challenges, mainly in grain production, have encouraged new investments and increased technology diffusion in agriculture [17], addressing environmental and community sustainability can remain challenging. Brazil has had challenges successfully developing agro-ecological extension approaches for agriculture at a federal level [18]. Agricultural education has been shown to be more challenging for environmental management in New Zealand [19] and for rural development policies in Italy [20]. For Peruvian dairy farmers, private agricultural advisors tend to increase farmer reliance on the external inputs these advisors are selling [21]. Acknowledging farmers' rational barriers to adopting more environmentally friendly practices [22] and engaging them in developing individualized solutions can improve sustainability [23].

Due to the middle-north region of Mato Grosso's relevance for agriculture and importance in contributing to Brazil's national and international economy, it is important to better understand farmers' and agricultural professionals' sources and preferences for agricultural training. This can reveal potential drivers of farmers' low level of interest in participating in public innovation programs. Addressing these shortfalls in program interest can meet the goal of enhancing the engagement of agricultural producers and professionals in this region in Brazil.

**Table 1.** AgriSciences program components in middle-north Mato Grosso state, Brazil.

| AgriSciences Program Components | Description | Methods | Participants (2019–2022) |
|---|---|---|---|
| Demonstrative Unit (DU) | Commercial rural property, where research and extension actions are already established. Offers producers and technicians local training programs for practical application of technologies and develops and evaluates research on advantages and disadvantages of such technologies. | • Field day<br>• Technology showcase<br>• Course<br>• Technical visit<br>• Lecture<br>• Meeting | 2261 |
| Multiplier Unit | Rural property close to DU disseminating and transferring one or more technologies developed and/or validated at the DU. Promotes technology adoption and enables exchange of experiences between producers. Disseminates knowledge in environment close to their familiar daily life. | • Course<br>• Technical visit<br>• Lecture<br>• Knowledge exchange<br>• Meeting | 33 |
| Community Engagement | Community formed by academics, rural producers and professionals, young people, and rural children. Intended to bring together younger people and rural dwellers to disseminate academic knowledge, scientific production, and technological innovation using correct approaches. | • Workshop<br>• Lecture<br>• Course<br>• Seminar | 1301 |
| Exchange of Leaders | International, practical experiences by academics and recent graduates. Allows exchange of rural youths, higher education students, and graduates in the United States. Focus on practical teaching of new practices for Mato Grosso. | • Course<br>• Hands-on<br>• Internship | 54 |

Thus, there were three general research objectives of our study. The first objective was to develop baseline profiles of crop farmers and agricultural professionals in middle-north Mato Grosso. Our second objective was to identify the sources of and preferences for public and private agricultural knowledge and education by both agricultural producers and professionals in this region. Finally, our third research objective was to determine the extension method (e.g., field day, course, workshop, seminars, etc.) that our audience of farmers and professionals prefers in order to receive such knowledge and education. Customizing agricultural training to better meet the preferences and needs of producers and professionals can improve agricultural production practices and cropping system management in the long run.

## 2. Materials and Methods

### *2.1. Study Area and Methodological Approach*

The area selected for study was the middle-north macro-region of Mato Grosso state (MT) because of its central location within this state in Brazil. The region is important for the production, marketing, and distribution of commodity crops (e.g., soybeans, maize, and cotton) in MT [1,2]. Our study used qualitative, quantitative, and descriptive data and

analyses using the participatory rural appraisal (PRA) methodological approach. PRA is a research and data collection process intended to include the perspectives of all groups of interest of a community, causing a change in the traditional surveyor/surveyed roles so that multiple stakeholders participate in determining how data collection will be conducted [24]. The method also serves as a communication channel between those who share a common problem. We solicited feedback from agricultural producers and professionals to refine our surveys (Supplementary Materials) as well as collection of survey data.

### 2.2. Sampling and Survey Administration

Our research team surveyed 94 medium-to-large grain producers and 89 agricultural professionals during the spring and early summer of 2019. Producers were mainly from the cities of Nova Mutum (13.82681 S, 56.07165 W), Lucas do Rio Verde (13.073898 S, 55.91885 W), Sorriso (12.54209 S, 55.72081 W), and Sinop (11.85984 S, 55.50723 W), which lie on Route 163, which is among the larger cropping areas in South America. The middle-north region of Mato Grosso transitions from the Cerrado to Amazon biomes moving south to north from Nova Mutum to Sinop (Figure 1). Our survey design, implementation, and analyses are summarized in Figure 2.

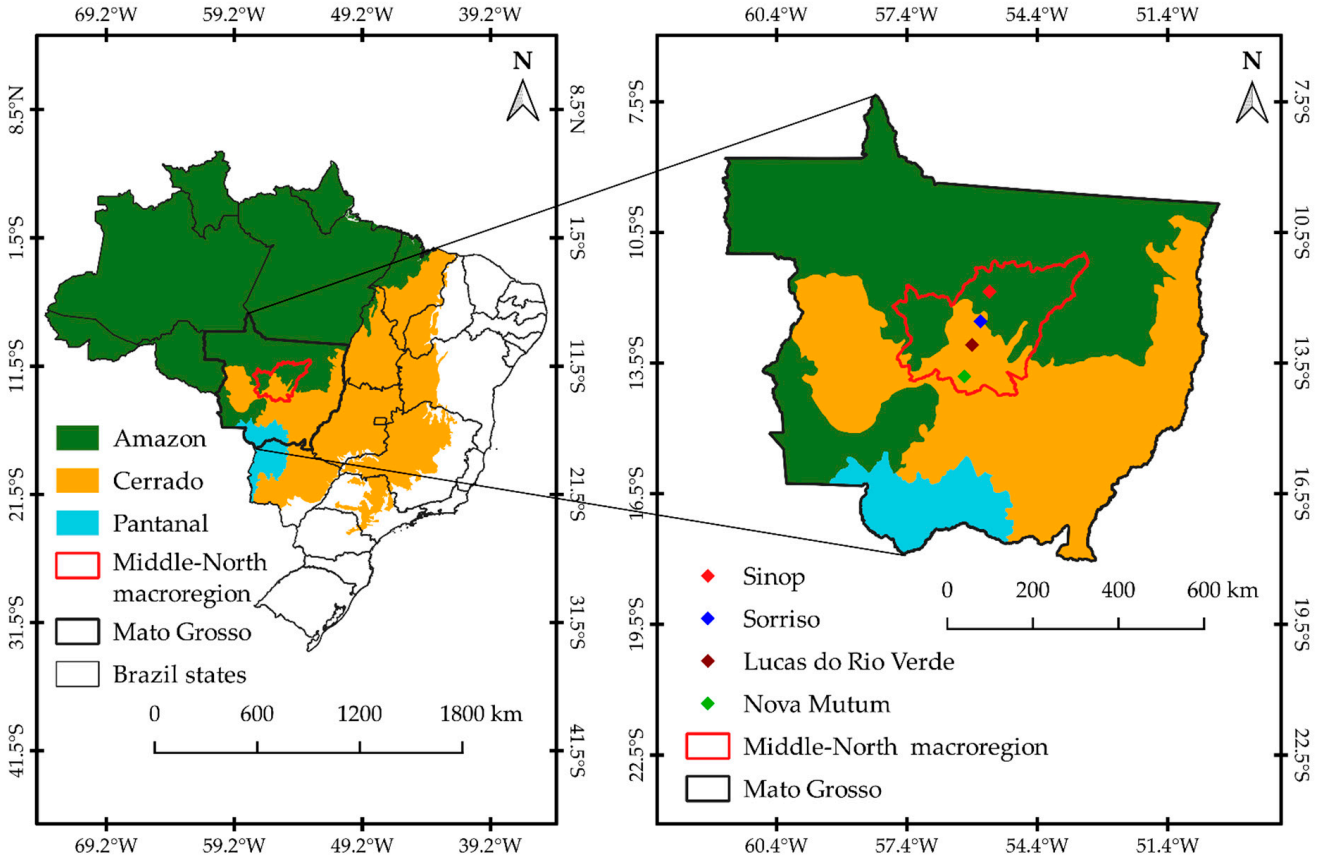



**Figure 1.** Survey city locations in the middle-north of the state of Mato Grosso, Brazil. Both maps show the Amazon, Cerrado, and Pantanal biomes in Brazil.

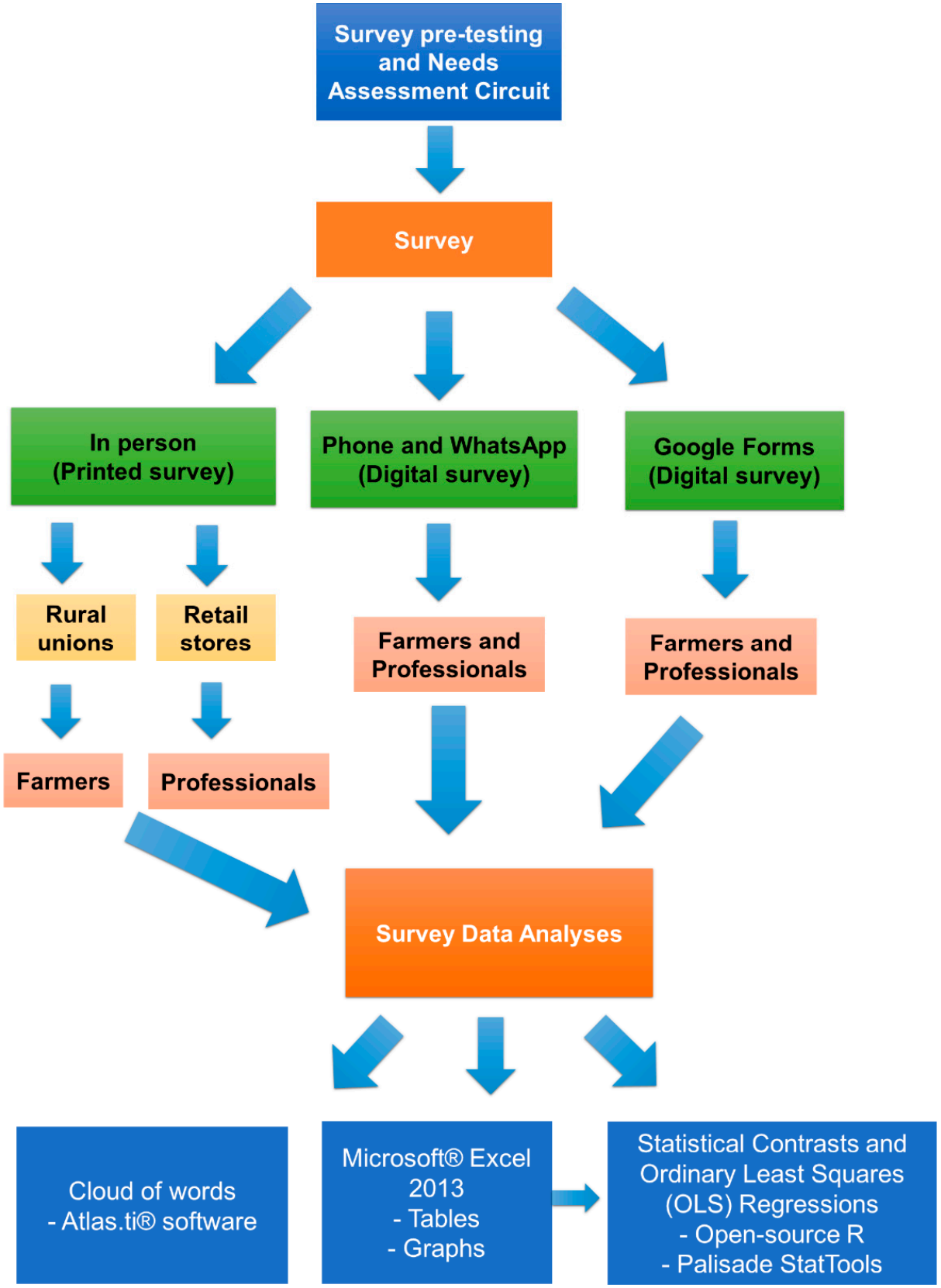



**Figure 2.** Survey flow chart for agricultural producers and agricultural professionals in middle-north Mato Grosso state, Brazil.

Surveys of agricultural producers and professionals were administered both in person and online, using the Google Forms platform. Survey questions were designed to take around half an hour to complete. A team of researchers and graduate students from the Universidade Federal Mato Grosso (UFMT), Empresa Brasileira de Pesquisa Agropecuária (Embrapa), and the University of Minnesota revised survey questions before final administration. We used the "Needs Assessment Circuit" (NAC) [25] which estimated time needed to answer survey questions and number of target responses for each town. NAC was selected based on its use in previous studies of agricultural stakeholder involvement [26]. Surveys of agricultural producers and professionals started during the spring of 2019. Due to low initial response to our online survey after a month, we directly surveyed both agricultural producers and professionals via unions and retailers over three months from June to August 2019.

Our project was presented to the trade unions of each town to facilitate communication to our target audience of agricultural producers. Producers answered questions on paper and sometimes by phone. Support of rural trade unions helped ensure at least two working days were available for direct contact with producers. Our team visited all four cities (Figure 1) and coordinated with agricultural companies to forward e-questionnaires to interested agricultural professionals and their teams. Presentations about our survey were given to at least ten agricultural companies in each city. This facilitated survey data collection in person using paper surveys and, in some situations, by using the online version of the survey and quick communication applications (WhatsApp®).

Our agricultural producer survey was divided into three sections. The first section included socio-demographic questions on age, gender, marital status, educational level, and residence. Additionally, respondents were asked about their length of experience or service in the agricultural sector. Agricultural producers were asked if they lived on-farm and, if not, how often they visited their farms, and who was responsible for the farm's technical decisions. The survey's second section asked questions on farm area, crop production and management, and participation in farm programs and agricultural training. Finally, questions in the third section asked producer preferences for agricultural extension topics, extension methods (e.g., field day, course, workshop, seminars, etc.), as well as general comments and suggestions.

The agricultural professional survey was also divided into three sections. The first section asked about the professionals' general background such as where they were located, education, occupation, number of farmers served, and crop area and types covered. The second survey section involved technology transfer to clients, probability of using information through current communication channels, frequency of reading specialized literature, and the amount of training carried out in a year. The final survey section asked about preferred extension methods, outreach duration and scheduling, and availability for in-person and online training. General suggestions and comments were also solicited.

### *2.3. Data Organization and Analysis*

Survey data were entered into Microsoft® Excel 2013 to generate tables and graphs. We coded survey responses to categorical questions in order to generate summary statistics and to use for multi-variate regression analyses [27]. Both agricultural producers and professionals specified the crop systems with which they were involved. Responses to questions commonly asked to both agricultural producers and professionals were tested for statistically significant differences between these two respondent groups using the Z-test for significant differences between proportions in open-source R. These common questions included residence, education, and source(s) used for agricultural training. We arranged open-ended responses for comments and suggestions as a running text and then built a cloud of words using the Atlas.ti® software. This program identified frequently used words by both producers and professionals for visual comparison. We ran Ordinary Least Squares (OLS) regressions in both open-source R and Palisade Decision Tools Suite's StatTools to

determine independent variables significantly impacting the proportion of public (versus private) training sources for both agricultural producers and professionals.

## 3. Results

### *3.1. Survey Respondent and Farm Area Characteristics*

#### 3.1.1. Agricultural Producers and Their Farms

Characteristics of agricultural producers are presented in Table 2. About one-quarter of producers (24.7%) were between 56 and 65 years old, while those aged 25 to 35 years comprised 23.6% of the sample. Most producers were male (91.4%) and were married (82.6%). Based on a Brazilian agricultural and livestock censuses conducted between 2006 and 2017, the cultivation of cotton, sugarcane, seeds and seedlings, planted forests, and aquaculture had minimal participation from women. These activities employ poorly paid wage labor, are highly mechanized, and are common on patriarchal farms [28].

Most surveyed producers (61.3%) reported having ≥20 years of farming experience (Table 2). Agricultural producers had a range of educational backgrounds, where 46.7% had up to a high school degree and 27.2% had an undergraduate college degree (Table 3). Of the 40 producers specifying other higher education or an undergraduate degree, 50% were agronomists (Table 2). Advanced degrees (6.5%) and technical education (3.3%) comprised the remaining balance of educational backgrounds (Table 3). Our results are consistent with a previous study reporting that rural producers in Brazil differed with regard to schooling and how technical information is obtained [29].

Most interviewed producers (68.8%) did not live on-farm (Table 2) and were more likely to manage farms located in areas outside of the four major cities compared to the farms serviced by agricultural professionals ($p$ = 0.005, Table 3). Typically, producers maintain a residence in an urban area, which allows access to a better living standard for their families (e.g., education, healthcare, entertainment, commerce, and other services). Finally, management decisions were made individually by the producer (29.2%) or were made together with some member of the family (42.7%) or with an external individual (24.7%). Thus, 96.6% of producers' agricultural property and enterprises are managed by the farmer, his wife, and children (Table 2).

Most farms managed by agricultural producers fell in the 500-to-1499-hectare (ha) size class (34.4% of producers), with 77.4% of the farms greater than or equal to 500 ha (Table 1). Most farms managed in our study were larger than observed in other regions of Brazil where only 0.9% of the farms are over 1000 hectares [30]. Mato Grosso is Brazil's largest agricultural state, producing 21.1% of the country's agricultural value [31]. Commodity crops include maize (*Zea mays* L.) or cotton (*Gossypium* sp.) grown as a second crop following soybeans (*Glycine max* L.) in the same production year [32]. Commodity crop production has historically transitioned from frontier development to greater intensification in order to reduce deforestation through collaboration of the private and public sectors with non-governmental organizations (NGOs) [33].

**Table 2.** Characteristics for crop producers from middle-north region, Mato Grosso state, Brazil in 2019.

| Producer Characteristic | *n* | % |
|---|---|---|
| Age (*n* = 93): | | |
| <25 | 5 | 5.4 |
| 25–35 | 22 | 23.6 |
| 36–45 | 18 | 19.4 |
| 46–55 | 18 | 19.4 |
| 56–65 | 23 | 24.7 |
| >65 | 7 | 7.5 |
| Gender (*n* = 93): | | |
| Male | 85 | 91.4 |
| Female | 8 | 8.6 |
| Civil Status (*n* = 92): | | |
| Single | 14 | 15.2 |
| Married | 76 | 82.6 |
| Divorced | 2 | 2.2 |
| Undergraduate area (*n* = 40): | | |
| Agronomist | 20 | 50.0 |
| Other professions | 15 | 37.5 |
| Administrator | 2 | 5.0 |
| Veterinarian | 1 | 2.5 |
| Economist/Accountant | 2 | 5.0 |
| Live on farm (*n* = 93): | | |
| Yes | 29 | 31.2 |
| No | 64 | 68.8 |
| Administrative decisions made (*n* = 89): | | |
| Individually | 26 | 29.2 |
| With husband (wife) | 15 | 16.9 |
| With husband (wife) and children | 23 | 25.8 |
| With someone outside the family | 22 | 24.7 |
| Outside the family | 3 | 3.4 |
| Years in agriculture (*n* = 93) | | |
| 0–10 | 16 | 17.2 |
| 10–19 | 20 | 21.5 |
| 20–29 | 23 | 24.8 |
| 30–39 | 20 | 21.5 |
| 40–50 | 11 | 11.8 |
| >50 | 3 | 3.2 |
| Farm area managed (hectares) (*n* = 93): | | |
| <500 | 21 | 22.6 |
| 500–1499 | 32 | 34.4 |
| 1500–3499 | 20 | 21.5 |
| 3500–9999 | 19 | 20.4 |
| >10,000 | 1 | 1.1 |
| Uses farm credit (*n* = 93): | | |
| Yes | 76 | 81.7 |
| No | 17 | 18.3 |

**Table 3.** Characteristics and preferences of agricultural producers and professionals in middle-north region, MT, Brazil in 2019.

| Respondent Characteristics and Preferences | Producers | | Professionals | | Z-Test |
|---|---|---|---|---|---|
| | *n* | % resp. | *n* | % resp. | *p*-Value |
| Location: | 91 | | 89 | | |
| Sinop | 19 | 20.9 | 29 | 32.5 | 0.108 |
| Sorriso | 23 | 25.3 | 28 | 31.5 | 0.450 |
| Nova Mutum | 16 | 17.6 | 12 | 13.5 | 0.580 |
| Lucas do Rio Verde | 9 | 9.9 | 9 | 10.1 | >0.999 |
| Other | 28 | 30.8 | 11 | 12.4 | 0.005 |
| Educational level: | 92 | | 89 | | |
| Up to high school | 15 | 16.3 | 2 | 2.3 | 0.003 |
| Completed high school | 28 | 30.4 | 1 | 1.1 | <0.0001 |
| Technical education | 3 | 3.3 | 14 | 15.7 | 0.009 |
| Other higher education | 15 | 16.3 | 0 | 0 | 0.0002 |
| College Degree (B.A., B.S.) | 21 | 22.8 | 47 | 52.8 | <0.0001 |
| Graduate Degree (M.S., Ph.D.) | 6 | 6.5 | 25 | 28.1 | 0.0003 |
| Works with crop system type(s) [a]: | 93 | | 85 | | |
| Just soybeans (S) | 6 | 6.5 | 1 | 1.2 | 0.155 |
| S-Maize (M) | 55 | 59.1 | 56 | 65.9 | 0.439 |
| S-Cotton | 7 | 7.5 | 28 | 19.7 | <0.0001 |
| S-M-Pasture | 28 | 30.1 | 26 | 18.3 | >0.999 |
| Other crop(s)/enterprise | 31 | 33.3 | 31 | 21.8 | 0.778 |
| Sources for agricultural training [a]: | 83 | | 86 | | |
| Public training sources: | | | | | |
| Regional extension | 39 | 47.0 | 22 | 25.6 | 0.006 |
| Universities | 10 | 12.0 | 16 | 18.6 | 0.333 |
| State research | 7 | 8.4 | 6 | 7.0 | 0.947 |
| Federal research | 21 | 25.3 | 18 | 20.9 | 0.623 |
| Private training sources: | | | | | |
| Chemical companies | 37 | 44.6 | 71 | 82.6 | <0.0001 |
| Fertilizer companies | 17 | 20.5 | 55 | 64.0 | <0.0001 |
| Retail companies | 40 | 48.2 | 44 | 51.2 | 0.816 |
| Independent consultants | 15 | 18.1 | 29 | 33.7 | 0.032 |
| Other private entities | 3 | 3.6 | 4 | 4.7 | >0.999 |
| Preferred topics for training [a]: | 90 | | 88 | | |
| Physical soil qualities | 40 | 44.4 | 44 | 50.0 | 0.554 |
| Soil conservation | 47 | 52.2 | 40 | 45.5 | 0.451 |
| Soil–plant–atmosphere relations | 26 | 28.9 | 17 | 19.3 | 0.188 |
| Soil preparation | 38 | 42.2 | 48 | 54.5 | 0.135 |
| GPS and precision agriculture | 35 | 38.9 | 34 | 38.6 | >0.999 |
| Weed management | 55 | 61.1 | 63 | 71.6 | 0.187 |
| Plant mineral nutrition | 42 | 46.7 | 61 | 69.3 | 0.004 |
| Correcting soil acidity | 39 | 43.3 | 53 | 60.2 | 0.035 |
| Plant fertilizer management | 50 | 55.6 | 64 | 72.7 | 0.026 |
| Soil biology | 49 | 54.4 | 37 | 42.0 | 0.132 |
| Soil fertility assessment | 49 | 54.4 | 62 | 70.5 | 0.040 |
| Other topics | 10 | 11.1 | 8 | 9.1 | 0.843 |
| Optimistic on future of agriculture: | 91 | | 88 | | |
| Yes | 68 | 74.7 | 83 | 94.3 | 0.0007 |

[a] Producers and professionals could specify multiple categories.

#### 3.1.2. Agricultural Professionals and Advisory Area

Agricultural professionals were statistically more highly educated than producers, with 52.8% being college graduates, 28.1% having a post-graduate degree, and 15.7% completing technical education beyond high school. Only 3.4% had some high school education or just a high school diploma (Table 3). Other research has highlighted the need for educated workers since they have to perform different jobs in the urban or rural agribusiness sector [34]. Table 4 summarizes responses to questions specifically

asked to agricultural professionals. Here, 43.8% of professionals provided assistance to 0 to 19 clients, 33.7% to 20 to 39 clients, and 18% to more than 60 clients. This was similar for farm area serviced with 59.1% of professionals being responsible for under 40,000 hectares (ha) and 25% for more than 60,000 ha. Large-scale soybean production is one of the most economically important crops in Brazil and crop extension plays a critical role in promoting scientific advances and new production technologies [35].

**Table 4.** Characteristics of agricultural professionals from middle-north region, Mato Grosso state, Brazil in 2019.

| Professional Characteristics | *n* | % |
|---|---|---|
| Number of rural producers assisted (*n* = 89): | | |
| 0–19 | 39 | 43.8 |
| 20–39 | 30 | 33.7 |
| 40–60 | 4 | 4.5 |
| >60 | 16 | 18.0 |
| Total area covered by professionals' work (*n* = 88): | | |
| 0–19,000 hectares | 24 | 27.3 |
| 20,000–39,999 hectares | 28 | 31.8 |
| 40,000–59,999 hectares | 14 | 15.9 |
| >60,000 hectares | 22 | 25.0 |

### *3.2. Agricultural Systems*

Based on the responses of agricultural producers and professionals regarding the crop(s) that they work with, five annual cropping systems were defined: (1) soybeans (S) only, (2) S-maize (M), (3) S-cotton, (4) S-M-pasture, and (5) systems involving other crops/enterprises. The S-M double-cropping system had the highest involvement from both producers (59.1%) and professionals (65.9%). For producers, this was followed by other crops/enterprises, S-M-pasture, S-cotton, and just soybeans. Professionals were similar, with the exception of S-cotton being more commonly worked with than the S-M-pasture integrated system. Professional involvement with S-cotton was statistically greater ($p \leq 0.0001$) than producers (Table 3), which may be due to the management complexity of cotton [36] requiring more agricultural professional advisory services.

Most producers plant one, two, or three annual crops in a year, typically following each other from the wet season (October to February) to dry season (March to September). Only 6.5% of producers and 1.2% of professionals are specialized in just soybeans. More common are involvement in either (1) S-cotton due to longer maturity for cotton or (2) S-M where a third sequential crop could be added, such as S-M-pasture, where the pasture is under-seeded during maize planting in February. Most producers (89.2%) and professionals (84.2%) were involved with soybeans double-cropped with maize as a second crop (*safrinha*). Fewer producers (33.3%) and professionals (21.8%) dealt with second/third crops such as bean, sorghum, and *Crotalaria juncea* (rattle pods grown as a cover crop). Furthermore, 30.1% of farmers cultivated pasture, typically as the third crop, while 18.3% of professionals worked with this type of integrated cropping system (Table 3). Third crops grown during the dry season (June to September) with no or very limited rainfall require more technology (e.g., irrigation), typically used by larger producers [37].

### *3.3. Contrasting Use of Public versus Private Agricultural Training*

Table 3 compares surveyed agricultural producers and professionals with respect to their sources for public or private agricultural training. Public sources of agricultural training include regional extension (e.g., Fundação MT, IMA, SENAR-MT), universities (e.g., UFMT), state research (e.g., EMPAER, INDEA), and federal research (e.g., Embrapa, MAPA) entities (Table 5). Private sector training sources were companies making agricultural chemicals (e.g., Bayer, Syngenta, Pioneer), fertilizers (e.g., Mosaic, Yara), retailing agricultural inputs (e.g., Agroamazônia, Agroinsumos), independent consultants, and

other private entities (Table 4). Agricultural producers were more likely to rely on regional extension ($p = 0.006$) compared to professionals.

However, professionals were significantly more dependent on chemical and fertilizer companies ($p \leq 0.0001$) as well as independent consultants ($p = 0.032$) for agricultural training compared to producers (Table 3). Of the 83 producers and 86 professionals that answered our question on source(s) of agricultural training, less than half of each group relied on public sources (7% to 47%). Less than half of producers relied on private sources as well (3.6% to 48.2%, Table 3). Over half of surveyed professionals relied on companies producing or retailing agricultural inputs (51.2% to 82.6%, Table 3).

These private entities had greater budgets on average compared to regional/state-level public entities. Private entities had budgets ranging from USD 15,655,000 to 1,630,600,000, while regional/state-level public sources only had budgets of USD 25,756,833 to 180,261,746 (Table 5). For the Universidade Federal de Mato Grosso (UFMT), this is the entire university system budget, where most resources are not directed to farmer outreach unlike the Serviço Nacional de Aprendizagem Rural de Mato Grosso (SENAR-MT), Empresa Mato-Grosssense de Pesquisa, Assistência e Extensão Rural (EMPAER-MT), and the Instituto de Defesa Agropecuária do Estado de Mato Grosso (INDEA). For example, the AgriSciences program at UFMT, which conducts direct outreach to area farmers, has an average annual budget of USD 169,523, of which only about USD 11,808 is directly from the UFMT university system.

**Table 5.** Public and private agricultural training entities and 2021 budgets in Brazil.

| Type | Class | Abbreviation | Entity Name | 2021 Budget (USD/Year) | | | |
|---|---|---|---|---|---|---|---|
| | | | | International | Brazil | Mato Grosso | Source |
| Public | Regional extension | Fundação MT | Fundação de Apoio à Pesquisa Agropecuária de Mato Grosso | - | - | n/a | - |
| | | IMA | Instituto Matogrossense de Algodão | - | - | n/a | |
| | | SENAR-MT | Serviço Nacional de Aprendizagem Rural de Mato Grosso | - | - | 25,756,833 | [38] |
| | Universities | UFMT | Universidade Federal de Mato Grosso | - | - | 180,261,746 | [39] |
| | | | AgriSciences | - | - | 169,523 | |
| | State | EMPAER-MT | Empresa Mato-Grosssense de Pesquisa, Assistência e Extensão Rural | - | - | 30,468,664 | [40] |
| | | INDEA | Instituto de Defesa Agropecuária do Estado de Mato Grosso | - | - | 43,059,919 | [40] |
| | Federal | Embrapa | Empresa Brasileira de Pesquisa Agropecuária | - | 657,227,049 | n/a | [41] |

**Table 5.** *Cont.*

| Type | Class | Abbreviation | Entity Name | 2021 Budget (USD/Year) | | | |
|---|---|---|---|---|---|---|---|
| | | | | International | Brazil | Mato Grosso | Source |
| | | MAPA | Ministério da Agricultura, Pecuária e Abastecimento | - | 787,328,902,333 | n/a | [42] |
| Private | Chemicals | - | Bayer (includes Monsanto) | - | 2,041,688 | n/a | [43] |
| | | - | Corteva (includes Pioneer) | 15,655,000 | n/a | n/a | [44] |
| | Fertilizers | - | Mosaic | 1,630,600,000 | n/a | n/a | [45] |
| | | - | Yara | 384,000,000 | n/a | n/a | [46] |
| | Retailers | - | Agroamazônia | - | n/a | n/a | - |
| | | - | Agroinsumos | - | n/a | n/a | - |
| | Independent | - | Independent Consultants | - | n/a | n/a | - |
| | Other | - | Other private entities | - | n/a | n/a | - |

Our results are comparable with Carbonera et al. 2020 [47], who found that agricultural producers in Santa Rosa, Rio Grande do Sul state in southern Brazil relied upon both private and public sources for agricultural training. Here, farmers were technically assisted by agricultural input suppliers, finance and other professionals, and private cooperatives. Public entities included the Association of Technical Support and Rural Extension Enterprises in Rio Grande do Sul (Associação Riograndense de Empreendimentos de Assistência Técnica e Extensão Rural—EMATER/RS) and City Administration. Producers also used non-governmental organizations (NGOs) for training. Increased producer demand for more technical assistance was observed in some of the relationships examined.

Agricultural producers had a lower number of responses (481) compared to professionals (594) regarding preferred topics for agricultural training. Word clouds of open-response questions answered by both agricultural producers and professionals are shown in Figure 3. Agricultural producers emphasized "soil" versus "management" for professionals. The three words most often mentioned by agricultural producers were soil, field, and research (Figure 3a). Agricultural professionals most often used the words management, soil, field, and producers (Figure 3b). Greater emphasis on "management" was consistent with professionals having statistically greater preferences for preferred topics for training having to do with more technical aspects of crop management, such as plant mineral nutrition ($p = 0.004$), fertilizer management ($p = 0.026$), soil fertility assessment ($p = 0.040$), and correcting soil acidity ($p = 0.035$, Table 3).

Ordinary Least Squares (OLS) regression results for both agricultural producers and professionals explaining the proportion of public training used (dependent variable) are shown in Table 6. Years of education, years in agriculture, number of crops grown, and those specializing in only soybeans were not significant in explaining use of public (versus private) training sources. For producers, years spent in agriculture and being from the city of Sorriso were also not significant. Agricultural professionals who received training from private companies selling agricultural inputs (resale) did not have any significantly different proportion of public training used compared to other professionals. Like agricultural producers, years of education was also not significant. Agricultural professionals that helped producers specializing in soybeans and that received training from resale companies (i.e., distributors) were not more or less likely to use more public training sources (Table 6). All other variables surveyed from both agricultural producers (Tables 2 and 3) and agricultural professionals (Tables 3 and 4) were not significant in influencing use of public training sources.


(**a**) Producers




(**b**) Professionals

**Figure 3.** Word cloud using Atlas.ti for (**a**) agricultural producers and (**b**) professionals in the middle-north region of Mato Grosso state, Brazil surveyed during the spring of 2019.

**Table 6.** Ordinary Least Squares (OLS) regression for proportion public training for both agricultural producers and professionals from middle-north region, Mato Grosso state, Brazil in 2019.

| **Proportion Public Training** | **Producers** | | | **Professionals** | | |
|---|---|---|---|---|---|---|
| **OLS Model: Independent Variables** | **Coefficient** | **Standard Error** | ***p*-Value [a]** | **Coefficient** | **Standard Error** | ***p*-Value [a]** |
| Constant | 0.65826 | 0.25337 | 0.0115 ** | 0.56507 | 0.20079 | 0.0063 *** |
| Private training source: | | | | | | |
| Chemical companies | −0.20100 | 0.07393 | 0.0083 *** | −0.35957 | 0.07259 | <0.0001 *** |
| Resale companies | −0.27186 | 0.07207 | 0.0003 *** | −0.05143 | 0.05403 | 0.3444 |
| Residence: | | | | | | |
| Sinop | −0.29254 | 0.10318 | 0.0060 *** | −0.09202 | 0.06498 | 0.1554 |
| Sorriso | 0.03919 | 0.08784 | 0.6569 | −0.16216 | 0.06462 | 0.0144 ** |
| Socio-demographics: | | | | | | |
| Female | 0.32599 | 0.13429 | 0.0179 ** | _ [b] | _ [b] | _ [b] |
| Single | 0.22590 | 0.09779 | 0.0239 ** | _ [b] | _ [b] | _ [b] |
| Years of education | −0.00565 | 0.01277 | 0.6595 | −0.00854 | 0.01233 | 0.4907 |
| Agricultural background [c]: | | | | | | |
| Managed area (ranges) | −0.00002 | 0.00001 | 0.0725 * | −0.000002 | 0.000001 | 0.0801 * |
| Soybeans only | −0.30665 | 0.19923 | 0.1284 | −0.34075 | 0.24407 | 0.1670 |
| Number of crops | 0.01103 | 0.02657 | 0.6795 | 0.06672 | 0.02151 | 0.0028 *** |
| Years in agriculture (range) | 0.00192 | 0.00296 | 0.5178 | _ [a] | _ [a] | _ [a] |
| Number articles read/year | _ [b] | _ [b] | _ [b] | 0.00032 | 0.00018 | 0.0812 * |
| Model summary: | | | | | | |
| Sample size (*n*) | 94 | | | 91 | | |
| Degrees of freedom (df) | 11 | | | 9 | | |
| R-squared ($R^2$) | 0.4159 | | | 0.4631 | | |

[a] Denotes significance at confidence level (α) of 0.10 (*), 0.05 (**), and 0.01 (***). [b] Independent variable question not asked. [c] For producers, this is managed by them, while for professionals this is related to the producers that they consult.

Agricultural producers that had significantly higher proportions of public training sources were less likely to receive training from chemical and resale companies, but they were more apt to be from the city of Sinop, female, and single. Producers that managed less area were more likely to use more public training sources, through this was marginally significant ($\alpha = 0.10$). Similarly, agricultural professionals that used more public training sources were less likely to receive training from private chemical companies and be from the city of Sorriso. Agricultural professionals that used public training sources significantly read more technical articles per year, consulted on a larger number of crops, and managed less agricultural area (Table 6).

### *3.4. Financial and Technical Assistance for Producers*

As summarized in Table 7, most surveyed producers use rural credit (81.7%) and technical assistance (83.5%) to support their farms. Banco do Brazil and SICREDI combined to make up 80.7% of responses for sources of rural credit, with bartering (11.6%), other types (6.2%), and Agricultura de Baixo Carbano (ABC) or the Low-Carbon Agriculture program (1.6%) making up the difference (Table 7). ABC is used by farmers in Brazil who are implementing sustainable agriculture, such as low-carbon practices [48].

**Table 7.** Producer use and preferences for financial and technical services in middle-north region, Mato Grosso state, Brazil in 2019.

| Producer Characteristics and Preferences | *n* | % |
|---|---|---|
| Rural credit: | | |
| Rural credit used (*n* = 93): | | |
| Yes | 76 | 81.7 |
| No | 17 | 18.3 |
| Type [a] (responses = 129): | | |
| Banco do Brasil (FCO, etc.) | 54 | 41.9 |
| SICREDI | 50 | 38.8 |
| ABC | 2 | 1.6 |
| Other type(s) | 8 | 6.2 |
| Barter | 15 | 11.6 |
| Technical assistance | | |
| Receives technical assistance (*n* = 91): | | |
| Yes | 76 | 83.5 |
| No | 15 | 16.5 |
| Source(s) [a] (responses = 176): | | |
| Regional extension (SENAR) | 21 | 11.9 |
| Universities | 5 | 2.8 |
| State research (EMPAER) | 2 | 1.1 |
| Federal research (Embrapa) | 14 | 7.9 |
| Private companies | 58 | 33.0 |
| Producer associations | 45 | 25.6 |
| Rural unions | 29 | 16.5 |
| Non-Government Organizations (NGOs) | 1 | 0.6 |
| Other sources | 1 | 0.6 |
| Preferences [a] (responses = 99): | | |
| Understanding cost–benefit analysis | 37 | 37.4 |
| New technology and science | 28 | 28.3 |
| Basic technical knowledge | 21 | 21.2 |
| Communication skills | 8 | 8.1 |
| Other | 5 | 5.0 |
| Preferred extension methods [a] (responses = 245): | | |
| Field days | 74 | 30.2 |
| Fairs and exhibitions | 45 | 18.4 |
| Presentations | 71 | 29.0 |
| Congresses and seminars | 48 | 19.6 |
| Other types | 5 | 2.0 |
| None | 2 | 0.8 |

[a] Producers could specify multiple categories.

Responses to sources of technical assistance were led by private companies (33%), followed by other private entities such as producer associations (25.6%) and rural unions (16.5%). Public sources of technical assistance (SENAR, Universities, EMPAER, and Embrapa) only totaled 23.7% of responses. Preferred technical assistance topics were cost/benefit (37.4%), new technologies/science (28.3%), and basic technical knowledge (21.2%) (Table 7).

Producers indicated a preference for presentations with social gatherings, exchange of experiences, and emphasis on practical dynamics in a familiar environment. Preferred agricultural extension formats as a percentage of responses were field days (30.2%), presentations (29%), congresses or seminars (19.6%), and fairs/exhibitions (18.4%) (Table 7). From October 2016 to May 2022, AgriSciences at the University Federal de Mato Grosso has organized numerous presentations, four field days (2019–2022), and one international congress (2016). There were 538 people that presented and/or attended the VIII SIMBRAS (Simpósio Brazileiro de Agropecuária Sustentável) from 6 to 8 October 2016 [49]. From February 2019 to December 2021, AgriSciences held 56 training events involving a total of 3649 people.

A total of 263 + 786 + 275 = 1324 people attended the first, third, and fourth Agricultural Field Days (2019, 2021–2022). Even though the second live event was canceled in 2020 due to COVID-19, more than 800 people downloaded the inaugural book for this [50], with book publication occurring the year after the field day (e.g., the third live event in 2021 had a book published in 2022 [51]). The total number of AgriSciences program participants have been 3649 + 2124 + 538 = 6311 since 2016. The most participants attended presentations (57.8%), followed by field days (33.7%) and congresses (8.5%).

### *3.5. Agricultural Professionals' Training*

Agricultural professionals' responses to questions on their baseline training as well as time availability for training are summarized in Table 8. The number of trainings that agricultural professionals attend per year was bi-modal. There were 40.9% of respondents that attend 0 to 3 trainings annually, while 40.9% attend 5 or more. Most professionals also read technical articles and books. Only 1.1% of respondents do not read technical articles, while 98.9% read such articles at least occasionally. Almost half (47.2%) of professionals that responded read 1 to 2 books per year (Table 8).

The duration (number of hours) that professionals considered ideal for technical and online courses was also bi-modal. While over one-third of professionals (36%) considered one to four hours as the ideal time, 23.6% favored 8 h and 29.2% of respondents preferred trainings more than 8 h long. A minority (11.2%) did not know. Most professionals (51.7%) reported having only up to one hour per day available for online trainings. Others reported having one to three hours available (29.2%) or a half day (6.7%). The remaining respondents (12.4%) reported having no interest in online trainings (Table 8).

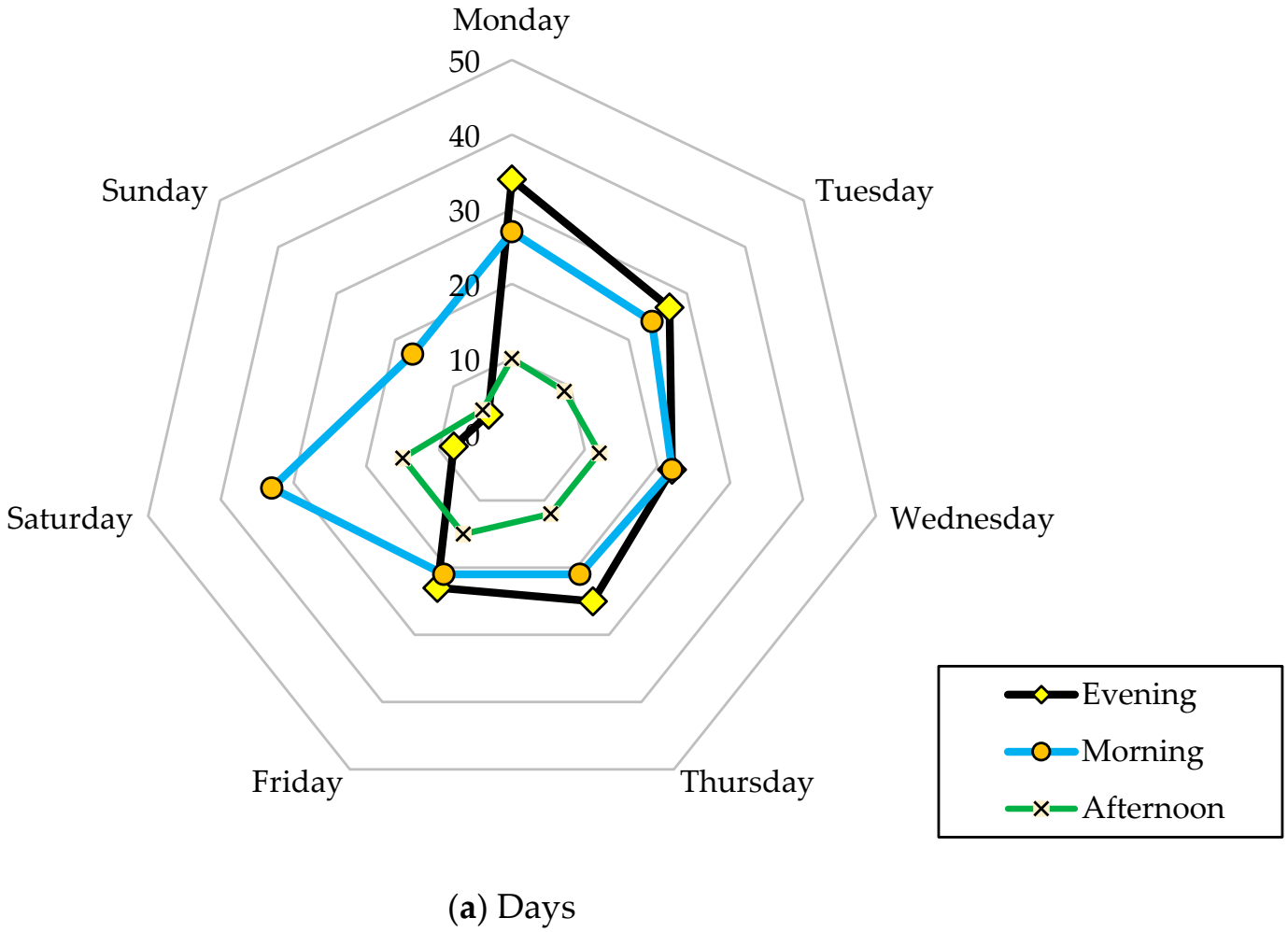
Agricultural professionals preferred trainings to be scheduled during times of the day, day(s), and month(s) that they were less busy, presumably when they were not consulting with producers. Saturday mornings were the most preferred, followed by weekday evenings compared to mornings and afternoons (Figure 4a). July and August are the most preferred months (Figure 4b) after second-crop maize (*safrinha*) has already been harvested or prior to cotton harvest. These two months correspond to the commodity cropping off-season in Mato Grosso during the middle of the dry season.

**Table 8.** Professionals' participation and availability for training in middle-north region, Mato Grosso state, Brazil in 2019.

| Professional Participation and Preferences | *n* | % |
|---|---|---|
| Participation in training and reading | | |
| Trainings attended annually (*n* = 88): | | |
| None | 3 | 3.4 |
| 1–3 training(s) per year | 33 | 37.5 |
| 4–5 trainings per year | 16 | 18.2 |
| >5 trainings per year | 36 | 40.9 |
| Technical articles read (*n* = 89): | | |
| Daily | 23 | 25.9 |
| Weekly | 31 | 34.8 |
| Monthly | 10 | 11.2 |
| Occasionally | 24 | 27.0 |
| Do not read technical articles | 1 | 1.1 |
| Books read annually (*n* = 89): | | |
| None | 29 | 32.6 |
| 1–2 books | 42 | 47.2 |
| 3–5 books | 11 | 12.3 |
| >5 books | 7 | 7.9 |

**Table 8.** *Cont.*

| Professional Participation and Preferences | *n* | % |
|---|---|---|
| Preferences for training: | | |
| Ideal length for agronomic course (*n* = 89): | | |
| 1–4 h | 32 | 36.0 |
| 8 h | 21 | 23.6 |
| >8 h | 26 | 29.2 |
| Do not know | 10 | 11.2 |
| Hours available for online training (*n* = 89): | | |
| Up to 1 h | 46 | 51.7 |
| 1–3 h | 26 | 29.2 |
| A half day | 6 | 6.7 |
| Not interested in participating in online program | 11 | 12.4 |
| | 0 | 0.2 |




(**a**) Days

**Figure 4.** *Cont.*

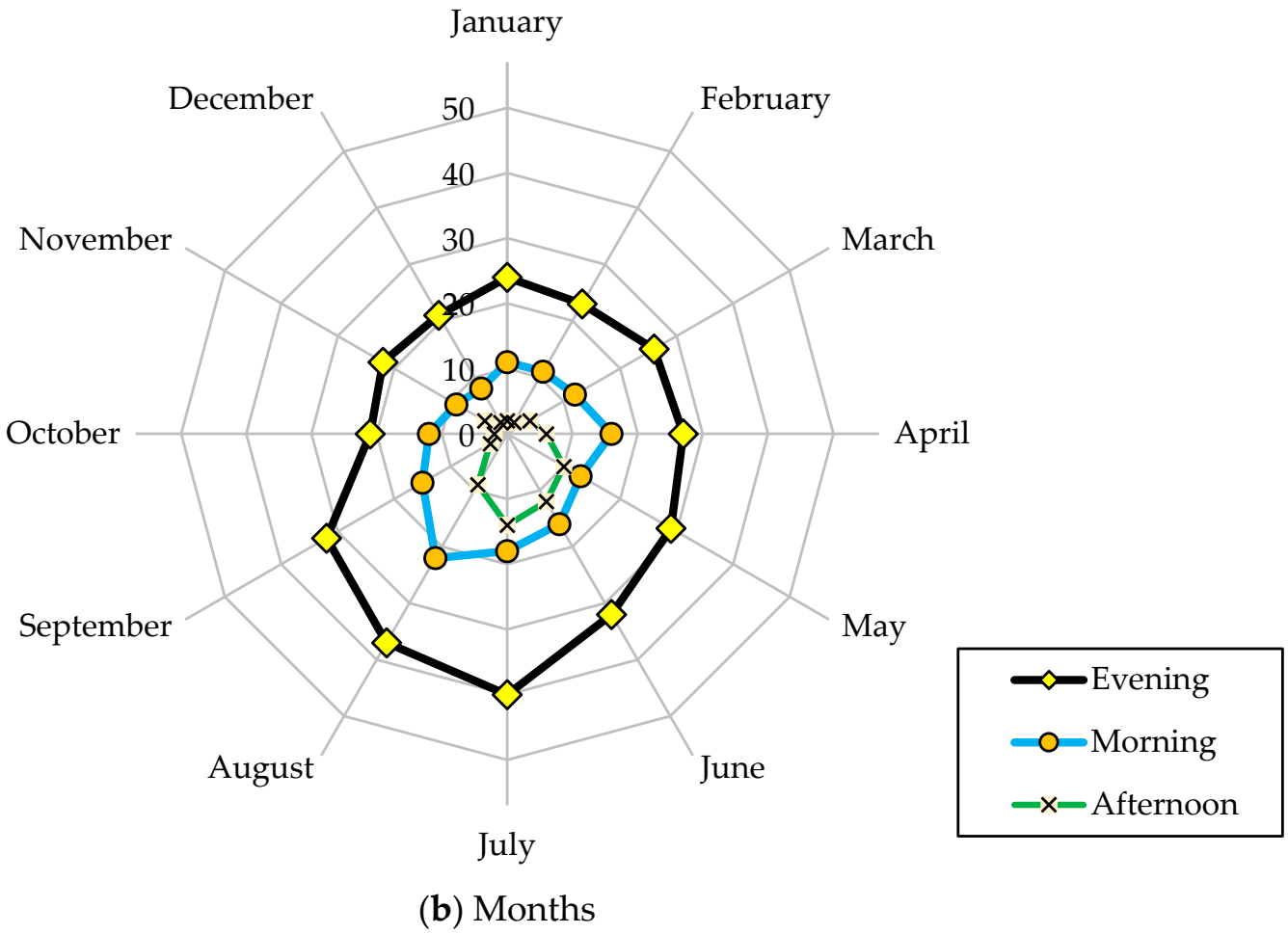



**Figure 4.** Agricultural professionals' preferred (**a**) days and (**b**) months for training.

## 4. Discussion

### *4.1. Improved Participation for Sustainable Agricultural Systems*

According to prior research, the Brazilian challenge is to maintain the capacity to produce and use soybeans profitably and sustainably [52]. Greater sustainability here involves crop rotation diversification and/or integrating commodity crops like soybeans and maize with perennial pasture for livestock grazing [53,54] or using soybeans during the pasture finishing of beef cattle in the region [55]. Integrated crop–livestock (ICL) systems have had low participation due to the management complexity of adding another enterprise or due to the coordination needed between specialized crop and livestock producers [56,57]. In addition to encouraging greater adoption of ICL, addressing social factors can also more broadly impact farm persistence and growth [58].

Access to rural credit in the Brazilian state of São Paulo increased the probability of adopting the ICL-Forest System (Sistema Integrado Lavoura-Pecuária-Floresta—ILPF) [59]. In our study, 81.7% of producers depend on financing for rural credit as a source for investment (Table 1), with 30.1% of surveyed producers using ICL systems (Table 3). Our ICL percentage was less than a prior assessment of integrated systems in Mato Grosso state where 89% of integrated systems involved just crops and livestock (rather than agro-forestry) and such ICL systems involved roughly 40.5% of 134 total producers (61 integrated + 73 non-integrated) surveyed [60]. Integrated systems are beneficial, diversifying rural revenues, recovering degraded pastures, improving physical, chemical, and biological attributes of soil, and reducing greenhouse gas emissions [61].

Increased participation of private companies in the development of agricultural markets in the 2010s was a major driver of production cost increases, which interfered with the

direction of technologies and producers' decision-making power [62]. Our results suggest that while most rural producers use strategies that may have more limited sustainability, many have adopted sustainable practices such as cover cropping. Sixty-nine percent of producers we surveyed used no-till which relies on glyphosate (i.e., Roundup®) [63]. Glyphosate use in Brazil for soybeans has been shown to reduce erosion but increase herbicide resistance in weeds [64]. The prevalence of producers using *Crotalaria juncea* as a cover crop (46.3%) was similar to those using biological nitrogen fixation (47.6%). More complex and expensive strategies such as integrated crop–livestock systems and recovery of degraded pasture lands were used by only 17.9% and 7.1% of producers, respectively.

### *4.2. Increasing Participation in Public Sources of Agricultural Training*

Our study identified factors influencing the use of public (versus private) sources of agricultural training by agricultural producers and professionals in the middle-north region of Mato Grosso state, Brazil. The entities that most contributed advisory support and capability toward developing programs were private agricultural companies and business support organizations (e.g., syndicates, associations). Public entities were less utilized, such as universities like Universidade Federal de Mato Grosso (UFMT), as well as state (e.g., EMPAER-MT) and federal (e.g., Embrapa) institutions. Brazilian agricultural commodity production lends itself to more dependence on the support industries for Brazilian agribusiness [65].

Our results suggest that UFMT and EMPAER-MT should continue to prioritize professional development activities for producers in rural areas (Table 3), such as on-farm field days [66]. Producers are more likely to be from smaller towns (30.8%) outside of the four major cities in the region compared to professionals (12.4%) and this difference is significant ($p = 0.005$, Table 3). In addition, AgriSciences also needs to hold on-farm events closer to Sinop where area producers are more likely not to use public training sources ($p = 0.006$, Table 6). Similarly, public training outreach to professionals from Sorriso needs to improve, since this group has lower participation with such extension ($p = 0.0144$, Table 6).

Well-structured technical assistance and rural extension can enhance field activities and improve rural development [67]. Publicly and privately funded agencies working in technology diffusion tend to become mediating or border organizations, assuming hybrid configurations such as multidisciplinary participatory platforms rich in partnerships, building innovations [68]. When training rural extension professionals, it is important to have continuity in conceptual discussion, systematization of innovative educational practices, and research on education, training, and results [69].

Hybrid learning platforms are also important, such as online videos and audio lessons, although such media are not widely deployed due to lack of internet connectivity in rural areas in Brazil [70]. Improved development of social media to enhance agricultural innovation and rural development in Canada has been limited by mobile telephone quality, having compatible technological equipment, and specialized technical assistance [71]. Keeping up with increasingly fast technological advances can ensure that rural producers and professionals are able to access updated information.

Both agricultural producers and professionals in the middle-north macro-region of Mato Grosso are more receptive to practical, in-service training while still being receptive to online training such as webinars, videos, etc. Professionals indicated the off-season period as the best time to improve their education and competencies. Therefore, the characterization provided in this study can be an excellent support to institutions in Mato Grosso state, Brazil and beyond that provide technical training, development, and assistance. Our results presented here can provide insight on how similar institutions can improve their training programs to both agricultural producers and professionals.

## 5. Conclusions

Identifying how to best meet the agricultural training needs of both agricultural producers and agricultural professionals from public extension sources is critical to improving the economic and environmental sustainability of commodity cropping systems. We surveyed 94 such producers and 89 agricultural professionals in the middle-north region of Mato Grosso state in Brazil's midwest, which specializes in the production of soybean, maize, and cotton. Most producers were male, married, and varied in age, with 59.1% using a soybean–maize annual rotation. Relative to producers, agricultural professionals were more educated, with 52.8% having a college degree compared to only 22.8% for producers. Agricultural producers were more likely to use public versus private sources of training if they received less training from chemical companies and retailers, were from Sinop, female, unmarried, and if they managed less farm area. Agricultural professionals were more likely to use public agricultural training sources if they received less training from private chemical companies, were not from Sorriso, read more technical articles, and if they consulted producers on managing more crops on less farm area.

Our research is a start for better understanding the agricultural training needs of farmers and farm consultants in our region. However, our analysis could be repeated in the future to allow for pre–post testing of improved extension outreach over time, since we have contact information for all survey participants. Other regions in Mato Grosso (MT) state as well as Brazil can conduct similar surveys of agricultural producers and professionals in the future to compare to our results. Future public research and extension activities (e.g., field days on Saturday mornings and presentations on weekday evenings) in the middle-north region of MT need to continue to support producers and professionals involved in more diversified cropping systems. However, more targeted outreach to more specialized producers is needed, ideally on-farm in more rural areas. Future work can improve our understanding of how to better balance private sector training with agricultural extension outreach from the public sector (e.g., universities, state, and federal agencies) to encourage greater sustainability in commodity cropping systems in Brazil and elsewhere.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15064712/s1, Farmer's survey (pp. 1–4); Professional's survey (pp. 5–7).

**Author Contributions:** Conceptualization, D.C.d.A. and J.A.V.d.R.; methodology, D.C.d.A. and J.R.V.; software, D.C.d.A. and J.R.V.; validation, D.C.d.A., J.A.V.d.R., J.L.V. and V.A.M.d.B.; formal analysis, A.K.H., J.A.V.d.R. and L.M.; investigation, D.C.d.A. and W.M.d.S.; resources, A.K.H., D.C.d.A. and W.M.d.S.; data curation, J.A.V.d.R. and J.R.V.; writing—original draft preparation, A.K.H. and J.A.V.d.R.; writing—review and editing, D.C.d.A. and A.K.H.; visualization, R.A.d.O.; supervision, A.S.d.O. and D.C.d.A.; project administration, D.C.d.A.; funding acquisition, D.C.d.A. and W.M.d.S. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by Serviço Nacional de Aprendizagem Rural de Mato Grosso (SENAR-MT), Programa Global REDD Early Movers de Mato Grosso (REM-MT), Projeto Rural Sustentável—Cerrado (PRS—Cerrado), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for granting a masters scholarship, Grupo Bragança Agronegócios (Mato Grosso) and Grupo Osvaldo Sobrinho.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Study data can be obtained by request to the corresponding author or the second author, via e-mail. They are not available on the website, as the research project is still under development.

**Acknowledgments:** We thank all cooperating producers and professionals in addition to the Universidade Federal de Mato Grosso (UFMT) in Sinop, MT, Brazil, Empresa Mato-grossense de Pesquisa, Assistência e Extensão Rural de Mato Grosso (EMPAER-MT), and the University of Minnesota for institutional support. Special thanks the Serviço Nacional de Aprendizagem Rural de Mato Grosso (SENAR-MT), Programa Global REDD Early Movers de Mato Grosso (REM-MT), Projeto Rural

Sustentável-Cerrado (PRS-Cerrado), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Fazenda Taguá Agropecuária (Grupo Osvaldo Sobrinho) and Fazenda Bragança (Grupo Bragança Agronegócios) for financial support. We also thank four anonymous reviewers whose comments and edits improved this work.

**Conflicts of Interest:** The authors declare no conflict of interest. Supporting entities had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

## References

1. Instituto Mato-Grossense de Economia Agropecuária (IMEA). Metodologia—Justificativa da Divisão do Mapa de Regiões. 2017. Available online: https://www.imea.com.br/imea-site/view/uploads/metodologia/justificativamapa.pdf (accessed on 22 September 2020).
2. Instituto Brasileiro de Geografia e Estatística (IBGE). Brazilian Institute of Geography and Statistics. 2021. Available online: https://www.ibge.gov.br/ (accessed on 19 September 2020).
3. Muchagata, M.; Brown, K. Cows, colonists, and trees: Rethinking cattle and environmental degradation in Brazilian Amazonia. *Agric. Syst.* **2003**, *76*, 797–816. [CrossRef]
4. Wesz Junior, V.J. O Mercado da Soja no Sudeste de Mato grosso (brasil): Uma Análise das Relações entre Produtores Rurais e Empresas a partir da Sociologia Econômica. *Dados Rev. Ciên. Soc.* **2019**, *62*, 1–36. [CrossRef]
5. Instituto Brasileiro de Geografia e Estatística (IBGE). Cidades e Estados. Mato Grosso. 2021. Available online: https://www.ibge.gov.br/cidades-e-estados/mt.html/ (accessed on 23 February 2023).
6. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo Agropecuário de 2017. 2017. Available online: https://cidades.ibge.gov.br/brasil/mt/pesquisa/10100/95260 (accessed on 23 February 2023).
7. Companhia Nacional de Abastecimento (CONAB). Acompanhamento da Safra Brasileira. 2022. Available online: https://www.conab.gov.br/info-agro/safras?view=default (accessed on 23 February 2023).
8. Fumagali Junior, G.N.; da Costa Silva, M.M. Efeitos dos cursos de Ciências Agrárias na Produtividade da soja no Mato Grosso: Uma Análise Especial. 2020. Available online: https://brsa.org.br/enaber-2020/#artigos (accessed on 15 October 2021).
9. AgriSciences. 2022. Available online: https://www.agrisciences.org/ (accessed on 20 June 2022).
10. Ragasa, C.; Ulimwengu, J.; Randriamamonjy, J.; Badibanga, T. Factors Affecting Performance of Agricultural Extension: Evidence from Democratic Republic of Congo. *J. Agric. Educ. Ext.* **2016**, *22*, 113–143. [CrossRef]
11. Gido, E.O.; Sibiko, K.W.; Ayuya, O.I.; Mwangi, J.K. Demand for Agricultural Extension Services Among Small-Scale Maize Farmers: Micro-Level Evidence from Kenya. *J. Agric. Educ. Ext.* **2015**, *21*, 177–192. [CrossRef]
12. Mittal, S.; Mehar, M. Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model. *J. Agric. Educ. Ext.* **2016**, *22*, 199–212. [CrossRef]
13. Suvedi, M.; Ghimire, R.; Kaplowitz, M. Farmers' participation in extension programs and technology adoption in rural Nepal: A logistic regression analysis. *J. Agric. Educ. Ext.* **2017**, *23*, 351–371. [CrossRef]
14. Charatsari, C.; Papadaki-Klavdianou, A.; Michailidis, A. Farmers as Consumers of Agricultural Education Services: Willingness to Pay and Spend Time. *J. Agric. Educ. Ext.* **2011**, *17*, 253–266. [CrossRef]
15. Adamsone-Fiskovica, A.; Grivins, M.; Burton, R.J.F.; Elzen, B.; Flanigan, S.; Frick, R.; Hardy, C. Disentangling critical success factors and principles of on-farm agricultural demonstration events. *J. Agric. Educ. Ext.* **2021**, *27*, 639–656. [CrossRef]
16. Estevão, P.; de Sousa, D.N. A Web como ferramenta de capacitação para a extensão rural. *Cad. Tecnol. Ciênc.* **2021**, *38*, 26656. [CrossRef]
17. Mazzali, L. O Processo Recente de Reorganização Agroindustrial: Do Complexo à Organização em Rede. PhD Thesis in Business Economics, Fundação Getúlio Vargas, São Paulo, Brazil, 1995. Available online: http://hdl.handle.net/10438/4638 (accessed on 16 December 2021).
18. Diesel, V.; Dias, M.M. The Brazilian experience with agroecological extension: A critical analysis of reform in a pluralistic extension system. *J. Agric. Educ. Ext.* **2016**, *22*, 415–433. [CrossRef]
19. Botha, N.; Coutts, J.; Roth, H. The role of agricultural consultants in the New Zealand Research, Development and Extension system. In Proceedings of the New Zealand Agricultural and Resource Economics Society Conference, Nelson, New Zealand, 25–27 August 2006; 11p. Available online: https://ageconsearch.umn.edu/record/31971/?ln=en (accessed on 6 March 2023).
20. De Rosa, M.; Bartoli, L. Do farm advisory services improve adoption of rural development policies? An empirical analysis in GI areas. *J. Agric. Educ. Ext.* **2017**, *23*, 461–474. [CrossRef]
21. Faure, G.; Huamanyauri, M.K.; Salazar, I.; Gómez, C.; de Nys, E.; Dulcire, M. Privatisation of agricultural advisory services and consequences for the dairy farmers in the Mantaro Valley, Peru. *J. Agric. Educ. Ext.* **2017**, *23*, 197–211. [CrossRef]
22. Vanclay, F.; Lawrence, G. Farmer rationality and the adoption of environmentally sound practices; A critique of the assumptions of traditional agricultural Extension. *Eur. J. Agric. Educ. Ext.* **1994**, *1*, 59–90. [CrossRef]
23. Hunt, W.; Coutts, J. Extension in Tough Times—Addressing Failures in Public and Private Extension, Lessons from the Tasmanian Wool Industry, Australia. *J. Agric. Educ. Ext.* **2009**, *15*, 39–55. [CrossRef]

24. De Freitas, A.F.; de Freitas, A.F.; Dias, M.M. O uso do diagnóstico rápido participativo (DRP) como metodologia de projetos de extensão universitária. *Rev. Ext.* **2012**, *11*, 69–81. [CrossRef]
25. Benge, M.; Warner, L. *Conducting the Needs Assessment #2: Using Needs Assessments in Extension Programming*; Publication #AEC684, 5 December 2019; The Institute of Food and Agricultural Sciences (IFAS), University of Florida: Gainesville, FL, USA, 2019; Available online: https://edis.ifas.ufl.edu/publication/WC347 (accessed on 22 December 2022).
26. Diori, H.I. A Critical Insight into Needs Assessment Technique and the Way Social Needs are Actually Assessed. *Adv. J. Soc. Sci.* **2021**, *8*, 3–9. [CrossRef]
27. Fávero, L.P.; Belfiore, P. *Manual de Análise de Dados: Estatística e Modelagem Multivariada com Excel®*; SPSS®e Stata®; Elsevier: Rio de Janeiro, Brasil, 2017; pp. 1–1216.
28. Balsadi, O.V.; da Mota, D.M. Diversidade de vínculos de trabalho de mulheres no censo agropecuário brasileiro de 2017. *InterEspaço Rev. Geogr. Interdiscip.* **2017**, *7*, 202113. [CrossRef]
29. Da Conceição, J.C.P.R. Capital Humano e Obtenção de Informações Técnicas na Agricultura: Perfil e Diferenças Regionais a Partir dos Dados do Censo Agropecuário de 2017. Instituto de Pesquisa Econômica Aplicada. 2020. Available online: http://repositorio.ipea.gov.br/handle/11058/10474 (accessed on 20 March 2022).
30. Global Forum for Rural Advisory Services (GFRAS). Activities—Global Good Practice Initiative. 2021. Available online: https://www.g-fras.org/en/ggp-home.html (accessed on 16 January 2022).
31. Statista, Inc. Leading States for Agricultural Production in Brazil in 2021, Based on Share of Production Value. 3 World Trade Center, 175 Greenwich Street, 36th floor, New York, NY 1007, USA. Available online: https://www.statista.com/statistics/1072317/agricultural-production-value-brazil-state/ (accessed on 23 December 2022).
32. Picoli, M.C.A.; Maciel, A.; Simões, R.; Santos, L.A.; Sanches, I. Agricultural production gains in Brazilian commodity hotspot: Case study state of Mato Grosso. In Proceedings of the XIX Brazilian Symposium on Remote Sensing, Santos, Brazil, 14–17 April 2019; Volume 19, ISBN 978-85-17-00097-3.
33. Arvor, D.; Daugeard, M.; Tritsch, I.; De Mello-Thery, N.A.; Thery, H.; Dubreuil, V. Combining socioeconomic development with environmental governance in the Brazilian Amazon: The Mato Grosso agricultural frontier at a tipping point. *Environ. Dev. Sustain.* **2018**, *20*, 1–22. [CrossRef]
34. Junqueira, V.H.; Bezerra, M.C.d.S. The new requirements of reproduction of workforce qualification for agribusiness. *Trabalho Educação* **2015**, *24*, 221–238. Available online: https://periodicos.ufmg.br/index.php/trabedu/article/view/9462 (accessed on 2 February 2022).
35. Ventura, M.V.A.; Batista, H.R.F.; Bessa, M.M.; Pereira, L.S.; Costa, E.M.; de Oliveira, M.H.R. Comparison of conventional and transgenic soybean production costs in different regions in Brazil. *Res. Soc. Dev.* **2020**, *9*, e154973977. [CrossRef]
36. Barros, M.A.L.; da Silva, C.R.C.; de Lima, L.M.; Farias, F.J.C.; Ramos, G.A.; dos Santos, R.C. A Review on Evolution of Cotton in Brazil: GM, White, and Colored Cultivars. *J. Nat. Fibers* **2020**, *19*, 209–221. [CrossRef]
37. Richetti, A.; Ito, M.A. Viabilidade Econômica da Cultura do Feijão-Comum, Safra da seca de 2016, em Mato Grosso do Sul. Embrapa. 2015. Available online: http://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1001428 (accessed on 12 March 2022).
38. Serviço Nacional de Aprendizagem Rural de Mato Grosso (Senar). Portal da Transparência—Transparência Senar. Available online: http://app3.cna.org.br/transparencia/?gestaoOrcamento-MT-2021-863 (accessed on 28 June 2022).
39. Universidade Federal de Mato Grosso (UFMT). Portal da Transparência. Controladoria-geral da União. Available online: https://www.portaltransparencia.gov.br/orgaos/26276?ano=2021 (accessed on 28 June 2022).
40. Secretaria de Estado de Fazenda (Sefaz). Governo do Estado de Mato Grosso. Orçamento Cidadão 2021. Available online: http://www5.sefaz.mt.gov.br/documents/6071037/11388742/Or%C3%A7amento+Cidad%C3%A3o+2021.pdf/7172b6c5-90e3-97f9-cbab-d88831597240 (accessed on 28 June 2022).
41. Empresa Brasileira de Pesquisa Agropecuária (Embrapa). Portal da Transparência. Controladoria-Geral da União. Available online: https://transparenciapublica.gov.br/orgaos/22202?ano=2021 (accessed on 28 June 2022).
42. Ministério da Agricultura, Pecuária e Abastecimento (MAPA). Portal da Transparência. Controladoria-Geral da União. 2022. Available online: https://www.portaltransparencia.gov.br/orgaos-superiores/22000?ano=2021 (accessed on 28 June 2022).
43. Bayer, S.A. e Controladas. Relatório da Administração. 2021. Available online: https://www.bayer.com.br/pt/balancos-financeiros-do-grupo-bayer-brasil (accessed on 28 June 2022).
44. Corteva. Corteva Annual Report 2021. Available online: https://investors.corteva.com/static-files/fb19f308-4766-4ca6-a3d6-bd0a8035f09a (accessed on 28 October 2022).
45. Mosaic. Performance Highlights. Annual Report 2021. Available online: https://s1.q4cdn.com/823038994/files/doc_financials/2021/ar/2021AnnualReport_FINAL.pdf (accessed on 28 October 2022).
46. Yara. Integrated Report 2021: Growing a Nature Positive Food Future. Available online: https://www.yara.com/siteassets/investors/057-reports-and-presentations/annual-reports/2021/yara-integrated-report-2021.pdf/ (accessed on 28 October 2022).
47. Carbonera, R.; Basso, N.; Buratti, J.B.L.; Kovalski, C.H.; Scheer, M.R.; Oliveski, F.E. Níveis de reprodução social e estratégias para a agricultura familiar. *Redes* **2020**, *25*, 2035–2059. [CrossRef]
48. De Magalhães, M.M.; Braga Júnior, S.S. Evolução recente e potencial da agricultura de baixo carbono. *Periód. Eletrônico Fórum Ambient. Alta Paul.* **2013**, *9*, 100–118. [CrossRef]

49. De Abreu, D.C.; Morales, M.M.; dos Anjos, A.F.T.; Felipe, R.T.A.; de Lima Dias, M.P.; de Paula Lana, R. (Eds.) *VIII SIMBRAS, Proceedings of the 8th Simpósio Brasileiro de Agropecuária Sustentável and 5th International Conference on Sustainable Agriculture, Mato Grosso, Brazil, 6–8 October 2016*; Universidade Federal de Mato Grosso: Sinop, Brazil, 2016; pp. 1–214. ISBN 978-85-921803-0-0.
50. Sobrinho, O.R.; de Abreu, D.C.; de Lima Dias, M.P.; da Silva, W.M.; de Souza Santos, D.M.; Molossi, L.; Somavilla, A.; Baldan, A. (Eds.) *2a Vitrine Technológica Agrícola: Atualidades na Pecuária de Corte para Baixada Cuiabana*, 1st ed.; Fundação UNISELVA: Cuiabá, Brazil, 2021; pp. 1–272. ISBN 978-65-86743-42-5.
51. De Abreu, D.C.; de Lima Dias, M.P.; Boscoli, D.Z.; da Silva, W.M.; de Paula Alberto, F.; Martins, A.R.R.; Pinheiro, D.T. (Eds.) *3a Vitrine Technológica Agrícola: Atualidades na Cultura do Milho em Sistema Soja e Milho-Safrinha*, 1st ed.; Fundação UNISELVA: Cuiabá, Brazil, 2022; pp. 1–230. ISBN 978-65-86743-50-0.
52. Cattelan, A.J.; Dall'agnol, A. The rapid soybean growth in Brazil. Embrapa Soja-Artigo em periódico indexado (ALICE). *Oilseeds Fats Crops Lipids* **2018**, *25*, D102. [CrossRef]
53. Pereira, C.H.; Patino, H.O.; Hoshide, A.K.; de Abreu, D.C.; Rotz, C.A.; Nabinger, C. Grazing supplementation and crop diversification benefits for southern Brazil beef: A case study. *Agric. Syst.* **2018**, *162*, 1–9. [CrossRef]
54. Pedrosa, L.M.; Hoshide, A.K.; Abreu, D.C.; Molossi, L.; Couto, E.G. Financial transition and costs of sustainable agricultural intensification practices on a beef cattle and crop farm in Brazil's Amazon. *Renew. Agric. Food Syst.* **2019**, *36*, 26–37. [CrossRef]
55. Molossi, L.; Hoshide, A.K.; Pedrosa, L.M.; de Oliveira, A.S.; Abreu, D.C. Improve pasture or feed grain?: Greenhouse gas emissions, profitability, and resource use for Nelore beef cattle in Brazil's Cerrado and Amazon biomes. *Animals* **2020**, *10*, 1386. [CrossRef]
56. Hoshide, A.K.; Dalton, T.J.; Smith, S.N. Profitability of coupled potato and dairy farms in Maine. *Renew. Agric. Food Syst.* **2006**, *21*, 261–272. [CrossRef]
57. Asai, M.; Moraine, M.; Ryschawy, J.; de Wit, J.; Hoshide, A.K.; Martin, G. Critical factors to crop-livestock integration beyond the farm level: A cross-analysis of worldwide case studies. *Land Use Policy* **2018**, *72*, 184–194. [CrossRef]
58. Inwood, S.M.; Sharp, J.S. Farm persistence and adaptation at the rural–urban interface: Succession and farm adjustment. *J. Rural Stud.* **2012**, *28*, 107–117. [CrossRef]
59. Carrer, M.J.; Maia, A.G.; Vinholis, M.d.M.B.; de Souza Filho, H.M. Assessing the effectiveness of rural credit policy on the adoption of integrated crop-livestock systems in Brazil. *Land Use Policy* **2020**, *92*, 104468. [CrossRef]
60. Gil, J.; Siebold, M.; Berger, T. Adoption and development of integrated crop-livestock-forestry systems in Mato Grosso, Brazil. *Agric. Ecosyst. Environ.* **2015**, *199*, 394–406. [CrossRef]
61. Garrett, R.D.; Niles, M.; Gil, J.; Dy, P.; Reis, J.; Valentim, J. Policies for reintegrating crop and livestock systems: A comparative analysis. *Sustainability* **2017**, *9*, 473. [CrossRef]
62. Da Silva, R.F.; Batistella, M.; Moran, E.; de Melo Celidonio, O.L.; Millington, J.D.A. The soybean trap: Challenges and risks for Brazilian producers. *Front. Sustain. Food Syst.* **2020**, *4*, 12. [CrossRef]
63. Possamai, E.J.; Conceição, P.C.; Amadori, C.; Bartz, M.L.C.; Ralisch, R.; Vicensi, M.; Marx, E.F. Adoption of the no-tillage system in Paraná State: A (re)view. *Rev. Bras. Ciênc. Solo* **2022**, *46*, e0210104. [CrossRef]
64. Cerdeira, A.L.; Gazziero, D.L.P.; Duke, S.O.; Matallo, M.B.; Spadotto, C.A. Review of potential environmental impacts of transgenic glyphosate-resistant soybean in Brazil. *J. Environ. Sci. Health B* **2007**, *42*, 539–549. [CrossRef]
65. Ministério da Agricultura Pecuária e Abastecimento (MAPA). Acesso à Informação. 2020. Available online: https://www.gov.br/agricultura/pt-br (accessed on 12 October 2022).
66. Pinheiro, D.T.; Santos, D.M.S.; Martins, A.R.R.; da Silva, W.M.; de Araújo, C.V.; Hoshide, A.K.; Abreu, D.C. Produtividade e qualidade nutricional dos principais híbridos de milho no cerrado mato-grossense. In *Chapter 3 in 3.a Vitrine Tecnológica Agrícola*; AgriSciences and Fundação UNISELVA: Cuiabá, Brazil, 2022; pp. 43–64.
67. Gonçalves, A.C.; Junior, L.R.; Fonseca, M.I.; Nadruz, B.V.; Bürger, G.R. Technical assistance and rural extension: A case study that demonstrates its importance for the improvement of milk production. *Rev. Bras. Hig. Sanid. Anim.* **2014**, *8*, 47–61. [CrossRef]
68. Cristóvão, A.; Koutsouris, A.; Kügler, M. Extension systems and change facilitation for agricultural and rural development. In *Farming Systems Research into the 21st Century: The New Dynamic*; Darnhofer, I., Gibbon, G., Dedieu, B., Eds.; Springer: Dordrecht, The Netherlands, 2012; pp. 201–227. [CrossRef]
69. Landini, F.; Brites, W.; Rebolé, M.I.M.Y. Towards a new paradigm for rural extensionists' in-service training. *J. Rural Stud.* **2017**, *51*, 158–167. [CrossRef]
70. Chowdhury, A.; Odame, H.H. Social media for enhancing innovation in agri-food and rural development: Current dynamics in Ontario, Canada. *J. Rural Community Dev.* **2013**, *8*, 97–119.
71. Kolling, C.E.; Rampim, L. Agricultura de precisão e digital: Perspectivas e desafios dos produtores rurais do estado do paraná. *Rev. Uningá* **2021**, *36*, eURJ3981. Available online: https://revista.uninga.br/uningareviews/article/view/3981 (accessed on 6 March 2023). [CrossRef]