STUDY REPORT

Case Study on the Effects of Climate-smart Agricultural Practices Implemented by ABR-Better Cotton Producers on Climate Change Adaptation and Mitigation in Brazil

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Executive summary

Better Cotton was seeking to identify and document climate-smart agricultural practices implemented by Better Cotton – ABR licensed producers in Brazil, as Brazil has been identified as one of the priority countries for Climate Action under the 2030 strategy to make cotton farming in the country more climate-resilient and sustainable.

The purpose of the study was to provide in-depth information on climate-smart agricultural practices implemented by Better Cotton - ABR licensed producers in Brazil, provide in-depth information on the selected climate-smart agricultural practices and assess their contribution to climate change mitigation, as well as the extent to which they have enabled the Better Cotton – ABR producers to adapt to the consequences of climate change. The study will also serve to disseminate successful climate-resilient practices and generate insights for learning and improvement.

The methodology adopted for the study was a desk research to establish an initial set of data to be collected, and this data was used to develop questionnaires for the collection of climate-smart agricultural practices among Better Cotton - ABR licensed producers and among stakeholders. The questionnaires included spaces to mention “out of the box” implemented practices.
The study had the cooperation of ABRAPA and state organizations, who shared the questionnaire with all their producer members. This cooperation proved crucial in contacting producers, as none of the state organization agreed to provide individual producer contact details. In total the questionnaire was sent to 379 farms. A total of 36 questionnaires were received and 20 interviews were conducted.
A field trip was undertaken to regions with prominent cotton production and number of members, with presential meetings and interviews with ABRAPA in the Federal District and the state organizations in Bahia, Goiás, Mato Grosso and Mato Grosso do Sul. The other state organizations were contacted remotely.

This study has identified and documented overall 27 climate-smart practices, divided in 5 parts. The first part, agricultural production systems, list the adopted practices and their implementation as crop rotation, implemented by 87% of respondents on all or part of the cotton area; mulch and cover crops used by 83%, No Tillage System 83%, reduced tillage system 83%, and 23% of respondents stated having crop livestock integration on the farm, 77% does not have this practice.
The second parts addresses soil fertility and fertilization, with liming and gypsum being the most adopted practice, used by 96% of the respondents on all or part of the cotton area; 93% use fertilizers and 77% use fertilizing the system on 100% or part of the cotton area, while 93% of the farms use agricultural machinery steering systems, and 70% implement precision agriculture practices. Although biological nitrogen fixation is not used for cotton, 97% of the respondents use the practice for soy.
The survey results show that for fuel and energy**,** 93% of the respondents stated that there is a strategy for the use of fuel, while only 7% do not have a strategy. For the use of energy, the numbers found are 76% and 24% respectively.
For seeds and phytosanitary products, 97% of the participating farms use superior seeds, and 100% use phytosanitary products on all or part of the cotton crop; 97% use integrated pest management, and 88% use biological and microbiological control on total or part of the cotton area; 48% of the participant farms state they have their own bio factory on the farm; For remote sensing respondents state the use on 59% on all cotton area, and 38% use the technology on part of the cotton area. The same numbers were found for smart trap use.
The last part of the survey collected data on other climate smart practices. Adoption of climate managing and meteorological monitoring was stated by 93% of the respondents, while 93% used byproduct and waste management practices; 52% of the farms had diverse income sources, and 24%

of the respondents use Rural Insurance; 41% of the respondents stated that their farm does have degraded areas and pastures that have been recovered, while 18% of participating farms reported irrigation on the farm.

The initiatives from Better Cotton and ABRAPA to support the adoption of climate-smart practices is the benchmark made by the institutions in relation to the raw material production chain, granting a certificate of compliance with these sustainable practices.

Producers joining the Better Cotton – ABR program are committed to practices described in the ABR protocol criteria 7 and 8, these practices are efficient in reducing GHG emissions, improving processes and ensuring the continuity of natural resources in the region, not only for their owners but also for the entire community. This became clear in the producers awareness analysis performed by the study, with the farmers perception of many of the effects of the practices on climate change mitigation.

The factors influencing climate change adoption among Brazilian producers are the awareness of producers that many of the practices they use serve to improve production and reduce production costs, can be considered climate smart. Another factor is to overcome producers' resistance to changes and adaptation to new management technologies.

The surveyed practices have effects on mitigating the effects of climate change. Also, product traceability, certification audits and monitoring and guidance practices for reducing fertilizers and phytosanitary products contribute positively to reducing the effects and causes of climate change.

The most important key recommendations are: to raise more awareness among cotton producers of the importance of the most direct consequences of climate change, providing tools so farmers have a better understanding of their farm's performance vis a vis greenhouse gas emissions and carbon capture accounting; support research on the use of biological products in an alternative pest management system, combining biological and chemical management strategies in the control of pests and diseases; organize long-term economic studies on the use of crop rotation and cover crops in cotton production, in order to monetize these practices and point out to producers also in this way the gains of these practices; encourage the creation of soil health departments among the different cotton producers' associations, establishing a network to help the initiatives to better disseminate the CSA practices and connect to each other, with training of the trainers (advisers) to overcome the knowledge gaps that need to be further fed with access to most recent knowledge.

A small climate perception survey conducted, following concerns about the reaction of cotton producers towards the theme, showed that 42% of the participating cotton producers indicate to perceive a change in climate, and 73% are concerned about climate-related risks and the future impacts that these may have on their farming operations.

Sumario Executivo

Better Cotton estava buscando identificar e documentar práticas agrícolas inteligentes implementadas por Better Cotton - produtores licenciados ABR no Brasil, já que o Brasil foi identificado como um dos países prioritários para a Ação Climática sob a estratégia 2030 para tornar o cultivo de algodão no país mais resiliente ao clima e sustentável.

O objetivo do estudo é conduzir um estudo de caso no Brasil para identificar e documentar práticas agrícolas inteligentes implementadas por produtores licenciados Better Cotton - ABR no Brasil, fornecer informações detalhadas sobre as práticas agrícolas inteligentes selecionadas e avaliar sua contribuição para o clima mitigação de mudanças, bem como até que ponto eles permitiram que os produtores de Better Cotton – ABR se adaptassem às consequências das mudanças climáticas. O estudo também servirá para disseminar práticas bem-sucedidas de resiliência climática e gerar insights para aprendizado e melhoria.

A metodologia adotada para o estudo foi uma pesquisa documental para estabelecer um conjunto inicial de dados a serem coletados, e esses dados foram usados para desenvolver questionários para a coleta de práticas agrícolas inteligentes entre os produtores licenciados Better Cotton - ABR e entre as partes interessadas. Os questionários incluíam espaços para mencionar as práticas implementadas "fora da caixa".

O estudo contou com a colaboração da ABRAPA e de entidades estaduais, que enviaram o questionário a todos os seus associados produtores. Essa cooperação provou ser crucial para contatar os produtores, já que nenhuma organização estatal concordou em fornecer os detalhes de contato dos produtores individuais. No total, o questionário foi enviado para aprox. 360 fazendas. Um total de 36 questionários foram recebidos e 20 entrevistas foram realizadas.

Foi realizada uma viagem de campo a regiões de destaque na produção de algodão e número de cooperados, com reuniões presenciais e entrevistas com a ABRAPA no Distrito Federal e com as entidades estaduais da Bahia, Goiás, Mato Grosso e Mato Grosso do Sul. Os demais órgãos estaduais foram contatados remotamente.

Este estudo identificou e documentou 27 práticas climáticas inteligentes, divididas em 5 partes. A primeira parte, sistemas de produção agrícola, lista as práticas adotadas e sua implementação como a rotação de culturas, implementada por 87% dos entrevistados em toda ou parte da área algodoeira; cobertura morta e culturas de cobertura utilizadas por 83%, Plantio Direto 83%, sistema de preparo reduzido 83%, e 23% dos entrevistados afirmaram ter integração lavoura pecuária na fazenda e 77% não possuem esta prática.

A segunda parte aborda a fertilidade e adubação do solo, sendo a prática mais adotada calagem e gesso, utilizada por 96% dos entrevistados em toda ou parte da área algodoeira; 93% usam fertilizantes e 77% usam adubação do sistema em 100% ou parte da área de algodão, enquanto 93% das fazendas usam sistemas de direção de máquinas agrícolas e 70% implementam práticas de agricultura de precisão. Embora a fixação biológica de nitrogênio não seja utilizada para o algodão, 97% dos entrevistados utilizam a prática para a soja.

Os resultados da pesquisa mostram que para combustível e energia, 93% dos entrevistados afirmaram que existe uma estratégia para o uso de combustível, enquanto apenas 7% não possuem uma estratégia. Para o uso de energia, os números encontrados são de 76% e 24%, respectivamente.

Para sementes e produtos fitossanitários, 97% das fazendas participantes utilizam esta prática, sendo que 100% utilizam produtos fitossanitários em toda ou parte da cultura do algodão; 97% utilizam manejo integrado de pragas e 88% utilizam controle biológico e microbiológico em toda ou parte da área de algodão; 48% das fazendas participantes afirmaram ter biofábricas própria na fazenda, 52% não; para sensoriamento remoto e uso de armadilhas inteligentes, os entrevistados declaram o uso em 59% e 38% em toda ou parte da área de algodão.

A última parte da pesquisa coletou dados sobre outras práticas climáticas inteligentes. A adoção de gestão do clima e monitoramento meteorológico foi afirmada por 93% dos entrevistados, enquanto 93% utilizam práticas de gerenciamento de subprodutos e resíduos; para diversificação de renda 52% das fazendas tem essa prática e 48% não tem, sendo esses números para seguro rural 24% e 76% respectivamente; fazendas que tiveram áreas degradadas e recuperação de pastagens somaram 41%, e 59% relataram não ter tido essas atividades. Para água e irrigação 82% das fazendas participantes não relataram esta prática, enquanto 18% relataram ter irrigação na fazenda.

As iniciativas da Better Cotton e da ABRAPA para apoiar a adoção de práticas climáticas inteligentes é o benchmark feito pelas instituições em relação à cadeia produtiva da matéria-prima, concedendo um certificado de conformidade com essas práticas sustentáveis.

Os produtores que aderem ao programa Better Cotton – ABR estão comprometidos com as práticas descritas nos critérios 7 e 8 do protocolo ABR. Essas práticas são eficientes na redução das emissões de GEE, melhorando os processos e garantindo a continuidade dos recursos naturais da região, não só para seus proprietários, mas também para toda a comunidade. Isso ficou claro na análise de conscientização dos produtores realizada pelo estudo, com a percepção dos agricultores de muitos dos efeitos das práticas na mitigação das mudanças climáticas.

Os fatores que influenciam a adoção das mudanças climáticas entre os produtores brasileiros são a conscientização dos produtores de que muitas das práticas que utilizam servem para melhorar a produção e reduzir os custos de produção, podendo ser consideradas climaticamente inteligentes. Outro fator é superar a resistência dos produtores às mudanças e adaptação às novas tecnologias de manejo.

As práticas pesquisadas têm efeitos na mitigação dos efeitos das mudanças climáticas. Além disso, a rastreabilidade de produtos, auditorias de certificação e práticas de monitoramento e orientação para redução de fertilizantes e produtos fitossanitários contribuem positivamente para a redução dos efeitos e causas das mudanças climáticas.

As principais lições aprendidas com os esforços de mudança climática no Brasil são que os agricultores brasileiros são capazes de produzir algodão, usando as tecnologias disponíveis e com o menor impacto ambiental possível.

As principais recomendações mais importantes são: aumentar a conscientização dos produtores de algodão sobre a importância das consequências mais diretas das mudanças climáticas, fornecendo ferramentas para que os agricultores tenham uma melhor compreensão do desempenho de sua fazenda em relação às emissões de gases de efeito estufa e à contabilização da captura de carbono; apoiar pesquisas sobre o uso de produtos biológicos em um sistema alternativo de manejo de pragas, combinando estratégias de manejo biológico e químico no controle de pragas e doenças; organizar estudos econômicos de longo prazo sobre o uso da rotação de culturas e culturas de cobertura na produção de algodão, a fim de rentabilizar essas práticas e apontar aos produtores também dessa forma os ganhos dessas práticas; incentivar a criação de departamentos de saúde do solo entre as diferentes associações de produtores de algodão, estabelecendo uma rede para ajudar as iniciativas a disseminar melhor as práticas da CSA e conectar-se entre si, com treinamento dos instrutores (assessores) para superar as lacunas de conhecimento que precisam ser ainda mais alimentado com acesso ao conhecimento mais recente.

Uma pequena pesquisa de percepção climática realizada a partir da preocupação com a reação dos cotonicultores em relação ao tema mostrou que 42% dos cotonicultores participantes indicam perceber uma mudança no clima e 73% estão preocupados com os riscos climáticos e os impactos futuros que estes podem ter em suas operações agrícolas.

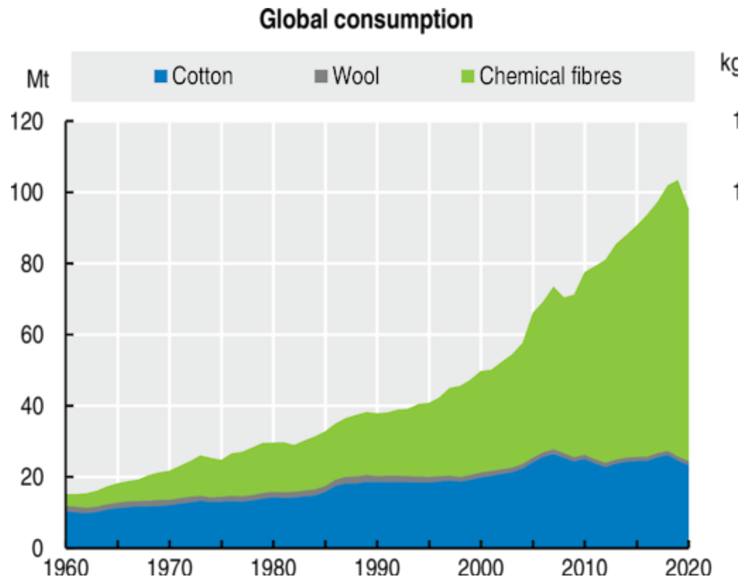
Summary

1. Introduction.

Cotton lint is the most important vegetal fiber in the world nowadays and is woven into fabrics, either alone or combined with other fibers. It was in early use in India, but in many countries, it is the latest of the natural fibers to be used. In early times wool was the principal fiber of western and southern Europe, hemp in northern Europe, flax in Egypt and silk and ramie in China. The invention of the saw gin and the development of the factory system caused a rapid expansion in the use of cotton, together with the ease of production and adaptability to machine manufacture.

Over the past decades, global demand for textile fibers has grown strongly, but most of this demand has been met by synthetic fibers, see chart 01.

Chart 01 – Historical trends in consumption of textile fibers (OECD-FAO 2021).



Moreover, the global per capita consumption of cotton fibers has increased little over time, but has decreased in recent years. The prospects for global cotton use depend on developments in developing and emerging economies. Demand from developing regions with lower absolute levels of consumption but higher income responsiveness will put an upward trend on global demand as the incomes and population of these countries are projected to increase. As a result, it is expected that that global consumption of cotton products will grow at a slightly higher pace than global population in the coming decade (OECD-FAO).

2. Cotton production scenarios.

2.1 Global Cotton Scenario – Main Producers, Importers, Exporters.

The global cotton market was estimated at a worth of US$ 38,54 billion, and is expected to reach US$ 46,56 billion by 2029 (MDF 2022). India, China, Pakistan and United States are major producers of cotton worldwide. United States exports most of its cotton produce as it has a less developed textile industry. Asian countries not only dominate the cotton production, but they are also the biggest consumers. China, India, Pakistan, and Bangladesh are the largest cotton consumers worldwide, accounting for one of the highest global consumption. In recent years Vietnam and Uzbekistan have also emerged as a major consumer of cotton.
In India, the supremacy of the textile sector exists, as it consumes most of the country's cotton. Cotton is grown in more than 60 different countries, including India, China, Brazil and the USA. Major cotton producing countries are listed I table 01 (USDA 2023).

Table 01 – Major cotton producing countries (USDA 2023)

(1000 MT)	2018/19	2019/20	2020/21	2021/22	2022/23*
China	6.096	5.977	6.445	5.835	6.423
India	5.661	6.205	6.009	5.313	5.334
United States	3.999	4.336	3.181	3.815	3.196
Brazil	2.830	3.000	2.356	2.552	2.896
Australia	479	136	610	1.274	1.197
Turkey	816	751	631	827	1.067
Pakistan	1.655	1.350	980	1.306	849
Other	4.263	4.413	4.065	4.337	4.095
Total	25.800	26.168	24.276	25.259	25.058

*Estimated

China is the largest cotton producer and are also cotton importers. Bangladesh produces a minor amount of cotton locally, and imports almost 99% from different regions. Major cotton importing countries are listed in table 02 (USDA 2023).

Table 02 – Major cotton importing countries (USDA 2023)

(1000 MT)	2018/19	2019/20	2020/21	2021/22	2022/23*
Bangladesh	1.524	1.633	1.807	1.785	1.676
China	2.096	1.554	2.800	1.707	1.633
Vietnam	1.509	1.411	1.587	1.444	1.372
Pakistan	621	871	1.176	980	936
Turkey	785	1.017	1.160	1.203	914
Indonesia	664	547	502	561	392
India	392	496	184	218	370
Other	1.657	1.334	1.383	1.398	1.323
Total	9.248	8.864	10.598	9.296	9.617

*Estimated

The United States is the leading exporter of cotton worldwide, followed by Brazil and Australia. Benin is the largest cotton producer in West Africa. The major cotton exporting countries are listed in table 03 (USDA 2023).

Table 03 – Major cotton exporting countries (USDA 2023)

(1000 MT)	2018/19	2019/20	2020/21	2021/22	2022/23*
United States	3.230	3.370	3.560	3.184	2.613
Brazil	1.310	1.946	2.398	1.682	1.676
Australia	791	296	344	779	1.328
India	767	697	1.348	815	479
Greece	295	319	355	311	278
Benim	303	211	342	305	283
Mali	294	256	131	283	207
Other	2.043	1.837	2.155	1.973	1.757
Total	9.032	8.939	10.632	9.331	8.621

*Estimated

2.2. Brazil Cotton Scenarios.

Commercial production in the country began in the 18th century, in the states of the Northeast Region. In 1760, Maranhão exported the first bales of cotton to Europe, produced of arboreum type cotton, which have longer fibers. Brazil quickly became one of the world's largest producers. The process was driven by the British demand for raw materials after the Industrial Revolution and the Independence of the United States, which stopped supplying the British market. To increase the supply of raw material, herbaceous cotton cultivars, with shorter fiber staple length but more productive, were brought to Brazil. Initially tested in São Paulo, which established itself as a major producing center for a period, the cultivars quickly began to be cultivated in Goiás, Mato Grosso, Minas Gerais, Rio de Janeiro, Espírito Santo and Paraná.

At the beginning of the 20th century, cotton fabric factories were built in the main production and industrial centers of the country. At that time, São Paulo and Paraná alternated with the largest national producers. However, in the 1980s, the “cotton weevil” pest (Anthonomus grandis, Boheman), spread and devastated the crop in Brazil. In a short time, the infestation destroyed entire plantations in the Northeast and caused a reduction in the planted area between 1981 and 1995, eliminating 800,000 jobs. Added to this, in the following decade, the Brazilian government reduced taxes on cotton imports, which placed the Brazilian fiber in an unfavorable situation and drastically reduced cotton cultivation in the national territory.

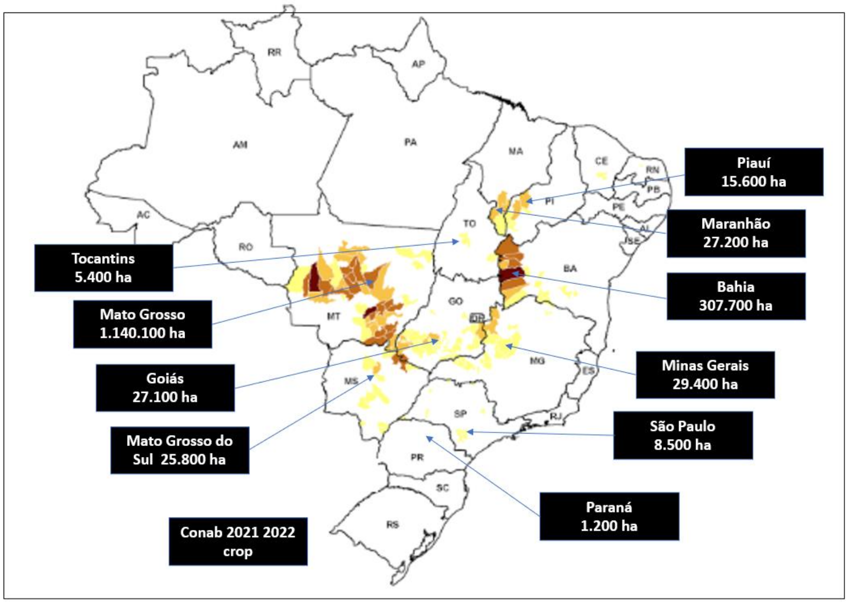
As of 1997, a new cycle of activity in cotton began, with complete mechanization of cultivation (from planting to harvest), the intensive use of chemical inputs and the rotation of herbaceous cotton with soybean and corn crops. As a result, the productivity of the crop increased significantly, and Brazilian cotton lint once again gained prominence in the international market. The changes were accompanied by efforts to maintain competitiveness, such as the adoption of a modern business model for farming. Investments in research, tax incentives and the new professional positioning of producers were essential elements in the recovery of the cotton sector and its consolidation. Cotton farming expanded from Mato Grosso to other regions of the Cerrado, initially to Mato Grosso do Sul, then Goiás, Bahia, Minas Gerais and, finally, Maranhão, Piauí and Tocantins. There, the producers found a favorable climate and topography and relied on agricultural research to adopt technologies that allowed the full mechanization of crops. With work on genetic improvement, cultivars adapted to the new production centers emerged and cotton cultivation began to be carried out in large areas.

The strengths of Brazilian cotton production are its great production aptitude, with favorable climate and soil, large, capitalized producers, usually associated to strong organizations, very high technological level, which allows gains in scale in production, good quality of the produced fiber with traceability.

As weaknesses it can be mentioned the dependency of the external markets, which dictates product price; high production cost, due to the high degree of mechanization and use of inputs, mostly imported and dependent on the exchange rate; problems in production flow logistics (road transport and ports); low degree of association among smallholder producers, mainly in the semi-arid region; difficulty to switch to another culture, due to the specificity of the used machinery in cotton production like harvesters and cotton gins.

The main production regions for cotton are shown in map 01, with a clear concentration of production in the States of Mato Grosso and Bahia, both localized in the cerrado region.

Map 01 – Brazil main cotton producing regions in the 2021 2022 (Conab 2023).



According to the CONAB 2023 survey, for the 2022/23 harvest, the planted area in Brazil is estimated at 1.633.500 hectares, with an estimate of raw cotton production of 4.064 kg/ha (1674 kg/ha lint), and total production for the period is expected to reach 6.637.900 tons (2.734.300 tons lint) (table 04).

Table 04 – Planted area, productivity and production of Brazilian raw cotton (CONAB 2023)

State	Planted area (hectares)		Productivity (kg/hectare)*		Production (tons)*	
	21/22 Crop	22/23 Crop**	21/22 Crop	22/23 Crop**	21/22 Crop	22/23 Crop**
Mato Grosso	1.140.100	1.170.900	3.778	4.341	4.307.300	5.082.900
Bahia	307.700	308.000	4.229	4.753	1.301.300	1.463.900
Minas Gerais	29.400	29.400	3.765	3.975	110.700	116.900
Maranhão	27.200	28.100	5.209	4.397	141.700	123.600
Goiás	27.100	25.400	4.500	4.532	122.000	115.100
Mato Grosso do sul	25.800	29.300	4.636	4.834	119.600	141.600
Piauí	15.600	15.100	4.075	3.905	63.600	59.000
São Paulo	8.500	11.900	3.907	3.842	33.200	45.700
Rondonia	8.100	8.100	3.900	3.900	31.600	31.600
Tocantins	5.400	5.900	4.333	4.043	23.400	23.900
Ceará	2.300	2.300	1.690	1.413	3.900	3.200
Paraiba	1.200	1.200	951	1.059	1.100	1.300
Paraná	1.200	1.600	3.075	3.075	3.700	4.900
Alagoas	500	500	1.905	1.177	1.000	600
Rio Grande do Norte	300	300	3.813	3.872	1.100	1.200
Brazil	**1.600.400**	**1.638.000**	**3.915**	**4.405**	**6.265.200**	**7.215.400**

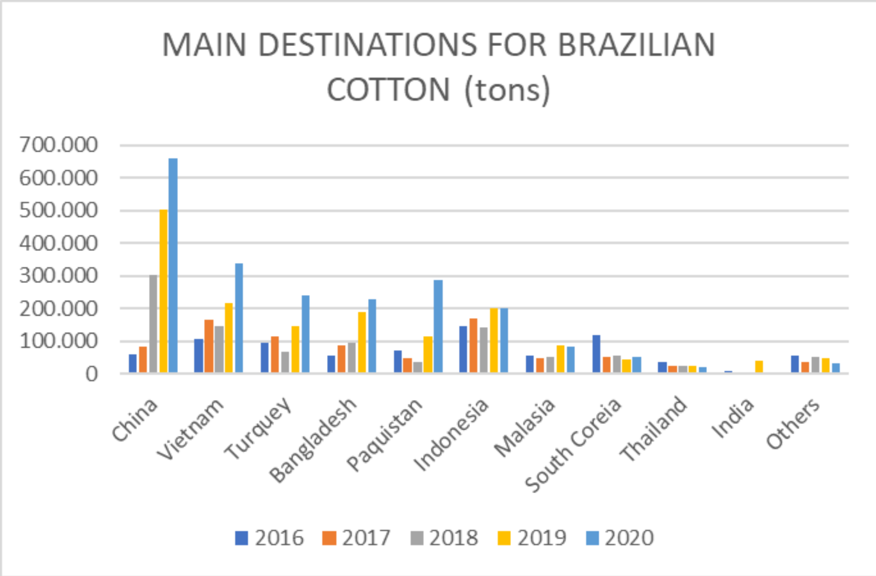
* Raw cotton **Forecast

For the 2021-2022 crop, production in the Bahia and Mato Grosso States accounted for 89,5% of raw cotton, while the estimated participation for the 2022-2023 crop amounts to 90,7% for both states This variation in the planted area is the result of a shift from other crops to cotton in the western region of Bahia State, where there was an increase in relation to the past harvest (AIBA 2023). For years, Mato Grosso has been developing solid cotton farming, the state has become a leader in the Brazilian production process. Planting takes place in December - first crop, and January - second crop, after a soy crop planted in September of the previous year.

Cotton is grown mostly on large farms, which are managed as companies (inserted in the agribusiness), which have considerable investments in production, ginning and storage infrastructure. They carry out large costing and investment credit operations and use large-scale mechanization in all stages of the production process, generally having their own technical assistance, both for cotton cultivation and for the machinery used, and they employ specialized labor.

Bangladesh, Turkey and China were the main destinations for Brazilian cotton exports for the month of January 2023, totaling 25.800 tons. Together, the three countries accounted for 60% of the entire volume for the month (Chart 02).

Chart 02 - Brazilian cotton top export destinations - Jan/2023 (SECEX; ANEA).



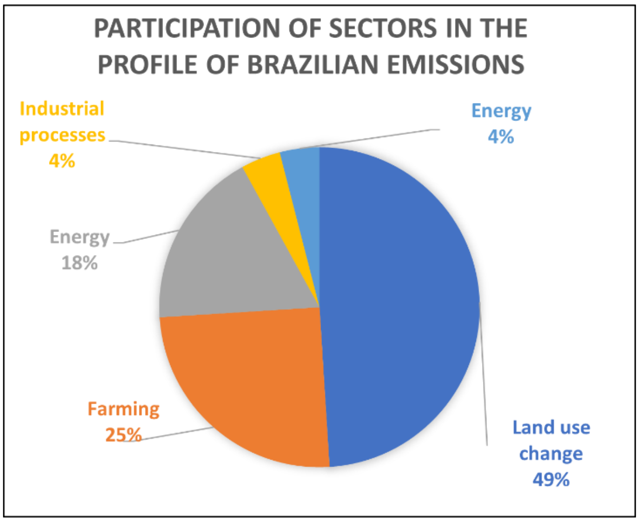
The biggest 2017 exporting companies for Brazilian cotton are listed in table 5 (Trase Earth 2017), these 10 companies were responsible for 69,1 % of total exports. This total value is a composite of traded sub-products, which are converted to their original raw equivalents.

Table 05 - Brazilian cotton biggest exporting companies (Trase 2017)

Exporter group	Volume (tons)	% of total exports
SLC Agricola Pejucara Ltda	131.210	6,9%
AMAGGI	96.474	5,1%
Bom Futuro mAgricola Ltda	96.066	5,0%
CARGILL	76.639	4,0%
LOUIS DREYFUS	69.506	3,6%
EISA - Empresa Interagricola	47.731	2,5%
ADM	44.698	2,3%
Bom Jesus Agropecuária Ltda	36.735	1,9%
MITSUI & CO.	30.086	1,6%
Terra Santa Agro	29.553	1,5%
Total exports	953.941	100,0%

Source: Trase Earth 2017

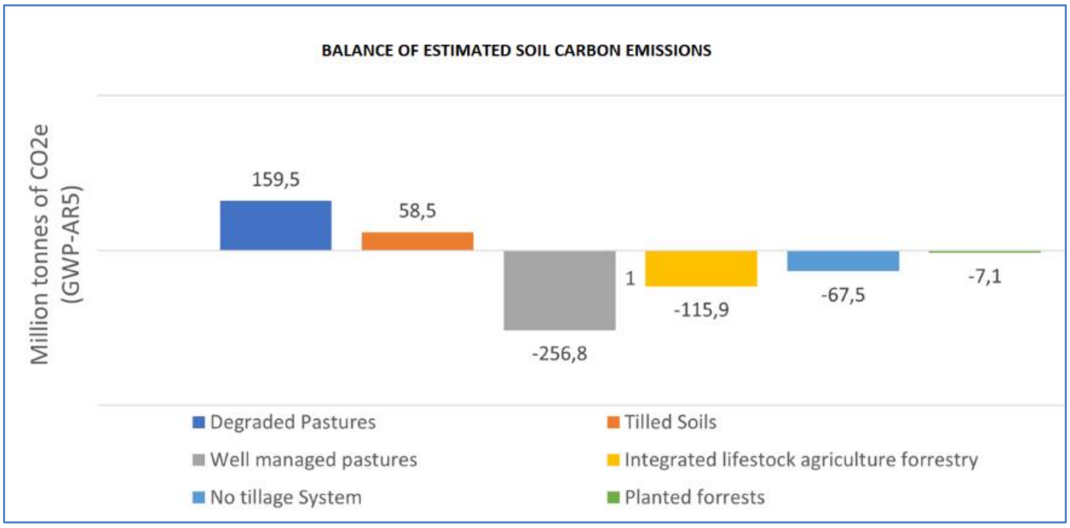
2.2.1 Brazil scenarios for climate change adaptation and mitigation, and cotton production.



Brazil, despite having a relatively clean electricity grids reliant on hydropower and renewable energy, is the globe's fifth-largest emitter of greenhouse gas mostly because of deforestation, agriculture and other land use. In graph x the participation of sectors in the profile of Brazilian emissions can be verified (SEEG 2023).

In 2021, the soil carbon balance resulted in an estimated net removal of 229 million tons of CO_2e, representing an increase in net removal of 4.6% compared to the 2020 balance, estimated at 219 million tons of CO_2e. The balance of carbon emissions by soil from the agricultural sector in 2021 in Brazil can be seen in the graph below (SEEG 2023), showing the importance of the expansion of good agricultural practices, with the promotion and adoption of mitigation and adaptation, contributing to the national climate goals by promoting carbon removal, in addition to boosting the search for more sustainable production.

Agriculture is highly influenced by climatic factors, such as temperature, rainfall, soil and air humidity, winds and solar radiation, in such a way that climate and its variability are the main risk factors for agriculture. The increase in temperatures due to climate change will result in an increase in water



consumption by agricultural crops and a reduction in water availability, putting production capacity at risk.

Impacts of climate change that can alter agricultural productivity:

- Increased frequency and intensity of extreme weather events that cause natural disasters such as droughts, increase of the occurrence of "veranicos" – dry spells in the crop season, floods and frosts;
- Frequency of days with extreme temperatures, whether high or low, and the decrease in the temperature gradient between day and night impact plant metabolism;
- Change in the occurrence and severity of pests and diseases;
- Greater concentration of high-intensity rainfall in a short period of time.

Practices for climate risk adaptation are:

- Cultivars with high tolerance to drought and water deficiency;
- Change in production systems with practices that allow better rainwater infiltration and maintenance of moisture in the soil;
- Change in crop management, introducing integrated systems, No Tillage System, and irrigation;
- migrate to the other regions of the country, where temperatures are milder and the risk of frost will be lower;
- Management of pests and diseases, by diversity and crop rotation, biological control and development of studies on pest risks due to climate change;
- Recovery and Conservation of Permanent Preservation Areas and Legal Reserve, allowing to maintain springs, water courses, water cycle, milder temperatures and ecosystems with natural predators of pests;

- Transition to integrated production systems such as crop-livestock-forest, crop-livestock, forest-livestock which depend less on external resources and reduce vulnerability to climate risks;
- Use of instruments for risk management in agriculture, like ZARC, developed by Embrapa - Brazilian Agricultural Research Corporation, designed to identify minimum requirements of each crop in each Brazilian municipality for maximum yield and minimum climate-related risks. CARC identifies suitable municipalities and sowing periods with less climatic risk for the cultivation of crops in different crop cycles and soil types, ensuring the economic viability of the investments.

Brazil has committed to supporting adaptation strategies such as climate smart agriculture practices, improved water management, improved monitoring and early warning, the development of knowledge and decision-support systems, and the development of new crop varieties and technologies to support farming. Also, strengthening of economic-financial mechanisms to encourage sustainable soil and water management in rural areas, as an example the ABC + program.

An important working approach entails formulation and structuring of models or new rural-development elements that include innovation and transfer of new technological options that promote resilience, adaptation and sustainability in face of the deleterious effects of climate change. More significant than technology is the scope of this approach, i.e., the tools and information technology transfers that provide means of access to developed and adapted technologies. To this end, the development of user-friendly information systems should be pursued, along with strengthening and restructuring of the Rural Technical Support (ATER) system and training of its technical staff (Brazil NAP 2016).

Production systems that result in reduced carbon losses and increased carbon stock in the soil are essential for climate smart agriculture. In this regard, Brazil's nationally determined contribution, through the ABC+ program, to reducing its greenhouse gas emissions in 2025 and 2030 includes soil carbon accumulation through the adoption of management practices of low carbon agriculture, like the No Tillage System (NTS), recovery of degraded pastures, integrated production systems (which combine crops, livestock and/or forests in the same area, or ILPF), biological nitrogen fixation, treatment of animal waste, and the planting of forests. These practices have in common the ability to reduce greenhouse gas emissions, increase the efficient use of natural resources, and generate productivity gains (Plano ABC 2023).

It is the context of production systems that cotton production is involved. Research has shown that cotton cultivated under the no-tillage system, in addition to showing an increased fiber yield, also increases the N content in the top 5 cm of the soil, and the organic carbon stock increased 20% after nine years, at up to 40-cm depth **(Barcellos 2018)**. The C accumulation in tropical Brazilian soil cultivated with cotton under the NTS exceeds by almost five times the goal of the '4 per 1000' initiative presented during the 21st United Nations Climate Change Conference. The results indicate that cotton cultivation under the NTS is an important technology for farmers to change the process of land use and management. In addition to increasing cotton yield and soil carbon accumulation, NTS provides greater productive resilience.

2.3 Insights for Smallholder cotton production in Brazil.

The cultivation of herbaceous cotton, under rainfed conditions, was one of the most important for small and medium-sized family-based producers in the semi-arid region of Brazil, where it has occupied an area of over two and a half million hectares. The plantings were carried out using share systems on large farms by residents and non-resident workers, who worked with the farmers through the payment of a share fee, and the planting was based on arboreal cotton, in a consortium system with corn and beans, in close combination with livestock, which ensured a sustainable model for the reality of that time.

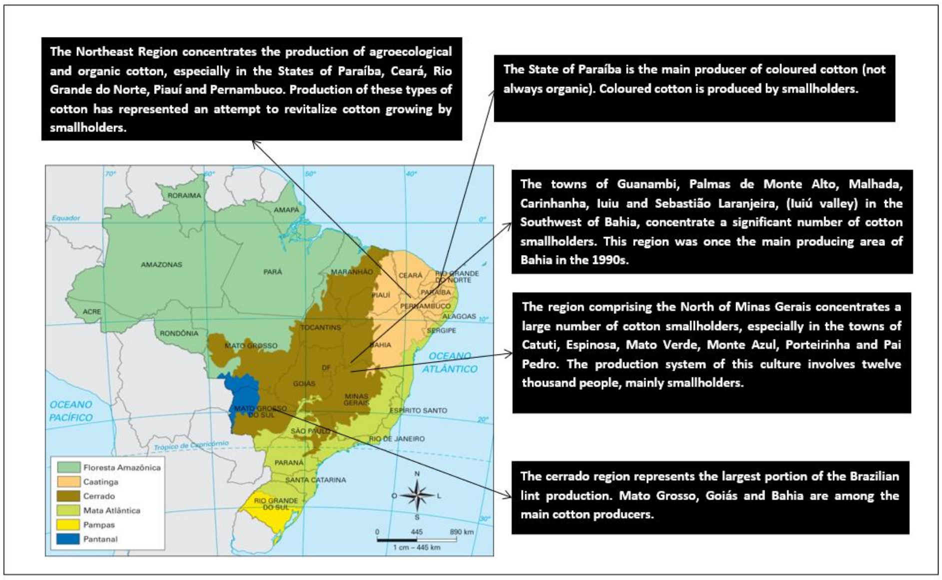
At the end of the 1970s, cotton from the northeast, even though it generated thousands of jobs in the field, was already losing ground, due to its low profitability, low productivity, lack of minimum price policy, lack of technical assistance and rural extension, financing and the disorganization of the production chain, which operated under the strong presence of intermediaries and large mill owners, who were the main beneficiaries of the generated profits.

In the early 1980s, the intensification of labor issues, the low economic profitability of the exploration model, lack of government support, low use of technology, combined with the arrival and consolidation of the cotton weevil (Anthonomus grandis), as the main pest of the crop in 1983, determined the breakdown of the model, accounting for the rural exodus that occurred at the time.

Currently, the cotton area in this region is very small, with low productivity due to water deficit occurring with high frequency, and the inability to coexist with the boll weevil. In the 1980s, the southwest of Bahia was one of the largest cotton producers in Brazil, growing approximately 300.000 ha, in the traditional smallholder farming system. Most have abandoned farming. Today, the region still has smallholder cotton production, together with the north of Minas Gerais, as the crop is still one of the few income alternatives since it is adapted to soil and climate conditions and has good market outlets.

One of the alternatives that have been adopted by smallholder farmers is the production of cotton with special characteristics, such as varieties with natural-colored fibers, organic and agroecology, which allow obtaining differentiated prices in relation to conventional cotton, adding value to production and increasing profitability per area. There are currently opportunities, in the states of Ceará, Rio Grande do Norte, Paraíba, Pernambuco and Alagoas, in market niches, for organizing and strengthening organic and agro-ecological production centers for white and colored cotton, where smallholder farmers work through sale contracts, but at a given price.

Map 02 – Brazil smallholder cotton producing regions.



Second to the last census (IBGE 2017), Brazil had 3.224 cotton farmers, of which 2321 were smallholders, and 906 medium and large farmers.

Weaknesses for smallholder cotton production in Brazil can be mentioned:

- Risky production system due to irregular distribution of rainfall and increase in pests, as production is mainly located in or near the Caatinga biome, which has less rainfall.
- Lack of interest and/or exodus of young people hinders succession in smallholder farming.
- Small amounts and geographically dispersed producers, which makes everything more expensive and harder: logistics, processing, certification.
- Higher prices for smallholder cotton of other countries, as average quality does not allow for price differentiation (such as the Egyptian cotton or the Peruvian Pima).
- Complex logistics and trade contacts, company's willing to buy smallholder cotton do not know who to contact, little information on prices, expected amounts, payment terms.
- No consistent production chain established, spinning companies are reluctant to process smallholder cotton, especially when coloured cotton.
- There is no guarantee that order's will be delivered, due to production risks, like weather and phytosanitary conditions, and lack of stock.
- There is no prompt availability of cotton; buyers must wait for the crop season.
- Absence of public policies focused on small cotton producers;
- Lack of scale in production, making production costs high compared to larger properties;
- Technical Assistance/weakened extensionism;
- Lack of properly trained labor.

2.3.1 Insights smallholder climate smart agricultural cotton production.

The ambition to promote adaptation to climate change by family farming is not an easy task. For the adoption of CSA techniques and technologies and the application of these, it is important to make smallholders aware of the importance of these techniques and technologies and climate change mitigation.

Some insights on CSA can be noted from the questionnaire sent by the COOPERCAT cooperative, located in the northern region of Minas Gerais. Most cited is the lack of trained professionals, lack of information on several topics, like on adequate and adapted machines and implements, on the use of gypsum for improving soil quality in the caatinga - the biome that only occurs in Northeast Brazil, and is inserted in the context of the semi-arid climate, with a dry season when most plants lose their leaves, prevailing in the landscape the clear and whitish appearance of the trunks of the trees., use of solar based electric power equipment as means of income diversification.

The use of no-tillage and minimum cultivation system is hampered by the inexistence of appropriate equipment for these practices under smallholder circumstances, and lack of specific studies for caatinga soils. Another difficulty is the rainfall regime, inherent to the Caatinga biome, and is marked by accentuated space-time irregularity and long periods of drought, where most of the precipitation usually occurs in three months, and the establishment of cover crops to create straw / mulch. However, smallholder farmers use crop rotation to grow fodder for animal supplementation, resulting in some increase of soil organic matter. The recovery of degraded areas and pastures is a necessary process in the region, due to the lack of proper soil management, contributing to their deterioration.

Remarkable is the interest in solar electricity, as the biome presents high luminosity and a high solar radiation index. The use of solar energy with the introduction of photovoltaic panels in small rural properties can provide energy for self-sufficiency, for use in irrigation systems, machinery used in dairy production facilities and domestic use. As the semi-arid region produces sun all year round, the excess energy production can be connected to the grid, providing another source of income on the rural property.

The COOPERCAT region is focused on smallholder nonorganic / non ecological cotton production. For this, farmers use commercially available cotton varieties, with GMO technologies, which provide ample control of high-voracity pests, substantially reducing the number of pesticide applications, from 25 to 30 sprayings per cycle, to a maximum of 15 applications, to control especially the boll weevil. The impact of this technology provides smallholders farmers some competitiveness in cotton production.

Most farmers (80%) of the cooperative make use of Integrated Pest Management (IPM), where pesticide use is guided by monitoring of crops, indicating the need for intervention, whether for the application of pesticides, but also for the need of plant nutrients and growth regulators. This practice is commonly used, but the need to evolve towards providing new means of monitoring through precision agriculture is recognized.

The use of biological and microbiological control, aimed at reducing the number of applications and the amount of synthetic pesticides for the control of the boll weevil, is not yet widely disseminated. The technology is still in the field testing phase, and requires a period of evaluation and behavior of pests and parasites, in addition to requiring trained and constant labor in the area. The on farms structure also brings high costs. Tests with drone technology are being carried out.

AMIPA - Associação Mineira dos Produtores de Algodão, is working on the biological control in cotton with the use of several organisms, one of them the production and use of Catolaccus, a genus of parasitic wasps in the Pteromalidae family. Catolaccus grandis has been used by cotton growers in Texas to combat crop damage caused by boll weevil.

Collective monitoring of the incidence of the boll weevil with the installation of traps, and field monitoring of ramularia disease is used in the region, as the weevil is the main pest of cotton, making collective action a necessity. Also, it is legally prohibited to grow cotton in a 90 day period of the year, called “vazio sanitário”, the practice aims to restrict the food source for insects in a coordinated way throughout the country. For Minas Gerais state this period normally comprises July 1st to September 30th of each year.

COOPERCAT provides members with services of professional climate management and meteorological monitoring, for decision-making in day-to-day agricultural practices, to carry out annual planning, anticipating relevant seasonal conditions for the harvest, anticipate incidence of pests and diseases, and coping with periods of intense rain or drought.

2.4 Climate smart agricultural practices global scenario.

Climate-smart agriculture is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that addresses the interlinked challenges of food security and accelerating climate change. CSA aims to simultaneously achieve three outcomes, using the three pillars that form the basis of climate-smart agriculture (World Bank Group 2021):

1. **Increased productivity**: Produce more and better food to improve nutrition security and boost incomes, especially of 75 percent of the world's poor who live in rural areas and mainly rely on agriculture for their livelihoods;
2. **Enhanced resilience**: Reduce vulnerability to drought, pests, diseases and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns;
3. **Reduced emissions**: Pursue lower emissions for each calorie or kilo of food produced, avoid deforestation from agriculture and identify ways to absorb carbon out of the atmosphere.

Operational experience implementing climate smart agriculture worldwide points to a large spectrum of approaches that deliver productivity and resilience gains alongside lower emissions. However, to secure these outcomes, a few main recommendations include (World Bank Group 2015):

- **Ensuring access** to existing and new climate-smart technologies for poor farmers. These technologies can help reduce yield gaps and improve resilience;
- **Closing the gender gap**. Providing women farmers with proper resources and support will help raise yields and improve food security;
- **Reducing GHG emissions** through improved fertilizer use and improved livestock breeding and waste management.

FAO also considers that the production, processing and marketing of agricultural goods are central to food security and economic growth. Production has been achieved through a number of production systems which range from smallholder mixed cropping and livestock systems to intensive farming practices such as large monocultures and intensive livestock rearing. The overall efficiency, resilience, adaptive capacity and mitigation potential of production systems can be enhanced through improving its various components:

- Improving soil nutrient content;
- Water harvesting and use;
- Pest and disease control;
- Resilient ecosystems;
- Genetic resources;
- Harvesting, processing and supply chains.

Uncertainty in projections makes it difficult to determine the precise impact of climate change on future agricultural productivity, but most scenarios show significant negative effects should be expected worldwide and especially in economically underdeveloped regions. Importantly, agricultural production is not only affected by climate change but contributes substantially to the problem with yearly greenhouse gas (GHG) emissions, combined with forestry and other land uses. It is in this environment that the concept of CSA has become increasingly relevant.

But many operational aspects of CSA are still under investigation as local contexts determine the enabling environment as well as the trade-offs and synergies between productivity, adaptation, and mitigation. Farmers must identify what can be considered climate-smart given their biophysical, agricultural, and socio-economic context. The frequent result is that, even when farmers, agrarian organizations, large scale farmers, and policy maker have embraced the concept of CSA, they struggle with the implementation and tend to look for simple protocols to follow.

2.5. Climate smart agricultural practices in cotton production.

Cotton is considered a sun loving crop, adapted to dryer environments, and shows the ability to withstand drought so that they can recover from dry spells and resume growth and fruiting. However, cotton is sensitive to various climatic parameters during different stages of crop development, including temperature and rainfall.

This inherent resilience of the cotton crop can be enhanced by increasing the degree of adaptation through soil management interventions, breeding and selection of more temperature tolerant cotton varieties, crop diversification with cover crops and crop residues, reduce dependence on synthetic fertilizers and chemical pesticides. Moreover, practices that enhance soil organic matter have significant impact on climate change and mitigation, as soils that are rich in organic matter capture more water, retain it well and minimize evaporation losses, and also function as carbon sinks.

U.S. cotton growers lead the world in quantities of responsibly produced cotton, and through USDA sponsored projects supports farmers in production of sustainable and climate-smart cotton. The Better Cotton certified producers are focused on climate smart practices: natural resources, which deals with soil health, water and biodiversity; crop protection - focuses on the adoption of Integrated Pest Management (IPM) and practices which promotes a combination of biological, cultural and mechanical or physical practices to reduce the need for synthetic pesticides. The standard also has as a cross-cutting priority on climate change, as producers are encouraged to select locally relevant practices and activities which help farming communities adapt to climate change and/or mitigate its effects.

According to the Sustainable Cotton Ranking (SCR 2020), the share of more sustainable cotton increased to 21% of the global production in the 2017/18 season (12% in 2015/16, which was reported in the 2017 report), with approximately 5.3 million metric tons of cotton lint. For this ranking 4 sustainable cotton production standards were considered:

- The volume of organic cotton lint produced in 2017/18 was 180,871 MT, in 19 countries by 182,876 farmers on 356,131 hectares.
- Cotton made in Africa, in 2018, a total volume of 580,000 MT of CmiA cotton lint was produced in ten African countries by 1 million smallholder farmers, on 1,780,000 hectares.
- The production of Fairtrade cotton lint was 16,906 MT in 2017/18. in eight different countries.
- In the 2017/18 season, 5.1 million MT of Better Cotton lint was produced in 21 countries on five continents, produced by 2 million farmers on 5.3 million hectares of land. Better Cotton represents the largest share of more sustainable cotton. ABR has the largest volume in this.

The market share of cotton covered by the recognized programs for the 2020-2021 season was 24% of the 24.4 million tonnes produced, or 5.9 million tonnes (Textile Exchange 2022). Better Cotton accounted for 4.670 million tonnes (19.16%), CmiA Cotton Made in Africa had 677 thousand tonnes (2.78%) in its program, certified organic cotton produced was 342 thousand tonnes (1.40%) and Fair Trade had 18 thousand tonnes (0.07%).

All other cotton programs together, including BASF e3, ICPSS, ISCC, organic, REEL cotton, and the USCTP, had a combined market share of around 5 % of all cotton in 2020/21.

Assuming that sustainability standards have criteria on climate smart practices, it can be stated that approx. 29% of global cotton production is produced accordingly.

3. Study objectives.

The study objectives are to identify and document climate-smart agricultural practices implemented by Better Cotton - ABR licensed producers in Brazil, provide in-depth information on the selected climate-smart agricultural practices and assess their contribution to climate change mitigation, as well as the extent to which they have enabled the Better Cotton producers to adapt to the consequences of climate change. More specifically, the case study covers the following key research questions:

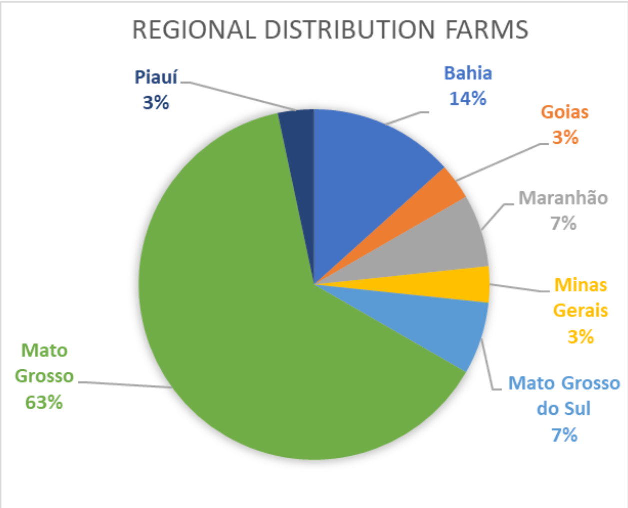
- What are the major climate-smart practices implemented by the Better Cotton – ABR licensed producers in Brazil?
- In which regions are these practices being implemented and for how long?
- What are the different initiatives from Better Cotton and ABRAPA to support the adoption of these practices?
- What factors affect the adoption of these practices?
- How well have these practices enabled the Better Cotton-ABR producers and their communities to adapt to the consequences of climate change?
- What are the factors influencing climate change adaptation among the producers?
- What effects those practices have on climate change mitigation?
- What are the key lessons learned from climate change efforts in Brazil? What has worked well and could be scaled up?
- What are the major challenges observed?
- Have there been any unintended outcomes of the climate-smart practices promoted by the program, either positive or negative?

4. Methodology.

In order to understand the agricultural practices implemented by producers regarding climate change and mitigation, it is necessary to get a closer look at the daily routines of rural properties.

To answer the research questions, SustenÁgil has undertaken a desk research and developed a questionnaire containing a set of data to be collected. This questionnaire was discussed with the Better Cotton team and approved. The questionnaire has been presented to ABRAPA, who recommended to contact the state organizations. The state organizations found the questionnaire too long, and included questions on farm size and planted cotton area, which are confidential. With the collected suggestions, a more simplified version was used in ABAPA, AMPA and AMPASUL state associations.

The support of all state associations has proven essential, they agreed that their teams send the questionnaires, asking producers to dedicate some time to answer the questions. None wanted to share direct contact details of their cotton producers. Moreover, farms are in full crop season with soy being harvested and cotton care activities in full progress, which also made scheduling of interviews with producers more difficult.

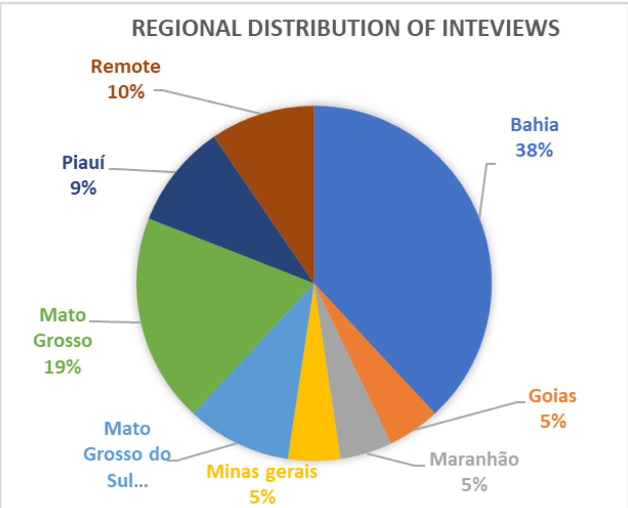


The distribution of respondents is shown in the graph.

The questionnaire was divided into topics like conservation tillage systems, crop rotation, cover crops, climate-smart fertilizers, nitrogen fixing organisms, phytosanitary products and integrated pest management, precision agriculture, seeds, integrating livestock and crop production, and included spaces for producers to mention “out of the box” implemented practices.

In-person interviews were done with producers and producer organizations in regions with prominent cotton production and number of members: the states of Mato Grosso with AMPA – Associação Matogrossense dos Produtores de Algodão in Cuaibá; West of Bahia with ABAPA - Associação Baiana dos Produtores de Algodão in Luis Eduardo Magalhães, Goiás, with AGOPA – Associação Goiana dos Produtores de Algodão, and Mato Grosso do Sul, with AMPASUL – Associação dos Produtores de Algodão do Mato Grosso do Sul. The other state organizations were contacted remotely.

The sample distribution for the interviews is shown in graph.



The consultation of interested parties was based on the analysis of organizations that influence or are impacted by climate change.

A field trip was undertaken to regions with prominent cotton production and number of members, with presential meetings and interviews with ABRAPA in the Federal District and the state organizations in Bahia, Goiás, Mato Grosso and Mato Grosso do Sul. The other state organizations were contacted remotely.
In total the questionnaire was send to approx. 360 farms. A total of 36 questionnaires were received and 20 interviews were conducted.

It is important to stress that the definition of the sample of interviewed producers will not be based on statistical analysis, and will not be done randomly, and in order to aggregate analysis and validate the results of the field interviews, regional focus groups will be used.

5. Results – Climate-smart Agricultural Practices

5.1 Context.

Climate smart Agricultural Practices (CSA) for cotton production are practices that reduce the carbon footprint of crop production and capture carbon. This captured carbon is then converted into plant material and/or organic matter in the soil, improving soil health Mechanized operations in the field, such as cotton planting and harvesting, and cultural treatments, such as fertilization and correction of soil acidity, are the main precursor activities of GHG emissions. The gases whose emission is typically related to the activities of the agricultural chain are Carbon Dioxide ($CO2$ - plant decay, insect and microbial activity in the soil, fossil fuels, plants through respiration, deforestation), Methane ($CH4$ - livestock) and Nitrous Oxide ($N2O$ - fertilizer).

To collect the climate-smart practices implemented by the Better Cotton-ABR licensed producers in Brazil, a series of climate practices was mentioned in the survey, for evaluation by farmers and stakeholders, divided in 5 distinct areas. The results are listed below, with insights, survey results, factors / challenges affecting the adoption of the practices and what effects does this practice have on climate change mitigation and adaptation as stated in the answers obtained during the survey.

5.2 Agricultural production systems.

Production systems are composed of a set of cultivation systems within the scope of a rural property, defined from the production factors (land, capital and labor) and interconnected by a management process.

5.2.1 No till planting system.

Brazil is one of the countries in which the practice of No-Tillage (NT) has been most widely implemented, evolving from 200 hectares in 1972 to 35,91 million hectares for the 2021-2022 crop (Fuentes Llanillo et al 2021). The expansion of the NT practice throughout the country was strongly associated with the expansion of soybean-based sequential cropping systems involving crops such as maize, wheat or cotton. NT practice saved time with soil preparation, improved soil moisture conditions and generated the additional growing period that permitted 2 crops per season where it was not possible before.

However, the use of NT as a lone practice is no guarantee for sustainability, and technology transfer and adoption efforts are also required to reinforce the application by farmers of the 3 basic principles: minimize soil tillage, which is limited to the planting line to place the seeds; establish permanent soil cover with crop residues and mulch and/or live plants; crop rotation with increased bio-diversification of plant species in relation to crops and use of plants with a high contribution of biomass-carbon, resulting in what is commonly called the No Tillage System (NTS). Thus, considering these 3 principles of no disturbance of the soil, permanent soil cover and crop diversification, it is estimated that only 10 to 15% of the 35,91 million hectares, or 3,6 to 5,4 million hectares, fit the concept of NTS (FEBRAPDP 2022).

One of the main difficulties farmers have is how to manage soil compaction/densification, as in year 4 or 5 after tilling the soil this problem appears. However, practice has shown that it is possible to develop crop rotation systems capable of preserving and/or improving the physical quality of the soil over time, avoiding the appearance of compacted layers. A second difficulty is the climate limitation for the establishment of cover crops at the end of the rainy season.

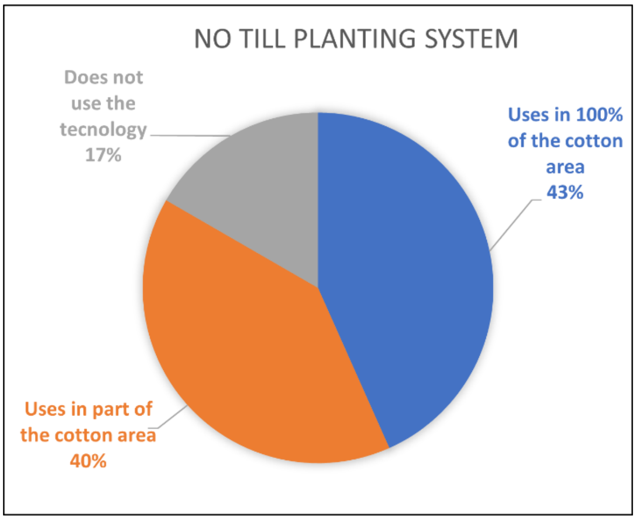
In the decision making process many farmers opt for more at hand solutions, like tilling the soil with harrows which leave some mulch on the soil surface, but in applying this practice root galleries are destroyed and the NTS is set back to year 1 again. Also, in the 10-15% of farmers applying the correctly the 3 principles, innovative thinking leads to smart solutions, like establishment of cover crops before crop harvest.

The Cerrado soils in Brazil have serious limitations for agricultural use due to low natural fertility, low water retention capacity, low resilience and high susceptibility to erosion. Management of these soils through NTS, with high addition of biomass C, are practices that can restore the soil organic carbon stock, enhance productivity and economic viability of these soils, while also playing a crucial role in restoring ecosystem productivity, soil quality and environment.

The planting of cotton in clayey and sandy soils of the Cerrado, when implemented with NTS, presents high rates of carbon increment, much higher than the rate suggested by the international initiative “4per1000” for the reduction of greenhouse gases. This was concluded by a study conducted by Embrapa Cotton, resulting from experiments in this line of research for about fifteen years in clayey soils in Goiás and 11 years in more sandy soils in Bahia (Embrapa Algodão 2022).

The adoption of soil preparation practices in the past has increased the erosive processes in many areas and, as a consequence, the silting up of watercourses, reservoirs, dams and aquifers. The use of the NTS with a permanently covered soil can assure that all rainwater infiltrates into the soil, which would raise aquifer and water table levels, allowing the flow of water courses to become more regular during the year and reducing the volume of the instantaneous flow that caused floods after intense rains. Soil cover has the main objective of providing protection against agents that cause erosion, like heavy rain and wind, as it prevents the direct impact of raindrops on the soil. In practice this means that for a cotton crop, which needs approximately 750 mm of water, in a precipitation regime of around 1.500 mm for the western Bahia cotton region for example, grown with the NTS, about 50% of the 1.500 mm infiltrates into the soil.

Failures in the implementation of NTS lead to several problems, compromising the stability of agricultural production, among them increased soil bulk density and soil resistance to root penetration, leading to reduction of porosity and water infiltration rate in the soil with occurrence of erosion, dragging of nutrients, fertilizers and correctives by the runoff. The main symptoms are premature expression of water deficit, on the occasion of small droughts / summers, and reduced yields.



Survey results. The answers collected in the survey indicate that producers still are not aware of the difference between No Tillage (NT) and the No Tillage System (NTS). As mentioned, NTS is based on the three pillars of no soil preparation, permanent soil cover, with the maintenance of crop residues on its surface, and crop rotation. In practice, they carry out crop succession instead of crop rotation and use recurrent disc rippers every 4-5 years to loosen the soil. Soil compaction and lower input of phytomass as the main difficulties stated with the adoption of NTS. 43 % of the respondents stated to practice 100% of their cotton area using the NTS, 40% using it partially and 17% does not use the system. Average of 16 (7-25) years in use.

Insights:

Traditionally farmers have a strong mentality focused on inputs and not on the processes, the vision that inputs will solve their problems. As a consequence, a dependency on inputs was created and this economic-commercial logic is very much embedded in the production model, representing a factor through which one always looks at the symptoms, never the cause. The main challenge to overcome this situation is a change of mentality among producers, as materially processes can change, but without a mental change, things do not really happen.
There is a lack of agronomic planning, and paradigms need to shift so that new technologies can be effectively practiced and their benefits visualized. Initially, the adoption on a small scale, in some plots of the property, is recommended, and the subsequent and gradual evolution of change over time. This is a learning and building process, and it takes time to adjust to the reality of each environment and production structure present on the farm.
The data generated by the scientific community in Brazil indicate that the potential for mitigation and reduction of GHG emissions for this practice is very high, with cotton included in the production system, as long as the soil is not disturbed and there is a gradual contribution of straw to the soil.

The positive impacts for the NTS, when correctly used are several:

- NTS improves the chemical, physical and biological characteristics of the soil, which leads to better fertility and soil quality in the medium to long term, increasing the productive potential of the crop.
- The presence of constant ground cover, like straw / mulch or living plants, prevents the upper soil layers from having a large temperature variation, due to direct impact from sunrays, keeping it with lower soil surface temperatures.
- Constant ground cover also influences rainwater infiltration, reducing conditions for soil erosion by reducing the impact of raindrops reaching the soil surface. The cover protects the soil also from wind erosion.
- The presence of constant ground cover reduces the loss of water by evaporation and, therefore, the fields will have greater resilience in the face of bad weather, such as dry spells. Because, even if there is a longer dry period, the cover layer will help to lose less water through evaporation, guaranteeing a certain level of moisture in the soil, and a greater availability of moisture for plant roots.
- The presence of mulch / straw also assists in maintaining the ideal soil temperature for seed germination, which can help the crop achieve higher germination rates.
- The NTS has a direct relationship with the amount of organic matter and carbon in the soil, as it raises its the organic matter content, being an important means to increase the presence of organic matter in the soil (in the medium and long term).
- The NTS contributes to soil fertility, due to the recycling of nutrients in the fields, reducing the crop's dependence on fertilizers.
- NTS promotes several savings, especially with regard to less use of fuel, labor and time.

What factors / challenges affect the adoption of this practice?

Farmers views.

- The main challenge for adoption of this practice mentioned by respondents is soil compaction, making a mechanical intervention necessary to loosen the soil.
- Factors linked to fertility correction of Brazilian soils to establish its production potential, in order to correct the acidity and fertility of many soils, makes it necessary to incorporate correctives/fertilizers into a tilled soil, depending on the case, have to be carried out every 3 or 4 years.

- Another challenge mentioned is the establishment of cover crops and the formation of a dense straw layer, or even failure in the establishment, due to lack of rainfall in regions that do not allow the planting of commercial second crops.
- Another factor in crop rotation that weighs in the adoption is an economic one, farmers are looking for the most profitable crop for the farm.
- Also mentioned as a challenge was the inexistence of appropriate machines and equipment for smallholder use of NTS.

What effects does this practice have on climate change mitigation?

Farmers views.

- One of the roles of the NTS is to enrich the system's biota and promote an increase in organic matter. Also, better infiltration of water into the soil and consequently less erosion and silting of rivers and water bodies are observed.
- NTS improves soil structure, reducing water and nutrient losses, better balance in soil temperature and carbon sequestration, which prevents excessive release of this gas into the atmosphere.
- Because there is not an intervention with mechanized soil tillage, this impacts on the condition of development of micro and macro biologicals in the soil, allowing plants to develop a root system with better use of existing nutrients in the soil.
- This practice contributes in the process to reduce the use of agricultural machinery and the burning of fossil fuels. By preserving crop residues, soil coverage and less soil disturbance are ensured, managing to preserve CO2 for a longer time in the form of organic matter, which reduces its release, in addition to increasing the capacity to exchange ions and decreases the leaching of nutrients.

Farmers responding the survey are well aware of the effects of NTS on climate change mitigation, as is shown in the next table, 78% of the answers acknowledge the effects, while 22% connect NTS with other benefits.

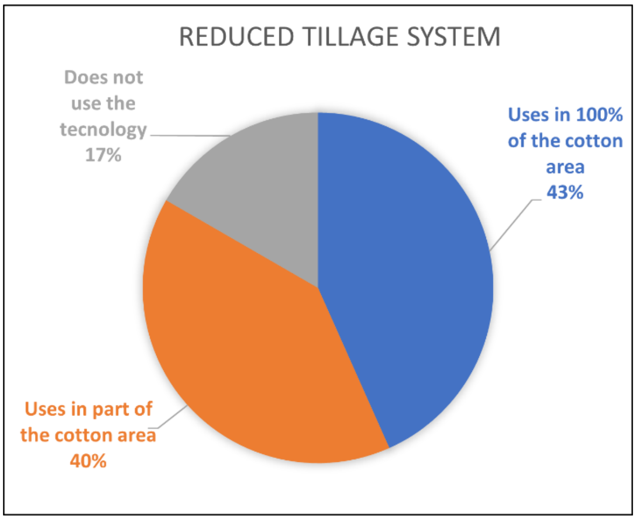
Farmers perception of effects of NTS on climate change mitigation	% of practices mentioned	Cumulative %
Increase in organic matter and carbon fixation in the soil	28%	78%
Less erosion, both wind and soil	14%	
Lower CO^2 emissions	13%	
Reduction in the use of herbicides and fertilizers	13%	
Lower consumption of fossil fuels and consequent lower release of CO2 into the atmosphere	11%	
Better water infiltration decreasing water loss	8%	22%
Reduce average soil temperatures	6%	
Environmental temperature reduction	5%	
Better relative humidity levels	3%	

5.2.2 Reduced tillage system.

Minimum tillage is a soil preparation system used between the traditional soil cultivation with plows / discs and the no-tillage system. The NTS has 4 fases over time:

- Initial phase, from 0 to 5 years, rearrangement of soil structures, low organic matter content, low accumulation of straw, reestablishment of microbial biomass;
- Transition phase, 5 to 10 years, reaggregation of soil structures, beginning of straw accumulation, beginning of soil organic matter accumulation, beginning of phosphorus accumulation;
- Consolidation phase, from 10 to 20 years, straw accumulation, carbon accumulation, increase in CEC, better nutrient cycling;
- Maintenance phase, over 20 years, continuous flow of carbon and nitrogen, high accumulation of straw, nutrient cycling, less demand for nitrogen and phosphorus.

And it is in the period between the initial and transition phase that soils present a high degree of soil compaction. And farmers use of agricultural machinery to till the soil, and, as a consequence, return to the initial phase losing the gains obtained.



Survey results. Also here, the data collected here indicate that producers still are not aware of the differences between the different conservation agriculture systems. Especially for cotton, the reduced tillage system is used by 43% of the respondents (40% use tillage in part of the cotton area). Average of 13 (7-25) years in use. This can be a consequence of the (legal) demand to destroy the remains of cotton plants after harvest, as a measure to lower the boll weevil infestation for the next season cotton crop. This can be done chemically, but many producers use the opportunity to use disc rippers to loosen the soil.

Insights: Part of the cotton production systems practiced in Brazil, which is called no tillage system, is in fact produced using reduced tillage, because at some point, usually in the fourth or fifth year, farmers use mechanical equipment to revolve or loosen the soil, to a greater or lesser extent, as mentioned above.

In order to have a reduction in GHG emissions, but above all an increase in the stock of carbon in the soil, two factors are important: the supply of straw and not tilling the soil. Depending on soil management, minimal cultivation without intense soil disturbance can contribute to straw input and carbon increase, but nothing is compared to NTS when practiced according to the 3 basic principles. However, minimal tillage is better than plowing or disking. It is important to emphasize that the minimum mobilization of the soil, like harrows do, is enough to disturb the surface layers of the soil where most of the stored C is concentrated. This revolving is already enough for GHG emissions to increase.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Minimum tillage has positive factors for adoption as it is easier than the no-tillage system, and is also used in fields that were previously not well prepared, and which require special care in improving their physical and chemical structures.
- The initial fertility of the soil, with the need to incorporate "calcareous" soil amendments to the system which, depending on the case, can be carried out every 3 or 4 years.
- More severe soil compaction factors, when even the no-tillage system is not recommended, has proven to be very efficient and with good results.
- The criteria for adopting this management are based on characteristics of each area, such as soil compaction level, relief, soil texture, soil chemistry. To make this decision requires a more technical analysis.

What effects does this practice have on climate change mitigation?
Farmers views.

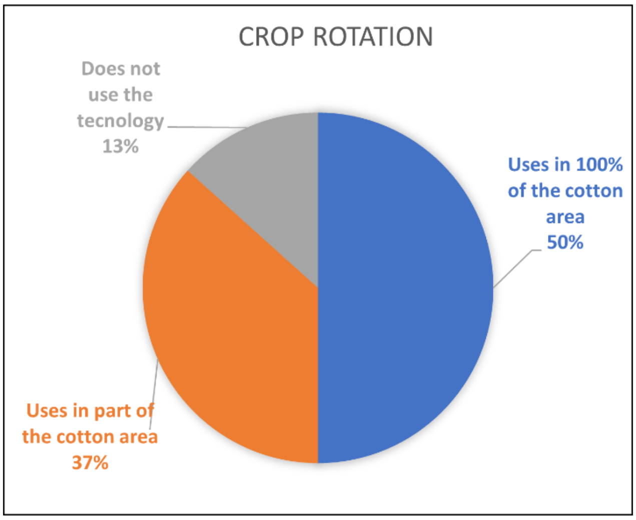
- Minimum tillage is an intermediate system between NTS and conventional planting that significantly reduces soil movement, contributing to minimize the production of CO_2 as it still fixes some carbon in the soil, although in a smaller volume than the direct planting system, as it still leaves some mulch on the surface.
- Because there is less mulch in the system, there is an increase the ambient temperature, lower relative humidity and reduced microorganisms in the system, with an increase of the risk of erosion in sloping areas. Losses of organic matter are higher than in the no-till system and smaller than in the conventional tillage system.

The percentage of farmers responses indicate that there is a lower awareness of the effects of and benefits of minimum tillage, as shown in the next table.

Farmers perception of effects of minimum tillage on climate change mitigation	% of practices mentioned
Minimum tillage is used to slow down the soil compaction process, which will reduce the need for operations to loosen the soil, thus contributing to the mitigation of climate change.	50%
Minimum tillage is not the same as NTS but burns much less carbon than plowing and discing, thus has lower CO^2 emission.	12%
Higher risk of erosion.	12%
Destruction of perennial weed species of difficult control, reducing the use of herbicides.	8%
Others.	19%

5.2.3 Crop rotation.

Crop rotation consists of annually alternating plant species in the same agricultural fields. The chosen species ideally should have, at the same time, commercial and soil recovery purposes. Some plant species used in crop rotation, like legume crops as soy, contribute by fixing nitrogen through specialized bacteria called Bradyrhizobium, leaving nitrogen to leaving nitrogen for the next crop. The correct implementation of crop rotation with increased straw and root development increases carbon sequestration in the soil and mitigates GHG emissions.



Survey results. The data collected on crop rotation indicate that most producers adopt this practice, 50% of the respondents say the cotton crop is 100% produced using this strategy, while 37% use it partially, and 12% does not use the practice. Average of 20 (7-35) years in use.

Insights. Crop rotation alone is not enough to decrease greenhouse gas emissions, as there is no point in rotating crops and continuing with non-conservationist soil management. Farmers are not always willing to alternate the cultivation of different crops. Change is normally a question of human beings themselves, who believe that any change generates some inconvenience, whether in handling the new culture, logistics, sales, etc. In the case of cotton, there is also the question of the possibility of a greater financial return per cultivated hectare. Sometimes the owner is convinced of the effectiveness of the technology, but the farm's team, seeing the extra work and unknown tasks to be fulfilled, can be reluctant. This practice contributes to the incrementation of the macro and microfauna present in these environments, increasing variability and competition between these agents, significantly improving the system.
Sometimes producers are obliged to produce crops that have dividends from the previous harvest, which even require payments from different spheres, with this generates successive plantings, ending up being very harmful to the soil, for the system as a whole, and in some cases may compromise production permanently, due to the great exposure of pests or compromised soil health.

What factors / challenges affect the adoption of this practice?

Farmers views.

- The main factor that reduces the adoption of the practice is the low economic result of the crops that are the option for crop rotation.
- In Mato Grosso, the practice of crop rotation is small, due to the fact that climate permits the sequential cultivation of commercial crops that have high profitability, making it impossible to implement a cover crop as a third crop in the same season.

- The problem is markets for the crops that are planted with the intention of soil recovery. Some of these crops have a potential that is still little explored in Brazil, which would facilitate the implementation of rotation with crops with greater carbon sequestration potential.
- The commercialization of these products with different uses by the industry could further encourage rotation with crops adapted to the soil conditions of areas of low agricultural potential today.
- This practice of crop rotation is widely used in the most marginal areas, especially in the sandy areas of the farms. More clayey areas are generally not used in crop rotation, but in crop succession, considering the question of profitability and sustainability in the business line.
- Crop rotation can be a good alternative for crop development, however it is not always possible to use this tool, due to the short sowing window according to the rainfall calendar, where rainfall is scarce in the winter period, when compared to other regions of the country.
- Some crops can host or even multiply pests and diseases for crops that will be planted in succession, especially nematodes, but also crop rotation can provide a reduction or slowdown of infestation of the crop by certain pests, such as the boll weevil, through the use of sanitary filters such as the planting of bait crops.
- With crop rotation it is possible to break the cycle of diseases and pests, increase the organic matter in the soil, reduce weeds that are difficult to control and have a greater cycling of nutrients. The producer sometimes has to give up a monoculture, in exchange he will be earning much more by investing in the soil.

What effects does this practice have on climate change mitigation?
Farmers views.

- When there is more than one crop in rotation in the system, the benefits are distinct root systems, contributing to soil decompression, without the need for mechanical interventions, less pressure from diseases and pests and phytoremediation of contaminants. Therefore, we have fewer machines operating on top of the areas and enriching the system with soil coverings, aiming at a reduction in soil temperature and an increase in relative humidity and less CO_2 emissions.
- Crop rotation is part of the NTS, and is critical to the sustainability of the agricultural system.
- Crop rotation using legume and grass species improves soil quality and enables better pest and weed control. This practice contributes in the process to reduce the use of agricultural machinery and the use of fossil fuels.
- Crop rotation allows to better explore the soil since crops have different characteristics in relation to nutrient utilization, water utilization, nutrient cycling, increases microbial life in the soil, greater carbon fixation in the soil and the effects of the greenhouse gas caused by it. Provides reduction in the use of chemical fertilizers as well as agricultural pesticides.
- Crop rotation contributes to the reduction of fungi, bacteria and nematodes that harm productivity, then specifically in terms of the environment, as large crops also sequester carbon from the environment.

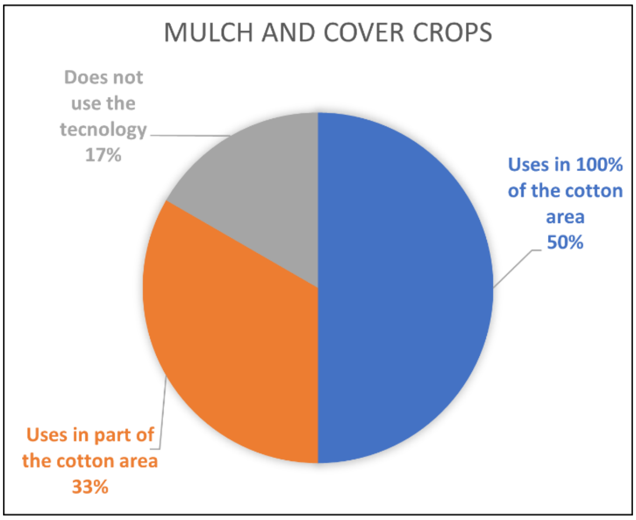
The analysis conducted to assess the awareness respondents have of crop rotation on climate change mitigation show that there is a less clear view of these effects, especially when compared to the NTS survey, Table below.

Farmers perception of crop rotation on climate change mitigation	% of practices mentioned
By rotating crops different root systems are acting on the soil, thereby achieving greater nutrient cycling, providing reduction in the use of chemical fertilizers, also providing nutrients to successive crops.	29%
Increase of organic matter in the soil and consequently more carbon retained.	21%
More efficient control of pests and diseases, fewer sprayings throughout the cycle, and less release of greenhouse gases.	21%
Root systems from different crops contribute to diminish soil compaction, less need for mechanical interventions and less emissions.	13%
Other mentions: less desertification, better water usage, lower temperatures, phytoremediation, higher productivity	15%

5.2.4 Mulch and cover crops.

There are several plant species that can be used alone or in combination for the production of mulch / straw, depending on the conditions of cotton growing areas. Green manure and cover crops are a natural and inexpensive climate solutions through their ability to capture atmospheric carbon dioxide in soils and also help make the soil healthier and more resilient to climate change.

Brazilian farms are increasingly using the practice of cover crops composed of a mixture of different plant families, bringing a greater diversity of plant biomass and improvements in various soil attributes, when compared to single species. This is because the plant families used in the mix have different growth habits, root exploration, nutritional and floristic composition. Also, these mixtures have a phased release of nutrients for the following commercial crop, some fix nitrogen and other nutrients from the soil; cover the soil for a longer period, which increases the physical quality of the soil; diversified material to increase soil organic matter content; diversified root systems for better exploration of soil layers, favoring greater cycling of nutrients, reduce nutrient leaching to surface and groundwater and improve soil hydro-physical properties; high production of dry matter in a short period of time; weed suppression. Some plant species used as cover crops, like legume species as Crotalaria, contribute by fixing nitrogen through specialized bacteria, leaving nitrogen to leaving nitrogen for the next crop.



Survey results. The data collected on mulch and cover crops indicate that most producers adopt this practice, 50% of the respondents say the cotton crop is 100% produced using this strategy, while 33% use it partially, and 17% does not use the practice. Respondents state an average of 16 (6-30) years in use.

Insights: Farmer's and their technical teams are cautious and skeptical to enter the no tillage system together with the cultivation of cover crops and green manures. Many only see this as a problem and difficulty because it changes their routines and the crops they have always worked with, and do not realize the benefits of plant diversification and the great opportunity for gradual improvement of the production environment. Cover crops are a great opportunity for a greater availability of dry matter (straw) for the adequate sowing of cotton. Without this mulch protecting the soil from sun, wind, rain and high temperatures common in tropical circumstances, many benefits of no tillage system will not be successfully achieved. Consequently, the accumulation of carbon in the soil over time will be less pronounced, consequently not capturing atmospheric CO_2.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Many factors mentioned in the crop rotation chapter apply to this chapter also.
- Soil cover can be a good alternative to manage cultivated areas, the challenge is to choose cover species that present high phyto mass production and nutrient recycling that are essential to maximize the productivity of cultures in succession, and not create problems bringing pests and diseases into the fields.
- The window for planting species for this purpose may be an impediment to the adoption of this technique in some regions.
- Cover crops are plants grown with the purpose of creating a layer of soil protection, improving water and moisture infiltration, control and suppression of weeds and less erosion.
- For this technique to be put into practice, there Is a necessity of technical knowledge, and knowledge of the soil, cover crops are a work of continuous improvement in the soil and techniques and tools to reach this result, because it is necessary to improve not only the issue of having straw on the ground, but also to have machines that can work in these conditions.
- As previously mentioned, there is a potential market for the development of products from the produce of species used in cover crops. Exploring these markets and developing these products, cover crops begin to bring a greater return to the farmer, no longer being used only for straw.
- Crops that produce a larger amount of mulch and straw are not economically attractive most of the time.

What effects does this practice have on climate change mitigation?
Farmers views. Also here, many effects mentioned in the crop rotation chapter were mentioned in this chapter.

- Straw and cover crops, in addition to preserving the soil from the action of solar radiation and erosion, increasing productivity, maintaining humidity and promoting nutrient cycling, contribute to the capture and maintenance of atmospheric CO_2 in the soil.

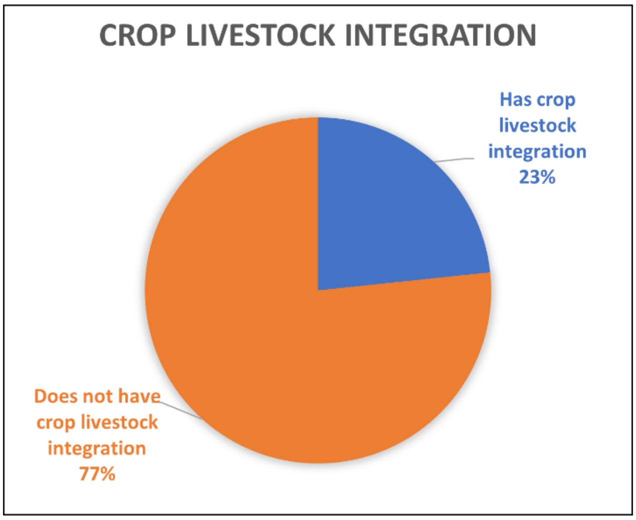
- The implementation of cover crops can help in the "recovery" of part of the nutrients that are in the deeper layers of the soil, with this we can more efficiently manage the use of chemical fertilizers in the subsequent crop.
- Greater gas sequestration, nitrogen fixation in the soil, increase of organic matter in the soil with this reduces the need for nitrogen fertilizers.
- Plants use CO2 in the photosynthetic process and allow their crop residues to increase the organic carbon content in the soil.

The farmers perception of cover crops and mulch effects on climate change mitigation in the study shows that the effects are quite clear for about 50% of the respondents, 34% mentioned that cover crops and mulch help mitigate climate effects due to carbon sequestration in the soil, and 16% stated there is less soil and nutrients that are washed away, nutrient cycling, reducing the need for chemical fertilizers. See table below.

Farmers perception of cover crops and mulch on climate change mitigation	% of practices mentioned
Cover crops and mulch help mitigate climate effects due to carbon sequestration in the soil.	34%
Reduction in environmental and soil temperatures and higher relative air humidity.	20%
Less soil and nutrients are washed away, nutrient cycling, reduces the need for chemical fertilizers.	16%
Less compacted soil.	13%
Lower risk of soil desertification.	7%
Other effects.	11%

5.2.5 Crop Livestock Integration System (ILP) – Forestry (ILPF).

The integrated crop-livestock systems (ILP) and ILP including Forestry (ILPF) are forms of sustainable agriculture, that depend on synergistic relationships between the elements of the plant and animal systems. These systems are important sustainability strategies, showing changes in the biological, physical and chemical properties of the soil, cycling of water and nutrients, promoting resilience to climate change through mechanisms such as nutrient cycling and improved productivity of both the crop and livestock. When well-managed, the pastures in the ILP system accumulate carbon in the soil. In the integration, the benefits of no tillage are added to the positive points of the pasture, which leads to an increase in the carbon content of the soil and a drastic mitigation of emissions. There is greater production efficiency per area, as in the integrated system the land is used all year round.



Survey results. The data collected on integrated crop-livestock-forestry systems that most farms, 77% of the respondents, do not have this activity on their farm, and 23% have. Farms with crop livestock integration surveyed state an average of 5 (5-5) years of the practice.

Insights: This ILP system is a diversification of the no tillage system with the introduction of the animal component. That is why the farmers consider that the adoption of this system is even more complex, since traditionally they are used to only agricultural production. Most of the time, farmers understand farming very well but do not understand livestock, and ranchers understand livestock but do not understand farming.

Changes in the structure of the property and the farm's technical team are necessary, with the necessity to establish a whole new and separate branch on the farm, making its adoption more difficult. But at the same time, it is a business opportunity, considering that the production of cotton, corn and soy provide basic inputs in the animals' diet, in addition to pasture. The ILPF system, with the forest component, is much more difficult when thinking about cotton, as cotton requires spraying, sometimes including aerial spraying, and trees can be a complicating factor. Also, the elimination of cotton crop residues after harvest, a mandatory practice regulated by law, is usually done with herbicides, making it difficult to grow trees nearby. If the strategy for climate-smart agriculture practices is thought of in a broader way, that is, not only addressing the cotton crop, but the property as a whole, it is very justifiable to include ILP due to the great potential of these technologies for GHG reduction.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Crop livestock integration consists of the implementation of different production systems for grains, fibers, meat, milk, biogas for the generation of electricity, among others, in the same area, in consortium, sequential or rotational planting.
- An important factor is the aptitude of the producer, there are farmers who like cattle, there are who don't, not all producers manage to carry out this system.
- Due to the short period of rain in some regions, it is not possible to form pasture with quality and enough quantity for the implementation of the system.
- One of the factors that most interferes in this practice is the issue of marketing the cattle, the proximity of trustworthy slaughterhouses, in addition to a high demand for investment in various equipment's with different functionality than for crop use.
- The high investment, lack of skilled labor and logistics, in order to adopt this practice, it is necessary that the property has a livestock structure - corral, water, specialized people. The system deployment cost is high.
- The system brings good yields, and a second or third "crop", called "safrinha de boi", or cattle crop.
- It brings alternatives and flow to the use of crop by-products, like cotton seed and cover crops used for pasture.

- ILP has the differential, the soil is covered with brachiaria grass species with its aggressive root system, improves the physical and chemical condition of the soil, and can be used in areas where it would not be possible to grow a good corn crop can opt for the ILP system.
- One of the factors that affect this practice is the investment needed that the producer has to disburse equipment to integrate the crop, livestock and forestry. There is still the view that these cannot be managed in the same area and that there is a loss of production, producers do not visualize the systemic gains.
- The practice provides a better use of residues and a better use of the area destined for cultivation throughout the harvest period, diversifying the options of source of income for the producer.
- More investment is needed in research and dissemination of practices that demonstrate long-term gains from adopting the ILP systems.
- The adoption of the ILP system can also favor regional integration, as cattle raising in Brazil has specialized sectors, starting with cow-calf ranching, where ranchers keep a herd of cows that are bred annually to produce a crop of calves. Then, heifer raisers bring cattle to the next phase, which is the fattening phase, which substitutes feed lots, to obtain the final result of the operation. This implies in specialized opportunities for each phase, and market for heifers entering the fattening phase.

What effects does this practice have on climate change mitigation?
Farmers views.

- It is an excellent alternative for optimizing properties, raising productivity levels, diversifying production and generating quality products. With sloped land that cannot be used for other crops, adding even more with intercropping, in succession or in rotation, so that there is mutual benefit for all activities. As a whole, it ends up reducing the environmental impact, increasing carbon sequestration, increasing soil organic matter, reducing erosion, improving microclimatic conditions and animal welfare.
- The ILP system offers an opportunity to implement brachiaria grass in the cultivation system without economically impacting the main crop, allowing for an increase in revenue and for the system, it enables gains such as less soil compaction and formation of soil cover.
- With the implantation, pastures allow the release of nutrients from the soil to the main crop, together with the accumulation of carbon in the soil, thus reducing gas emissions and contributing to direct planting in the subsequent harvest.
- It is a concept that represents the success of any entrepreneur in the agricultural sector. ILP has a biodiversity effect, regulates the microclimate, reduces greenhouse gas emissions.

Almost half of the respondents perceived the effects of the integrated crop livestock system on climate change mitigation, together with less use of chemical fertilizers, as can be seen in table below.

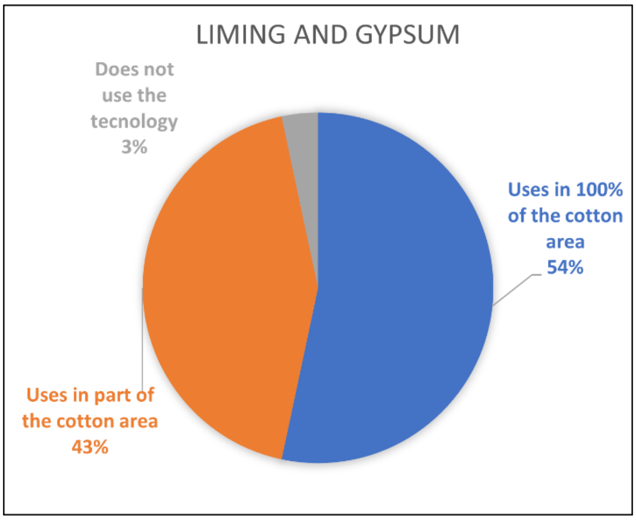
Farmers perception of effects of integrated crop livestock system on climate change mitigation	% of practices mentioned
Practice promotes the accumulation of carbon in the soil, thus reducing gas emissions.	42%
Diversifies and provides better use of land.	26%
Reduces the use of chemical fertilizers due to recycling of the fertilizers used.	13%
Income diversification.	11%
Other effects.	8%

5.3 Soil fertility and fertilization.

The soil's contribution to climate change, through the oxidation of soil carbon, is important. However, soils and agriculture can play an important role in mitigating climate change. In many regions, soil fertility has been declining for decades, and large amounts of fertile soil have been (continued to be) washed into rivers, lakes and oceans, and with it many soil organic compounds, i.e., organic matter. Climate-smart farming practices have the potential to store carbon in soil and plants and thereby help mitigate climate change, while increasing soil fertility and water-holding capacity, improving yields and good nutrition, creating drought-tolerant soils, restoring degraded farmland and rangelands, and nurturing biodiversity.

5.3.1 Liming and gypsum.

Liming and gypsum are important agricultural practices that favor the development of plants, resulting in greater absorption of water and nutrients by the roots, that is, it promotes positive effects on the production and profitability of crops. This increase in root development in the soil profile and aerial biomass promotes a greater return of C to the soil in the form of residues, which favors the fixation of CO_2 from the atmosphere in the soil. On the other hand, the use of correctives raises the pH, increasing the denitrification reactions and the microbial activity, which consequently increases the emission of N_2O and CO_2 via respiration, respectively. Thus, much attention must be given to the limestone and gypsum dosage applied to avoid environmental and also economic losses.



Survey results. The data collected on liming and gypsum use indicate that most producers adopt this practice, 96% of the respondents state the cotton crop is produced using this strategy (54% use it on 100% and 43% partially), and 3% do not have a strategy for this practice. Average of 23 (7-35) years in use.

Insights. Liming and gypsum use are very common in Brazilian agriculture, especially when it comes to cotton production, which requires high investments in soil fertility. For this reason, the chemical correction of the soil is a basic requirement respected by the cotton producer. What sometimes happens is the exaggerated use of doses, especially of gypsum in sandy soils, which can even lead to leaching and loss of cations (potassium, magnesium and calcium) to deeper layers of soil, when prepared conventionally with plows, harrows and subsoilers.

Although limestone, when reacting in the soil, releases CO_2 into the atmosphere, its benefits in terms of increased production and input of dry matter from shoots and roots make it possible to increase carbon in the soil, as long as conservation practices are respected and the soil is not disturbed.

The soil fertility practices adopted in many regions are examples for other regions in the country, some cases need more attention in correcting the acidity, but in general, by adopting these practices it is possible to meet the minimum production needs. Correct monitoring is necessary to enable the potential of the region's varieties.

What factors / challenges affect the adoption of this practice?
Farmers views.

- The use of liming and gypsum are activities that demand a high degree of investment, mainly on logistics and operational, high freight costs, depending on where the property is located.
- Liming is a practice that is easy to implement, the use of gypsum, on the other hand, is much more complex because the costs are usually quite high (note: this due to the distance from the gypsum mines to the farms).
- The real need to use these practices must be analyzed before making a decision. Also, the operational costs are mainly because of the use of fuel.
- There is a lack of technical information about the use of gypsum as a factor for improvements in soil quality.

What effects does this practice have on climate change mitigation?
Farmers views.

- The use of liming and gypsum carried out according to the need indicated by the soil sampling, contributes to the development of the root and aerial system of the plants, increasing the carbon capture efficiency ratio of the plant.
- A plant that develops better has the ability to sequester a greater amount of carbon from the environment, which is why the use of liming is very important.
- This soil fertility correction practice has provided more corrected soils in order to have plants with better use of nutrients, deeper soil profile and consequently plants with better developed root systems, providing them with greater tolerance to water and temperature stress. This scenario allows to work with earlier maturing varieties in some situations, reducing inputs with operations in pesticide applications and a greater opportunity to implement a post-harvest culture for the formation of mulch.
- Plant nutrition elements that come with liming and gypsum, such as calcium and sulfur, can benefit the decomposition of organic matter and accelerate carbon stocks in the soil, as well as reduce the use of other fertilizers.

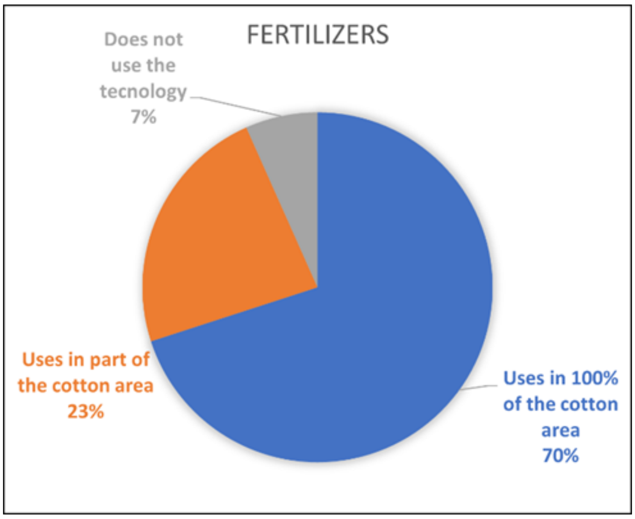
The table below shows that 41% of the respondents are aware of the climate change mitigation effects, while 45% states other effects of the practice.

Farmers perception of effects of lyming and gypsum on climate change mitigation	% of effects mentioned
This correction practice has provided more corrected soils in order to have plants with better use of nutrients.	45%
The practice improves the development of crops, consequently, increases carbon sequestration in the soil.	41%
require a high degree of investment.	3%
Other effects mentioned.	10%

5.3.2 Fertilizers.

Fertilizers promote an increase in agricultural productivity, with a consequent reduction in CO2 emissions per unit produced. However, the (excessive) use of chemical fertilizers is one of the main sources of emissions in agriculture. Nitrogen is important because of its impact on GHG emissions, as the element in the soil can be released into the atmosphere as N2O, which is more than 300 times more potent than CO2. Another important factor is the comparison of different sources of N in characterizing the real impact of using these fertilizers in order to mitigate the emissions. Better phosphorus (P) management practices aim to minimize P losses to the environment and increase the efficiency of P use for growing crops. Much of the potash (K) applied to a growing crop is not accumulated in the grain or fiber, but remains in the crop residues (stem, leaves and straw). K is easily leached. The use of Controlled Release Fertilizers is an important first step in mitigation of emissions.

The use of inorganic fertilizers in crop production can be reduced through better crop rotations, with green manure / cover crops, effective soil interactions and soil organisms, like for example, enhancement of mycorrhizae, a better root system and improves the absorption of phosphorus from soil.



Survey results. The data collected on fertilizers indicate that most producers use these inputs, 92% of the respondents state the cotton crop is produced using fertilizers (70% use it on 100% and 23% partially use the strategy), and 7% does not use fertilizers. Average of 22 (7-35) in use.

Insights. Fertilizer use is very similar to the previous topic regarding liming, that is, the cotton grower knows that to produce cotton in the Brazilian cerrado it is necessary to fertilize a lot, the cotton plant is very demanding on nutrients. However, excessive fertilization, including those carried out at inappropriate times in sandy soils, with the use of high doses of nitrogen in the early stages of cotton growth (V2-V3), favor N losses, including in the form of N2O (nitrous oxide), one of the greenhouse gases. Therefore, fertilizing at the right time and at the right dose is fundamental, not only for nitrogen, but for potassium as well. In addition to nutrient losses, there is a relation to the carbon footprint in the production process of each fertilizer, especially the production of nitrogenous ones that demand a lot of energy. Phosphorus also requires attention because cotton production areas, in general, are a high demand for phosphorus.

Currently, there is already a lot of protected nutrient technology on the market, these products are of great value for sustainability, however with a high added cost, and many producers still do not see their benefits. However, one can see a growing use of these fertilizers, mainly by producers who are more open to technology, more focused on sustainability.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Factors that affect adoption are the chemical needs of the soil and the cost of these fertilizers, and the consequent greater financial risk.
- The search for less demanding cultivars in fertilizers and species that achieve greater fixation of nutrients in the soil for the subsequent crop are factors that should be researched to increase the adoption of the conscious fertilization practice.
- The management of fertilization with other land use and conservation practices should also be more widespread to positively affect the adoption of this practice.
- The use of fertilizers is very present in all crops, in an agriculture where the focus is only on fertilizing to harvest, this becomes worrying, as it does not consider the effects of this practice on the environment, knowing that these elements are extracted from nature, and at some point, this may end.
- The demand for food in the world is increasing, the population is growing and needs to be fed, it is necessary to look for other alternatives of more ecological fertilization or less dependent on chemical fertilizers or extracted in nature.
- For profitable production the use of fertilizers is essential, since the need to produce more food in a smaller amount of area is increasing.
- Search for alternatives that make it possible to reduce the use of these fertilizers without reducing productivity.

What effects does this practice have on climate change mitigation?
Farmers views.

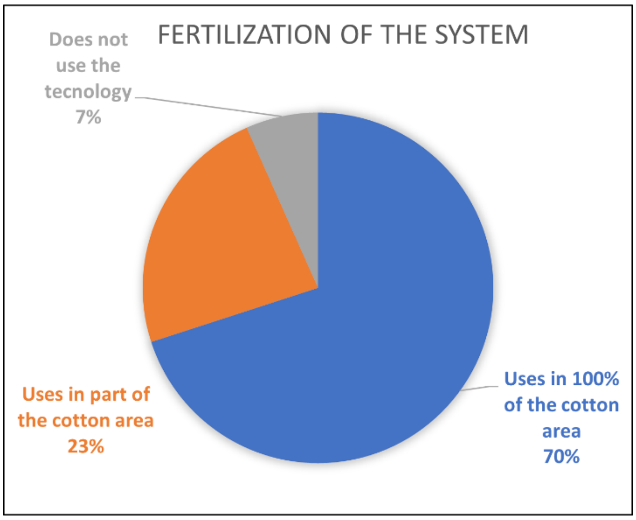
- The effect of this practice is a very large increase in productivity when used correctly, the plants develop better and consequently carry out carbon sequestration.
- The use of mineral fertilizers is not directly contributing to the reduction of greenhouse gas emissions, however, indirectly the use of these fertilizers contributes to a better development of the plants, free of diseases and with better nourished crops the capacity of this plant to sequester carbon from the environment is consequently greater. However, excessive use of chemical fertilizers can cause an imbalance in the environment when used improperly, and, as a result, the chemical compounds present in fertilizers can cause contamination of rivers, lakes and groundwater.
- Part of the fertilizers, mainly the nitrogenous ones, are produced through the use of petroleum. Application correctly can minimize its use. This can be done through good soil sampling, application at a variable rate and at the correct time for the established crop.
- The use of N sources with controlled release helps to reduce losses by leaching or evaporation after application. In addition, in order to have a better efficiency, the inputs are applied are applied in 3 installments, aiming to reduce these losses even more and have better use by the plants. As a result, it is possible to work with smaller doses, thinking about a higher percentage of operation efficiency. Today the farm operates on top of all these practices.

The perception of respondent farmers about the effects of fertilizers on climate change mitigation can be clearly divided in 3. 50% state the mitigation comes from the reduced use of fertilizers, while 17% responded that this mitigation comes from better nourished plants and higher yields, and 33% responded with technical and economic arguments. See table below.

Farmers perception of effects of fertilizers on climate change mitigation.	% of effects mentioned
The adoption of practices with reduced fertilizer dosages and proper soil management has direct effects on mitigating climate change.	50%
Production systems require greater attention when it comes to fertilizers, as they have a high cost, being one of the main elements that make up the integrated production system.	33%
In an indirect way, the use of these fertilizers contributes to the mitigation, because with better nourished crops the capacity to sequester carbon is.	17%

5.3.3 Fertilization of the system.

System fertilization is a soil fertility management strategy. It seeks to improve the use of nutrients by plants. This practice aims to meet the nutritional requirements of all species involved in the system. In traditional fertilization, the recommendation is made in isolation, directed to each crop. In system fertilization, fertilizers are not intended for a single crop, but for all crops in the production system. Crops that are more demanding and responsive to the addition of fertilizers receive somewhat higher doses of nutrients, and the crop in succession benefits from the residual fertilization and organic matter left by the previous crop. The rational management of fertilization avoids waste, reduces the transit of machines in the field, reduces production costs, has less environmental impact and optimizes labor and machinery. This greater efficiency promotes a significant improvement in the property's carbon balance.



Survey results: The data collected here indicate that producers still are not very aware of the differences between the use of fertilizers for crops and the use of fertilizers as a strategy for the production system. 70% of the respondents use the system on 100% of the cotton crop, while 23% use it partially, and 7% does not use this practice. Average of 17 (3-30) years use.

Insights. The practice of fertilization of the system, or Integrated Soil Fertility Management, requires greater knowledge of the nutritional needs of each crop, and how much is exported from the area by the production of each crop (soy and corn grains, cotton seed and fiber, for example). It is also necessary to know how much of nutrients there are in the soil and how much was supplied through fertilization. Only then will the farmer be able to efficiently implement "system fertilization". Therefore, it requires greater knowledge and management of soil, soil organic matter and fertilizers. Any improvement in the process of nutrition and fertilization of the cotton plant, such as fertilization based on the production system, certainly contributes to the direct or indirect reduction of GHGs, and thus to the mitigation of climate change.

What factors / challenges affect the adoption of this practice?
Farmers views.

- One of the factors involves a greater initial financial disbursement and greater structuring of fertilizer storage.
- The use of this strategy has helped to reduce the use of implements and machines to apply the indicated doses for each crop. Thus, an optimization in the operation, reduction of fuel consumption and maintenance of machines is observed.
- This practice allows to gain time during planting, permitting to start using planters with a greater number of rows, which resulted in more agility in the field.
- What can affect the adoption of this practice would be the lack of knowledge of this technique, if the plant does not use the nutrients in an ideal amount, it will not develop properly. It is necessary to have a better knowledge of this system.
- Soil texture affects the adoption of the practice, more sandy soils make the system fertilization difficult, due to the ease of nutrient leaching.
- Tests with means of quick verification of fertilizer residue in the soil for the subsequent less demanding crop is a factor that facilitates the adoption of the practice, to measure the dosage of the previous crop in the next crop. The gain and the correct adjustment end up occurring only in the following harvests.

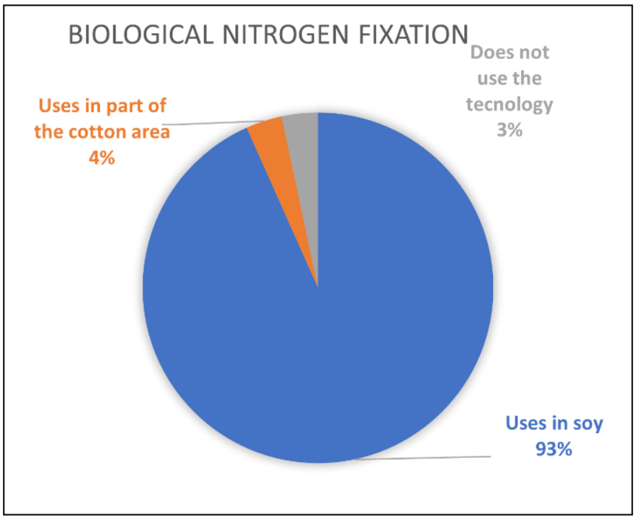
What effects does this practice have on climate change mitigation?
Farmers views.

- The main advantage of the system fertilization is to reduce one more entry into the area with the same objective.
- When nutrients provide this management possibility, there are financial savings, operational savings and a reduction in fuel consumption, thus reducing the emission of gases that can affect climate change.
- The practice contributes to reducing the use of mineral fertilizers or fertilizers extracted from nature, and also a reduction in the consumption of diesel oil, as there would be fewer application operations.
- The adoption of system fertilization involves higher doses, which can increase leaching losses due to high rainfall.

Also here, as was found in the fertilizer chapter, only part of the farmers have a clear perception of the effects of the fertilization of the system practice on climate change mitigation. 70% responded with technical and economic arguments. See table below.

Farmers perception of effects of fertilization of the system on climate change mitigation.	% of effects mentioned
Fertilization of the system allows a reduction in the use of fertilizers and also a reduction in the consumption of fuel, as there are fewer operations.	70%
Fertilization of the system reduces fertilizer use, reduces the traffic of machines in the field, this greater efficiency promotes a significant improvement in the property's carbon balance.	30%

5.3.4 Biological nitrogen fixation (BNF). Modern agriculture is based on the intensive use of nitrogen (N) fertilizers, which are produced from petroleum. The process used for the industrial manufacture of these fertilizers involves the emission of large amounts of carbon dioxide into the atmosphere. The use of alternative sources for the nutrition of plants, such as nitrogen-fixing bacteria from the genus Bradyrhizobium and the genus Azospirillum, implies a reduction in the consumption of fertilizers of fossil origin and the consequent reduction in greenhouse gas emissions.



Survey results. The data collected on biological nitrogen fixation indicate that most producers (93% of the respondents), use this practice on soy, one farm indicated the use on cotton as a test. Average of 21 (7-30) years in use on soy.

Insights. BNF is already traditional in Brazilian soy farming, and cotton, by being part of rotation or succession schemes with soy, tends to benefit from better soil conditions and N residues left by the soy crop. In the case of Azospirillum, although some cultures have shown positive responses to its use, in the case of cotton this has not occurred, and is not used for cotton.

Soybean BNF, with Bradyrhizobium, has enormous GHG reduction potential, being a public policy in Brazil for low-carbon agriculture. As for Azospirillum and other beneficial microorganisms, research and dissemination of technologies need to be improved.

What factors / challenges affect the adoption of this practice?
Farmers views.

- The use of this resource is a very common practice, which has contributed a lot to the development of legumes, especially in the case of soybeans, a reality that has proven to be very efficient for the development of the crop.
- Without BNF, soybean cultivation would be unfeasible, due to the high levels of nitrogen that the plant needs for its development.
- There is no information about the use in cotton culture.
- Depending on the crop to be planted, nitrogen fixation by bacteria is not enough for the crop.

What effects does this practice have on climate change mitigation?
Farmers views.

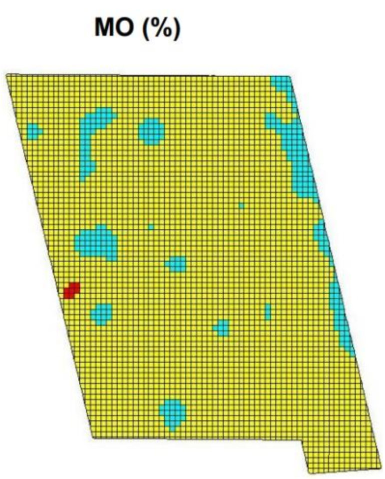
- This practice is extremely important, instead of applying nitrogen to the culture, it is possible to increase microorganisms in the system capable of capturing this nutrient from the environment and supplying it to the main culture. With this, there is a reduction of nitrogen compounds capable of supplying gases that impact climate change, in addition to reducing operational and diesel consumption to carry out this practice.

- The use of microorganism for the absorption of nitrogen by the plants favors the lower expenditure of fertilizers in the soil, less acidification or alkalinization of the soil.
- Biological nitrogen fixation decreases the use of industrial fertilizers, which in turn results in less loss of this nitrogen in the form of N2O by leaching, which is one of the greenhouse gases.

Although biological nitrogen fixation is not used in cotton, but most in soy production, respondents are quite aware of the effects of the use of the technology on climate change mitigation. Also here, economic aspects were mentioned by an important part of the respondents.

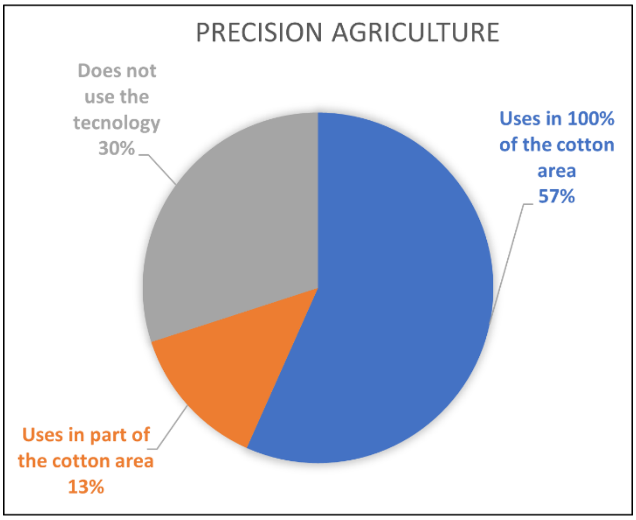
Farmers perception of effects of biological fixation of nitrogen on climate change mitigation.	% of effects mentioned
The biological fixation of nitrogen allows a drastic reduction in the use of this industrial fertilizers, and with this there is a reduction of the harmful effect of these fertilizers have on the emission of greenhouse gases.	48%
The use of microorganism for nitrogen fixation by the plants favors cost reduction on nitrogen fertilizers.	48%
Other.	4%

Biological nitrogen fixation (BNF) is the process through which nitrogen (N2) that is present in the atmosphere is converted into formats that can be used by plants. The reaction is catalyzed by an enzyme named nitrogenase, which is found in all nitrogen-fixing bacteria. In the context of agriculture, the symbiosis between nitrogen-fixing bacteria (called rhizobia) and legumes (family of plants that includes soybeans, beans, peas, and others) is the most important one. Not all plants biologically fix nitrogen in symbiosis with rhizobia, such symbiosis is restricted to leguminous plants and is characterized by the formation of specialized root structures known as nodules, in which the BNF process occurs. After the root nodules are formed, bacteria start to fix atmospheric nitrogen into organic compounds that are used by the plants, eliminating or reducing the need to use nitrogen fertilizers. This is why farmers do not use this technology for cotton, as it is not a leguminous plant. Other bacterial species (Azospyrilum sp.) that can fix atmospheric N2 have already been found in association with grasses such as maize, wheat, and sugarcane. In these plants, root nodules are not formed, and the amounts of fixed N are very low.



5.3.5 Precision agriculture.

Precision Agriculture (PA) provides accurate fertilizer recommendations and carry out the application of variable doses in each spot of the fields, saving time and reducing resource consumption, resulting in a more uniform harvest and consequently higher yields. The image shows a gradient of soil organic matter in a field. The variable and precise application of limestone and fertilizers decreases the amount of GHG emitted.



Survey results. The data collected on the use of precision agriculture as a strategy indicate that 57% of the respondents use the practice for cotton production, 13% use it partially, and 30% does not use the practice. Average of 10 (1-20) years in use.

Insights. Although there are a lot of data collected through soil and plant analyses, and in real time by agricultural machines, it is necessary to transform data into information, information into knowledge and knowledge into innovation. Large-scale agriculture, such as cotton farming, often generalizes management too much, becoming an agriculture of products, and not of productive processes, such as adequate soil management using no tillage system. Soils cultivated with cotton are very well chemically corrected, and what can be seen through the soil analyzes is that physically and biologically there are many improvements to be made. And precision agriculture will not be the sole solution that will improve this. Improving the form of distribution and application in quantities and in the most necessary places is a way to increase production efficiency, and thereby reduce GHG emissions. However, this should not the most important point to focus on when establishing guidelines for CSA.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Cost of precision agriculture technologies and skilled labor in the field are factors that affect adoption.
- The use of technological resources for mapping cultivated areas is a reality that requires a series of equipment and investments to arrive at solid and applicable information. However, this tool still has a high cost for implementation, requiring assistance from machines and qualified people.
- This practice is based on supplying nutrients more faithfully to the reality of the diversity of each plot, this does not always generate savings in the use of fertilizers, but puts them in a way that supplies the needs of the plant according to the established grid.
- A larger structure of people specialized in soil sampling, analysis interpretation and map generation is needed.
- Economy in the use of industrial fertilizers and correct direction for crop maintenance fertilization or correction of each plot.
- For the technology to be reliable, it is necessary to have a well-trained team with precise tools to carry out the activities.
- Nowadays, better satellites are available, with more precision, with correct tools to carry out precision agriculture, something not present a few years ago. As a result, better productivity can be obtained, as all areas are mapped, and locations that are not delivering production can be identified.
- With the use of PA, the producer manages to have a more conscious consumption of the inputs used, with that there is a gain in productivity and with a reduction in the cost of production.

What effects does this practice have on climate change mitigation?
Farmers views.

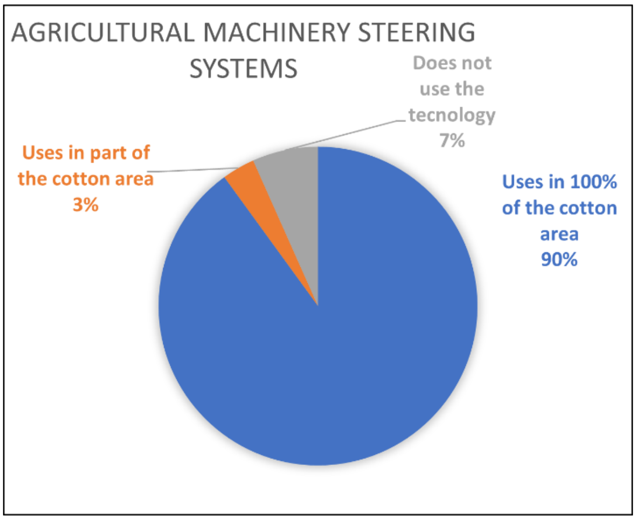
- Precision agriculture allows working in localized ways, acting only on problems. As a result, it is possible to significantly reduce the use of agricultural pesticides, correctives and fertilizers, and with fewer entrances with machines in the areas, consequently reducing diesel consumption.
- This practice has contributed to the refinement of the use of inputs and machines for cultivation. Advance planning with soil analysis in grids can determine variations within an area, which has optimized the application of these inputs efficiently.
- Reduction of GHGs through the actual fertilization necessary for soil variations in the crop, enhancing the production of biomass.
- Decreased production costs, effective improvement in pest control, faster and more assertive decision-making, leading to a variable and precise application, reducing the amount of GHG emitted.
- One of the main benefits that helps in mitigating changes is the rationing of inputs, as well as the strategic and intelligent use of fertilizers, in addition to carbon mapping.
- By promoting more accurate practices, better production is achieved by reducing waste of correctives and fertilizers.

The percentage of farmers responses indicate that there is a lower clear awareness of the effects of and benefits of precision agriculture on climate change mitigation, as 37% of the respondents link the technology to these effects, while 59% link precision agriculture to technical and economic purposes. See table hereafter.

Farmers perception of effects of precision agriculture on climate change mitigation.	% of effects mentioned
With the use of precision agriculture better production is achieved, reducing waste of correctives and fertilizers. 16	59%
By promoting more accurate practices provided by the technology, there is a positive effect on climate change mitigation, with a strategic and intelligent use of fertilizers addition to carbon mapping.10	37%
Other effects mentioned.	4%

5.3.6 Agricultural machinery steering systems (automatic pilot).

The use of agricultural machinery guidance systems (automatic pilot) in mechanized operations directly impacts the optimization of the use of fossil fuels and the operational yield of agricultural practices, as they avoid greater fuel consumption attributed to unnecessary maneuvers and greater agility for starting and in the conduct of operations. The application of inputs is also benefited by the use of autopilot, as it avoids overlapping or application failures and their deleterious effects.



Survey results. The data collected on the use of machinery steering indicate that 90% of the respondents use the practice for cotton production, 3% use it partially, and 7% does not use these systems. Average of 13 (7-20) years use.

Insights. Although this technology can improve operational efficiency, and thereby reduce the use of diesel, this should not the most important point to consider when establishing guidelines for CSA cotton farming.

What factors / challenges affect the adoption of this practice?

Farmers views.

- The biggest factor that affects the adoption of this technology is the investment cost of acquiring the technology, and the need for trained professionals.
- Currently, with the help of technology, activities in the field are much easier, for this to happen it is necessary to invest in people and machines, have a well-trained and qualified team, this qualification has a cost, and the acquisition of new machines also has a high cost. But it becomes necessary for today in agriculture.
- The use of automatic pilot is necessary in modern and efficient agriculture, as it contributes to operational yields, avoids excessive maneuvers, and reduces soil compaction.
- The use of software that calculates the best operating directions, which reduce maneuvering time and increase operating time, are fundamental for reducing operating costs, consequently fuel usage.
- Overlapping or ranges of applications is one of the factors that increases costs and reduces productivity. In order to implement this modality, the machines must be equipped with GPS and the operators must be qualified to use it.
- Standardization of applications and less crop trampling within each plot, allowing all crops to be tracked in the same trail.

What effects does this practice have on climate change mitigation?

Farmers views.

- This technology is used in order to reduce errors in maneuvers and overlapping of inputs. It also increases the agility of operations, thus reducing the consumption of fossil fuels.
- The autopilot system contributes to promoting a more accurate operation in the field, collaborating to avoid overlaps, where a machine consumes more fuel within this operation, as well as preventing failures in the execution, which ends up requiring future operations to try to circumvent this error, which also results in a greater displacement within that area.
- The technology helps decrease soil compaction. This requires less tillage, less consumption of fossil fuels and less greenhouse gas emissions.
- The autopilot helps reduce fuel consumption, reduces soil compaction, reduces loss of plants due to crushing, where this sequence of factors contributes a lot to the reduction of gas emissions.

Also here, the percentage of farmers responses indicate that there is a lower clear awareness of the effects of and benefits of steering systems on climate change mitigation, as 38% of the respondents link the technology to these effects, while 59% link precision agriculture to technical and economic purposes. See table hereafter.

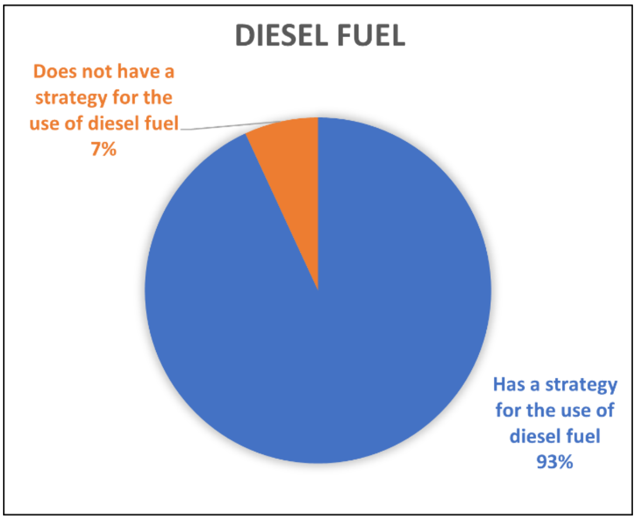
Farmers perception of effects of agricultural machinery steering systems on climate change mitigation.	% of effects mentioned
The agricultural machinery steering systems allows more accurate maneuvers in the fields, more efficiency in operating time, decreases fertilizer waste.	59%
The agricultural machinery steering systems promote more efficient operations, helps to reduce fuel consumption, thus contributes to the reduction of gas emissions.	38%
Others.	3%

5.4 Fuel and energy.

Fossil fuels used in farming systems and on farms are normally diesel fuel for agricultural machinery, tractors and trucks, and gasoline and/or ethanol for vehicles used in the administrative sector. And many farms still use electric power generators that run on diesel fuel.

5.4.1 Diesel fuel.

In agricultural crop management practices, the use of soil preparation operations such as plowing, subsoiling and heavy harrowing can be avoided with the use of direct planting, thus reducing fossil fuel consumption and the consequent reduction of GHG emissions from these sources. Unlike the traditional procedure, where the soil was plowed and harrowed several times before planting, in the NTS there are no such operations, the farmer opens a furrow with a special seeder and deposits fertilizers and seeds, and thus has a much lower demand for diesel fuel in tractors and the consequent reduction in GHG emissions.



Survey results. The data collected on the use of diesel fuel indicate that most producers have proceedings for the on farm fuel stations, 93% of the respondents state the cotton crop is produced using these proceedings, and 7% does not have. Average of 11 (6-20) years with proceedings.

What factors / challenges affect the adoption of this practice?

Farmers views.

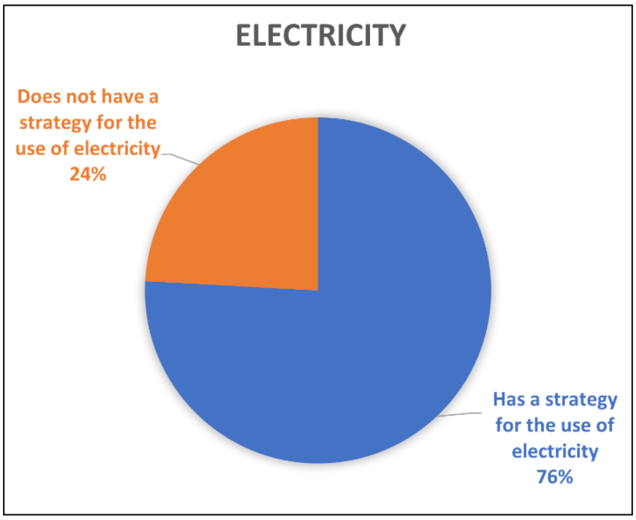
- The demand for diesel fuel in agriculture is still very high, but with the conscientious practices of soil management, and the use of technology such as the automatic pilot the consumption can be reduced.

- Currently most of the fleet of machines used in the agricultural environment is moved by fossil fuels, which generate gases. For a lesser impact of this gas emission, it is necessary to use technologies such as GPS and autopilot to reduce unnecessary maneuvers, and helps to perform tasks more efficiently.
- Despite being quite efficient, the intense use of diesel fuel triggers several environmental problems.
- Because of high fuel consumption, soil preparation should only be carried out where there is a measurement of its need, analyzing compaction, replacement of fertility focused on calcium and magnesium, only in these cases should intervention be carried out.
- Consumption is still high in harvesting equipment and has a high cost for agricultural production. The energy base could be modified with research into equipment with lower consumption or even changing the matrix.

What effects does this practice have on climate change mitigation?
Farmers views.

- The use of fleets of new machines that use fuel more efficiently to perform tasks more quickly associated with the use of pilot technologies can be an alternative to contribute to the reduction of GHG emissions.
- The change to a less polluting matrix with cost reduction for producers would bring even greater gains than obtained with the reduction of soil preparation operations and lower diesel consumption due to the non-execution of these operations.
- The use of fossil fuels, in addition to being extracted from nature, also causes pollution by its use. Through good practices agriculture, this is minimized, as it uses less fuel, and performs a more regenerative agriculture.
- The adoption of no-tillage allows for less soil disturbance and, consequently, less fuel use. This is one of the practices that could make an even greater contribution to reducing emissions.

5.4.2 Electricity. Farms make significant use of electricity for various purposes, such as irrigation, grain dryers and cleaning machines, patio lighting and household purposes. The average CO_2 emission factors for electricity are calculated by averaging generation emissions, considering all power plants that are generating energy. To avoid emissions, it is necessary for the producer to adapt the farm's facilities and equipment, and look for alternatives such as solar and wind energy.



Survey results. The data collected on the use electricity indicate that most producers, 71% of the respondents, have a procedure to achieve the highest possible efficiency in the use of the energy that powers the operations like grain receiving units and dryers, 29% stated not having these procedures. Average of 8 (7-10) years with proceedings.

What factors / challenges affect the adoption of this practice?

Farmers views.

- The implementation costs of these other matrices are still high, even with the credit lines the return on investment is still in the long term.
- Solar energy has been used a lot on properties.
- The lack of political support to invest in this energy sector has been a doubt for investment by agro companies.
- What can affect the adoption of this practice would be the government's taxes and fees charged on photovoltaic plants.
- The use of photovoltaic panels as an alternative and clean source contributes to supplying part of the energy needs of the farm and the cotton gin, providing clean and sustainable energy.
- This item applies well to the region of smallholder farming, remembering that this region has high luminosity and a high rate of solar radiation. The use of solar energy with the introduction of photovoltaic panels in small rural properties will provide them with energy self-sufficiency for use in the irrigation system, lighting of the house and machinery used in dairy production facilities. As the semi-arid region produces sun all year round, surplus production can be installed in the electricity grid in the ON GRID system, providing another source of income on the rural property.

What effects does this practice have on climate change mitigation?

Farmers views.

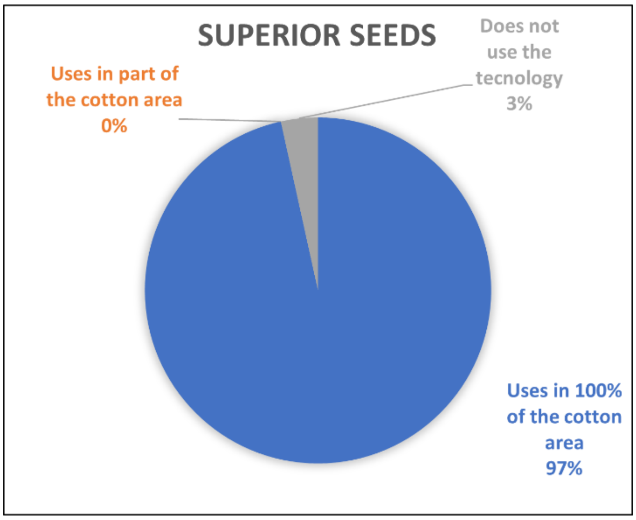
- One of the clean energies that is increasingly present in the production units is solar energy for electricity, generating credits with the energy companies. With this it is possible to produce parts of the farm's consumption.
- The effects are only positive, not being hostage to traditional energy, solar and wind energy does not cause any damage to the environment, and become important for the maintenance of natural resources.
- This practice has minor effects on climate change mitigation, but even so it is possible to have gains, especially by diversifying to a non-polluting matrix.

5.5 Seeds and phytosanitary products.

Genetic improvement offers the opportunity to increase carbon sequestration with the use of improved varieties, which reduce the need to apply agricultural pesticides to combat pests and diseases, spending less water in the preparation of pesticides and less fuel in tractors and machines used to apply these products to the crop. Plant breeding makes crops more productive per unit. Choosing well-adapted cultivars is a means of protecting crops against stresses such as extreme weather events caused by weather and pest and disease outbreaks.

The protection of crops, carried out mainly by the use of more efficient pesticides that require fewer applications in crops and, therefore, reduce operations in the field and, consequently, the burning of fossil fuel and the emission of CO_2 into the atmosphere. It is important to implement integrated pest management and the possibility of replacing it with biological control.

5.5.1 Superior Seeds. Seeds from genetic improvement offer the opportunity to increase carbon sequestration with higher produce per unit, better root development, better nutrient absorption and resistance to pests and diseases, reducing the need for plant protection.



Survey results. The data collected on the use of seeds from genetic improvement indicate that almost producers all farms have a strategy, only one farm stated it does not have a strategy for this practice. Average of 22 (7-35) years use.

Insights. In the tropical soils of the Brazilian cerrado, where most of Brazilian cotton is grown, more climate gains can be obtained by conservation management of the soil, as cotton farmers in Brazil already use the latest varieties developed by plant breeders. Very little additional short term effects in mitigating emissions can be expected from genetic improvement. However, better product quality and productivity can enhance the use of current areas without the need to open new areas with vegetation suppression.

What factors / challenges affect the adoption of this practice?
Farmers views.

- The main factor is the high cost of acquiring seeds from companies that own the technology in the form of "royalties".
- Adoption is affected by bringing together a large added value and royalties to be paid, and pests and diseases acquire resistance.
- The use of seeds from certified origin, as well as the use of varieties adapted to the needs and requirements of the farm, ensures the best use of resources and minimize technical losses.
- This technology has a price, the more technology embedded in the seed or the more genetically improved, the more expensive it becomes, but this is offset by achieving good productions.
- The strategy for using genetically modified seeds is to increase agricultural production in a more sustainable and ecological way.

- Genetic improvement can provide cultivated plants with a series of desired characteristics, such as: higher productivity, higher nutrient concentration, resistance to pests and diseases, resistance to herbicides, precocity, uniformity. These in turn manage to sequester carbon more efficiently.
- Factors such as research, costs and others directly influence the adoption of this practice.

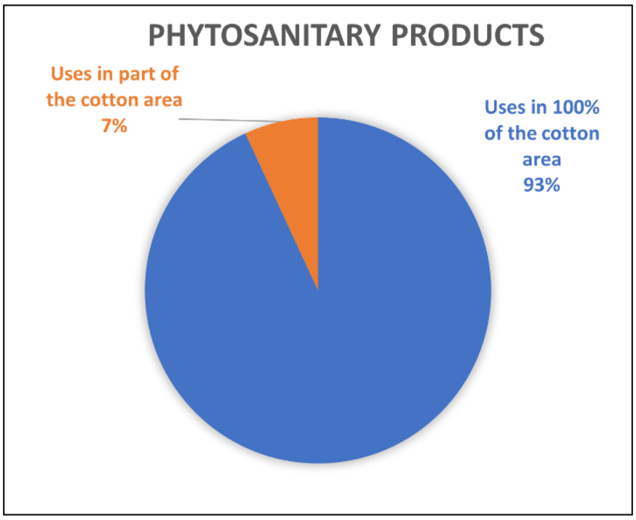
What effects does this practice have on climate change mitigation?
Farmers views.

- Genetic improvement makes an important contribution to the production process, as it provides less need for interventions with pesticides and better performance of materials to biotic stresses, thus adding to better productivity and lower production costs. It is also possible to reduce the re-entry of equipment into areas for such management.
- The use of certified seeds and varieties with technologies and genetic improvement contribute to the efficiency in controlling pests and diseases, reducing the need for machines to try to solve such problems, resulting in lower GHG emissions and greater CO2 capture.
- The use of quality seeds adds to the reduction of climate change because healthier plants have a much greater capacity to sequester carbon.
- Seeds from genetic improvement provide a crop with shorter cycles, making it possible to grow a second crop. With that we have 2 to 3 harvests during the year, with more live plants protecting the soil, absorbing Co2, making BNF and cycling nutrients to the soil, with that we have an increase in straw and MO in the soil.
- A quality seed always delivers better results, even more so in times of drought, when the plant is weakened by the lack of rain, with a better quality seed we will have plants with better vigor to withstand unfavorable weather conditions.
- The use of varieties provides better absorption of nutrients and resistance to pests and diseases, reducing the need for plant protection, thus contributing to the reduction of the application of phytosanitary products.
- Plants with GMOs provided ample control of highly voracious pests in cotton, substantially reducing the number of applications, which were 25 to 30 per cycle, reaching a maximum of 15 applications with the use of GMO varieties, because of the boll weevil - BICUDO. The impact of this technology provided family farmers with competitiveness in cotton production with environmental and social sustainability. And with the reduction in the application of pesticides and the like, there were fewer spraying operations and use of agrochemicals in the environment.
- The use of varieties is not very significant in terms of climate. There are more important factors to focus on before that.

The analysis conducted to assess the awareness of respondents of the effects of the use of superior seeds on climate change mitigation show that there is a less clear view of these effects. Also here, 52% of the farmers responded indicating technical and economic purposes – 30% stated less use of pesticides, and 22% indicated productivity and costs. However, 22% linked the same effects to climate change mitigation, and another 22% linked the use of superior seeds to more healthy crops, and even to more crops per season, as effects of climate change mitigation. See Table below.

Farmers perception of effects of superior seeds on climate change mitigation.	% of effects mentioned
Less use of chemical agents to control pests, diseases and weeds in crops.	30%
Contribution to the production process, thus adding to better productivity and lower production costs.	22%
Fewer sprayings of crops, reduction of the amount of pesticides, reduces operations in the field and consequently, the use of fossil fuel and less emission of CO2 into the atmosphere.	22%
Plants with better vigor to withstand unfavorable weather conditions; well-established and healthy crops have capacity to assimilate much more carbon; varieties permit 2 to 3 harvests during the year, with more live plants in the soil, absorbing CO2.	22%
Other.	4%

5.5.2 Phytosanitary products. With the use of more efficient pesticides, the Integrated Pest Management (IPM) integrates several strategies to protect the crop from attack by pests and diseases. Through the correct identification and constant monitoring of population levels of plant diseases and pests and their natural enemies, control only occurs when the level of economic damage to the crop is reached. This strategy requires fewer applications on the crops and, therefore, reduces the amount of pesticide, reduces operations in the field and, consequently, the burning of fossil fuel and the emission of CO2 in the atmosphere.



Survey results. Almost 100% of the farms use phytosanitary products, as stated by the respondents, only two farms said they do not use practice. Average of 21 (7-30) years use. Also, only one respondent said not to use IPM – Integrated Pest Management, all other respondents have the practice in place.

Insights. Large-scale agricultural production of cotton generally restricts the proper survey and management of pests and diseases. As a result, applications are scheduled because one cannot fully trust the climatic precisions for carrying out sprayings, especially when considering the immense cultivated areas. Thus, farmers believe that “calendar management”, i.e., sprayings guided by the development stage the cotton plants are in, needs to be carried out for proper "productive security", in order to reduce

the risk of losing the investments made in cotton production. However, Better Cotton-ABR certified producers have IPM strategies to guide pest and disease control.
Agricultural pesticides, although they have their share in the carbon footprint, are not the most relevant for GHG emission factors. Its applications may be, but little, so that the weight of the use of this sustainable technology would not be important in terms of GHG reduction and climate change mitigation. Its main benefits are in environmental quality, especially water and soil.

What factors / challenges affect the adoption of this practice?
Farmers views.

- For this practice it is necessary a qualified workforce, which has accurate technical knowledge, so that the surveys on pests and diseases are correctly carried out, and the sprayings are done correctly at the right time.
- Technical and operational knowledge is the biggest limitation. Availability of technology in certain equipment as well.
- A factor that also affects is the dissemination of IPM techniques among farmers and technicians, they have to be trained and qualified for scouting and practical actions.
- The lack of specialized labor in the field to carry out surveys of pests and diseases is one of the main problems faced, the correct identification of diseases, pests and natural enemies in the environment and their correct management also becomes a more difficult task. This directly impacts the indication of phytosanitary products for the control and resolution of the pests / diseases.
- The factors that affect the adoption of this practice are the high costs. Products that reduce applications usually cost more, even if the final cost is lower, which is not always noticed. Integration with pest identification, dosage, climate and equipment are also factors that affect this practice.

What effects does this practice have on climate change mitigation?
Farmers views.

- This practice has good contribution in terms of efficiency and cost reduction, since the integrated pest management brings reliable information for decision-making, so the sprayings only occur when needed, and if they have to be applied to total area or localized.
- This practice contributes to entries that are really necessary, and thus also contributing to fuel consumption savings.
- The Integrated Pest Management (IPM) contributes significantly to the mitigation of climate change, as the application of pesticides only occurs when the level of economic damage to the crop is reached, a strategy that leads to fewer applications in crops and, therefore, reduces the amount of pesticide, reduces operations in the field and, consequently, the burning of fossil fuel and the emission of CO_2 into the atmosphere.

Farmers responding the survey are not very aware of the effects of phytosanitary products on climate change mitigation, as 75% responded linking effects to technical and economic purposes, while 25% did link the use of phytosanitary products to this purpose.

5.5.3 Biological and microbiological control.

This is an important tool in Integrated Pest Management (IPM) in cotton cultivation. This technology can reduce the number of applications and the amount of pesticides used to control plant pests and diseases. Fewer applications mean fuel savings and improved carbon balance. In the cotton crop, although the several strategies that make up the integrated management are used to contain pest populations, the most adopted control is still the chemical one. But the constant use of this control method has led to the selection of resistant pest organisms, in addition to increasing the cost of production. For the Cotton crop several pest have the possibility for biological control, like caterpillars (Bacillus thuringiensis, baculovirus, genera Metarhizium, Beauveria e lsarya, Trichogramma pretiosum e Telenomus remus), aphids and weevils (Lysiphlebus testaceipes, Trissolcus basalis, Telenomus podisi, Steinernema, Heterorhabidits). The cotton boll weevil, the main pest of the crop in Brazil, is attacked by 13 species of parasitoids, with Catolaccus grandis and Bracon vulgaris being the ones that most contribute to the biological control of this pest. Both species are considered ectoparasitic wasps, that is, they are parasitoids that attach to the outer part of the skin of their hosts, from where they feed and develop. Additionally, with the partial replacement of insecticides by bio inputs, pollinating insects such as bees and wasps are favored in these areas (Embrapa 2022).

Survey results. The data collected on the use of biological and microbiological control for cotton production indicate that 44% of the respondents use the practice, 44% use it on part of the fields, and 12% does not use this technology. Average of 4 (3-7) years use. And 39% of the respondents have bio factories on the farm to produce the organisms, 61% has not.

Insights. It is necessary to improve the knowledge of the available technologies, the quality and the price of some commercialized materials. Products developed on the property sometimes prove to be ineffective for the proposed purpose.
Also, little is known about the carbon footprint of the production process of biological pesticides for agricultural use, and their potential to mitigate GHG emissions.
Although biological and microbiological products can help control pests and diseases, and thereby reduce the use of conventional agricultural pesticides, these practices are not the ones contributing to the mitigating climate change.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Biological and microbiological control is a management practice that is increasingly common in Brazilian agriculture, the use of these biologicals brings great benefits to the environment. But, as Brazil is a country that has a great diversity of pests and diseases, it does not we have enough products to control everything, so it is necessary to use chemical products.
- As it is still in the field testing phase, its use cannot be adopted on a massive scale and this requires a period of evaluation and behavior of pests and parasites.
- The greatest difficulty in this management is its sensitivity, in some cases, to environmental factors and mixing with pesticides in sprayings and requiring more care when applied, preferably at night or in milder weather.

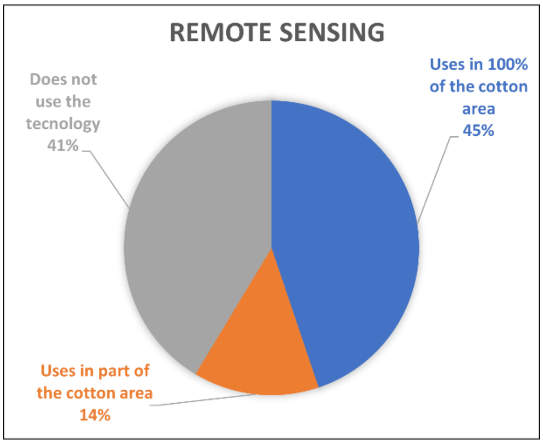
- Another point to be observed is the training of pest monitors, since most of these products must be applied preventively or with low initial infestation, which demands good knowledge on the part of the scouts.
- To be efficient with this tool, there is a need to better understand the microbiology of the soil, and develop a product for each problem that can meet the demand, because in nature several biological agents are present, including bacteria and fungi that act in favor and against the crop.
- One factor that affects use is the variation in its control efficiency, in addition to little knowledge about the best use.
- The lack of information and demonstration of gains with the use of micro and biological products affect the adoption of this practice.
- The use of nano technologies associated with micro and biological technologies can bring substantial gains in terms of reducing emissions and the use of chemicals.

What effects does this practice have on climate change mitigation?
Farmers views.

- The advantages of using these products are a reduced risk of environmental pollution, reduced exposure to toxic products for humans, absence of residues in food, non-extermination of natural enemies of pests and diseases. These products generally have a long cycle site of action, extending the action of the product, and may contribute to the reduction in the number of entries for application, consequently, reducing the use of fuels that contribute to climate change.
- The use of biologicals has the main objective of flooding the system with microorganisms that are considered "natural enemies", allowing the reduction of entries with chemical pesticides, and savings such as costs operations and fuel consumption.
- With the use of this technology, there is a more regenerative agriculture, less harmful to the environment, which also becomes more economically viable over time. From the moment these bacteria and microorganisms manage to develop in nature, there is improvement in the control of pests and diseases.
- Biological control contributes to the efficiency of pest controls throughout the cotton crop cycle, since, as it acts in the long term, it contributes by extending the window of economic damage level of a pest population, giving more time between chemical pesticide applications, thus reducing these.

The analysis conducted to assess the awareness of respondents of the effects of the use of biological and microbiological control show that 54% of the respondents indicate technical purposes, while 46% link the effects of the use to climate change mitigation, and 4% had other answers.

5.5.4 Remote sensing. Remote sensing technology has been used to detect and map pests and diseases in crops, not only for early detection and management, but also with the precision application of pesticides in specific places where infestation occurs. This strategy also requires fewer applications on the crops and, therefore, reduces the amount of pesticide, reduces operations in the field and, consequently, the burning of fossil fuel and the emission of CO_2 in the atmosphere.



Survey results. Almost 50% of the farms responded the questionnaire to use this technology, 4% make partial use, and 46% stated they do not use remote sensing technology for cotton production. Average of 4 (1-6) years use.

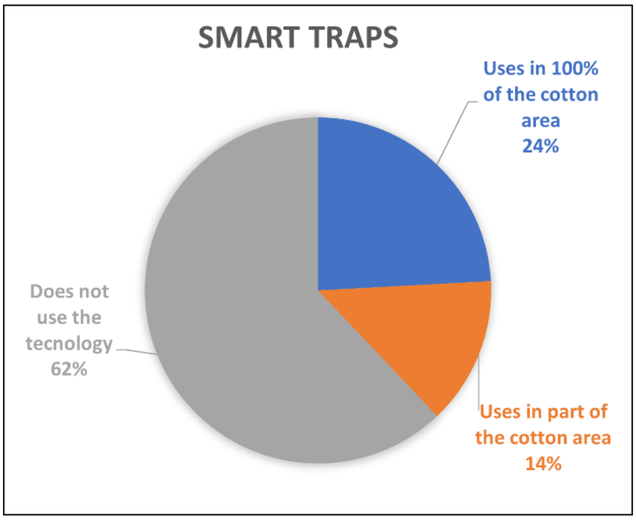
What factors / challenges affect the adoption of this practice?
Farmers views.

- Remote sensing is the use of images of the earth's surface to carry out studies and make decisions in the activities carried out. This enables detecting failures during the application of pesticides, locate possible critical points in the development of pests and diseases, and thus being able to direct the appropriate management.
- One of the factors that affect this practice is the high investment, and it requires specialized people, which makes it difficult for the many producers to obtain this technology.
- It is a more expensive system to implement, there is a need for advances in research, and on cloudy days the photos are without visibility of the area.

What effects does this practice have on climate change mitigation?
Farmers views.

- The use of this type of equipment helps to understand the situation of the crop very well in a more comprehensive and faster way for decision making.
- These tools tend to become more and more common and help to control expenses, directing actions only in areas that are targeted, reducing expenses with products and operation, and thus contributing to climate change mitigation.
- This practice helps to be more accurate and efficient in management, providing opportunities for savings in the use of pesticides and operational inputs. Maps are generated for decision-making and localized applications, resulting in a reduction in the application of chemicals and fuel consumption, preservation of macro and micro fauna.

5.5.5 Smart traps. Smart traps for pest monitoring, using pheromones, along with cloud-based data analysis, serve to reduce the labor costs involved with traditional IPM management, and produce more optimized pest management approaches based on real-time information. This strategy makes monitoring more efficient, with fewer sprayings and only where pests are present, and therefore reduces the amount of pesticides, reduces operations in the field and, consequently, mitigates emissions.



Survey results: The data collected on the use of smart traps for cotton production indicate that only 24% of the respondents use the practice, 14% use it on part of the fields, and 62% does not use this technology. Average of 2 years use.

What factors / challenges affect the adoption of this practice?
Farmers views.

- This practice can be an alternative to help in monitoring the crops, however it still does not follow up with the same level of detail that a person can see in the middle of the cotton fields.
- The traps and pest / disease identification are not very accurate yet.
- The technical knowledge necessary for those who manage the practice and do the follow-up to read the information is a challenge.
- The traps need ideal climatic conditions for the attractions to work well.
- The problem with this monitoring tool is that the traps and collection materials are in the hands of a few companies that manufacture this type of material, making the cost very expensive, and also requiring a trained and qualified team to carry out this activity.
- It is a technology under study, which has not yet proven its efficiency.

What effects does this practice have on climate change mitigation?
Farmers views.

- The practice results in the efficient use of pesticides, a reduction in the number of pesticide applications and a reduction in the emission of polluting gases.
- Technology has contributed to reducing the number of entries for insecticide applications, in addition to a gradual reduction in the pressure of pests, for example attractants for moths, sexual confusion hormone and traps for monitoring boll weevils.
- Traps manage to anticipate future problems that are coming to the crop, such as moths, making it possible to direct the necessary handling before the damage occurs, using recommended doses for pest control at an early stage, not needing to use the maximum dose of product to resolve damage.

5.6 Other climate smart practices.

5.6.1 Water and irrigation.

Irrigation is one of the main technologies for adapting to climate change, reducing climate uncertainties and bringing stability to production, and contributing to the accumulation of carbon in the soil through the possibility of exploring more than one annual crop.

Survey results: The data collected on the use of irrigation for cotton production indicate that 18% of the respondents use the practice, average of 7 years use, while 82% does not use this practice. The type of irrigation systems used are the center pivot system, driven by electricity. The irrigation systems were designed considering the local climate, crop necessities, soil type and infiltration rate and localization of the system.

Insights. The unavailability of water sources in adequate quantity, concomitant with the increase in pressure from society for the rational use of water in the countryside, and cotton production in large areas and the high cost of investment in irrigation projects are factors that make it difficult to use irrigation in cotton production.

Despite increasing the production of grains and fiber in the same area and agricultural year, irrigation alone is not capable of storing carbon in the soil. Although it allows agricultural production during almost the entire agricultural year, including cotton in regions where the lack of rain in the autumn-winter period limits its cultivation as a second harvest, if adequate soil management is not adopted, it is difficult to increase the input of carbon into the soil and thereby mitigate climate change.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Investment in irrigation can be an alternative to minimize the impacts of climatic conditions and to better explore the cultivation area, however one of the problems faced to adhere to this production method is the high cost of acquiring and maintaining the system.
- The high consumption of water for irrigation and energy in the operation can be a limiting factor for adherence.
- Farms do not use irrigation, when there are no water sources available to collect for irrigation.
- The high investment and the necessary licenses make its implementation difficult.
- The use of irrigation can allow an expansion of the productive window within the property, permitting better planning and management of the crops to be planted, and better explore the potential of properties.

What effects does this practice have on climate change mitigation?
Farmers views.

- The use of irrigation and water management provides an option to increase the effectiveness of agricultural production on the property, allowing a greater use of the productive window of the property, with the cultivation of more than one agricultural crop, which thus contributes to the mitigation of climate change throughout the harvest.
- The modification of the environment, soil salinization, contamination of water resources, excessive consumption of water, public health problems are considered the most important issues to be analyzed when studying the environmental impacts of irrigation.

- The capture of water from rivers and streams in large quantities can cause a decrease in its flow, especially in the dry season, which can alter all the aquatic fauna in the region.
- Irrigation allows the reduction of climate uncertainties, bringing stability to production, and contributing to the accumulation of carbon in the soil through the possibility of exploring more than one crop per year.

5.6.2 Income diversification.

Income diversification through non-farm income sources is a strategy for additional financial resources for the farmer´s family, and a way to curb fluctuations in farm income due to lower yields caused by climate adversities like erratic irregularities of rainfall and temperature pattern.

Survey results. 52% of the farms responded the questionnaire not to have income diversification, while 48% answered to have this practice. Average of 16 (3-30) years use.

Insights. Currently, producers earn their main income from agricultural resources. But there are producers with other incomes, and investments, however on a smaller scale.

What factors / challenges affect the adoption of this practice?
Farmers views.

- What makes this practice difficult is the producer's lack of knowledge in another area of activity that he is not used to, but it would be a good alternative, so that the producer is not hostage to just one agricultural activity.
- The factor that affects adoption is the paradigm that the rural producer have to produce only items related to direct agricultural produce. It may be necessary to work on changing the culture and supporting investments so that diversification becomes an increasingly constant reality on the properties.
- One option is to diversify the income of the property, using crop rotation, pig farming, pisciculture, among others. The producer manages to generate more income at different times of the year, and with different gains within the property, not being trapped only in monocultures.
- Lack of time to dedicate to prospect new diversification of income sources affects the adoption of this practice.

What effects does this practice have on climate change mitigation?
Farmers views.

- Obtaining an alternative source of income, in the midst of adverse weather conditions that make agricultural production unfeasible in that year, guarantees the producer a way to persevere and adapt.
- The variability of businesses around the unit can favor the farmer, create an ecosystem that generates profit, using resources generated within its own area, diversifying its sources of income and acting in commitment to the environment, favoring a more sustainable property.

5.6.3 Climate management and meteorological monitoring. This strategy can be used as a strategy for adapting and mitigating climate change, through professional services, to carry out annual planning, anticipating relevant seasonal conditions for the harvest, and obtain better results in crops, in control pests and diseases, and coping with periods of intense rain or drought.

Survey results. 93% of the respondents stated that they use the professionals services of climate management and meteorological monitoring, 7% answered not to use this kind of services provision. Average of 4 (3-5) years use.

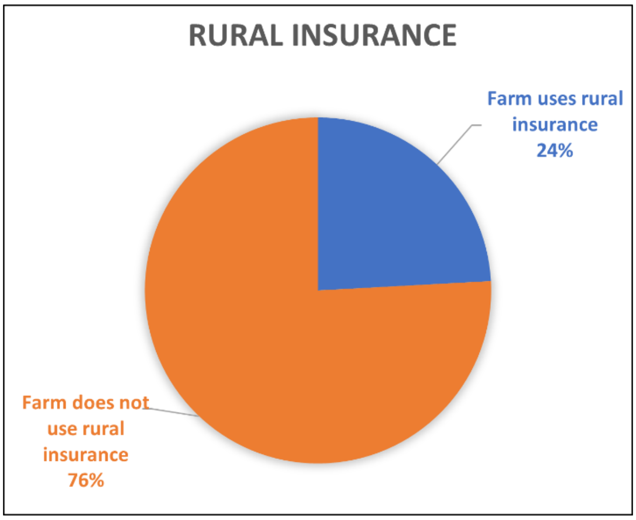
What factors / challenges affect the adoption of this practice?
Farmers views.

- Currently, the platforms available for analyzing precipitation and annual temperatures are available in different formats and can be accessed from any device, however, for monitoring with greater detail of information of the region, the acquisition of local autonomous stations is very important in large areas, making decision-making almost instantly.
- Weather forecasts are not always accurate, which may compromise success in decision-making.
- This is a very important practice, already carried out by many producers, who invest in weather stations and software that help in decision making. The difficulty of this tool or practice is the quality of the data delivered by the companies that provide this type of service, which are still in the process of being improved.
- There is the issue of quality of the internet signal or telephone signal or even satellite communication reaching the farm, the information arriving distorted or flawed.
- High initial investment is still one of the factors that can negatively affect the adoption of this practice. The use of state-of-the-art technologies to ensure greater accuracy in monitoring can facilitate cost reduction.

What effects does this practice have on climate change mitigation?
Farmers views.

- By anticipating harvest forecasts, it is possible to adjust management, plan the choice of genetics and positioning of plantings in ideal windows, making it possible to reduce the need for inputs, reducing operational interventions and ensure productivity.
- Meteorological monitoring allows operations to be planned throughout the crop cycle, which optimizes operations within the farm and provides a better parameter to avoid risks, thus ensuring better use of resources and avoiding operational waste.
- Daily weather forecasts enable planning of operations and sprayings, and supports decision-making in day-to-day agricultural practices. Making more effective and accurate decisions.

5.6.4 Rural Insurance. Rural Insurance is the main risk mitigation tool in the case of climate risks, ensuring the continuity of rural activity. It is not possible to control climatic events, and Rural Insurance is the best alternative to face possible economic losses caused by the frustration of the agricultural harvest.



Survey results. 76% of the farms responded the questionnaire not to have rural insurance for cotton production, while 24% answered to have this practice. No data of years of use.

What factors / challenges affect the adoption of this practice?
Farmers views.

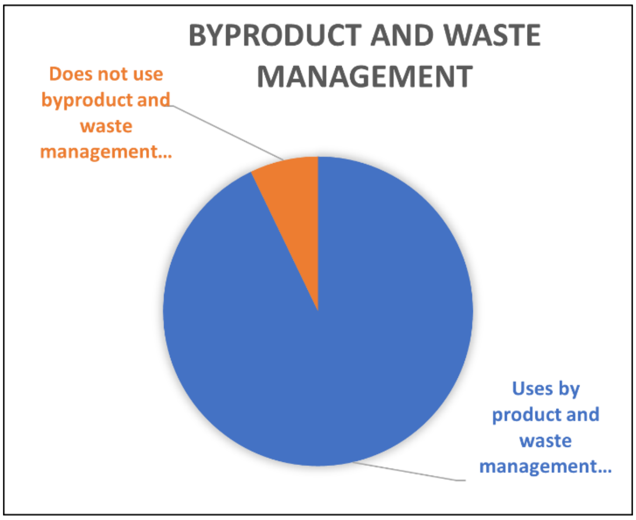
- Agricultural insurance on its production and infrastructure are important, since Brazil is a country with a tropical climate, with often unstable weather, or agents that are beyond the control of the producer, damages to the crop can occur to the point of production is lost. The guarantee of insurance coverage encourages the producer to continue his business.
- In the state of Mato Grosso, this type of climate occurrence does not occur easily, the insurance would not be for cases of climatic conditions, perhaps it would be the case for the corn crop because it is a crop that easily catches fire at harvest time. Or machine insurance, and cotton deposited at the cotton mills.

What effects does this practice have on climate change mitigation?
Farmers views.

- It is not possible to control climatic events, and rural insurance is the best alternative to face possible economic losses caused by the frustration of the agricultural harvest.
- The practice minimizes the risks caused by climate change.
- This practice does not contribute to reducing climate change.

5.6.5 Byproduct and waste management.

Agricultural by-product are discarded organic materials produced from the raising of plants and animals as part of agronomic operations including animal manure, bedding materials, plant stalk, leaves, other vegetative matter and discarded by-product from the on farm processing of produce. The management of these by-products leads to mitigation of the emission of Greenhouse Gases (GHGs). Also, on farm waste management (plastics, empty pesticide containers, building materials, old machinery and petroleum wastes) have impacts on climate change.



Survey results. 93% of the farms stated they have a strategy for byproduct and waste management, and 7% answered not to have a strategy. Average of 9 (5-10) years in use.

Insights: The byproduct and waste management practices are an important part of the Better Cotton – ABR standard.

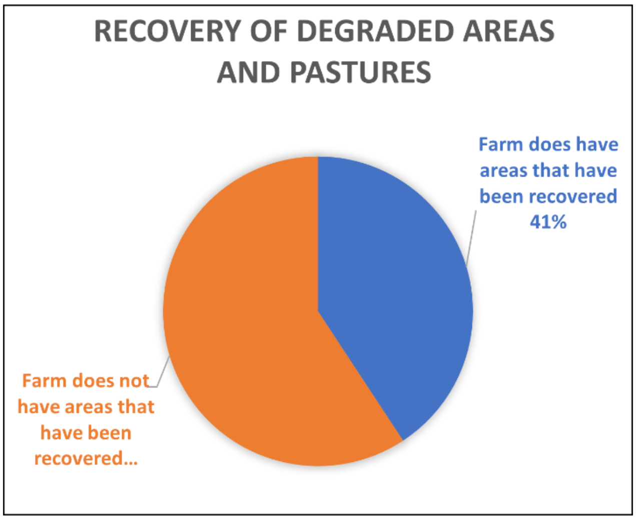
What factors / challenges affect the adoption of this practice?
Farmers views.

- These are indispensable practices for the property, the management of waste from empty containers of pesticides, lubricating oil and other contaminated materials, some waste can even generate some extra income for the producer.
- Waste management involves analyzing the waste generated by each process, as well as classifying and quantifying it, storing and identifying it, and then disposing of it, this process can affect the adoption of the practice.
- There is a lack of information on the efficient disposal of by-products and waste, and there are few places to carry out the proper disposal.
- A certain investment in structure and machinery is needed, which would make this practice difficult to adopt. But this activity can be profitable for the producer, since what was an environmental liability, becomes an asset with economic value.
- There is already a change in the way the producer acts with this residue, where it is becoming fertilizer, animal feed or even a business to sell this by-product.
- The use of agricultural by-products and residues, such as manure or vegetable residues, requires more detailed studies of their impacts when applied directly to cultivated areas. An investment in technologies for the application of these residues must be made so that they do not impact the main activities of the property.
- Another important factor is the storage of this residue and the impact it can have on the environment, such as the emission of gases and contaminants into the soil.

What effects does this practice have on climate change mitigation?
Farmers views.

- The recycling of agricultural waste, as well as its disposal in suitable places, results in less contamination of the environment.
- With the correct management of by-products and residues (plastics, empty pesticide packaging) being correctly disposed of and recycled correctly, it has an effect on the mitigation of climate change.
- Many of the by-products have high levels of organic matter (cotton hulls at the gin), and the use of these products reduces dependence on fertilizers, which come from fossil fuels. In addition, the recycling of empty packaging is fundamental in the chain, as it also reuses products that come from petroleum.

5.6.6 Recovery of degraded areas and pastures. This is one of the strategies for mitigating and adapting to climate change. Recovery helps combat climate change by restoring vegetation and soil carbon and removing carbon dioxide from the atmosphere.



Survey results. The data collected on the recovery of degraded areas and pastures indicate that 41% of the respondents had had this type of practice on the farms, and 59% did not. Average of 7 (10-14) years use.

Insights. Degraded pasture areas are not exploited for cotton production, given the demands the crop has on soil fertility. Only after due corrections, with subsequent cultivation of other crops, such as soy and sorghum, for example, is it justified to introduce cotton.
For the purposes of basic guidelines aimed at producing cotton with low carbon emissions, or another line in that direction, it seems not pertinent to include the recovery of degraded areas and pastures. On the other hand, if the policy for climate-smart agriculture practices is thought of in a broader way, that is, not directed only to cotton cultivation, but to the property as a whole, then it is very justifiable to include this topic, due to the great potential degraded and recovered pastures have for storing carbon in the soil. This can also be applied to the previously commented ILPF system.

What factors / challenges affect the adoption of this practice?
Farmers views.

- Areas with degraded pastures can become productive areas, with the adoption of good soil conservation practices, application of correctives and necessary fertilization and with the choice of varieties with characteristics that fit the soil requirements. The problem is the lack of guidance and planning for decision making.
- The financial factor is one of the main difficulties in its implementation, since in most cases these areas are in the hands of producers with difficulties, otherwise they would not be in these conditions.
- Many farms do not have degraded areas that need recovery, nor do they have cases of recovery of pastures for use in crops.

What effects does this practice have on climate change mitigation?
Farmers views.

- The task of recovering degraded areas is not an easy one, but it is a reality and deserves attention, good management practices and soil conservation with the application of investments can give return in the short and medium term. Thus, turning areas already deforested into productive areas, which undoubtedly contributes to an increase in the production chain, and with a direct impact on the demand for new areas.

- The correct management of the property's areas with a focus on maintaining and caring for APP's (Permanent Preservation Areas) and Legal Reserve Areas also contribute positively to mitigating climate changes.
- The recovery of degraded areas of a property allows, in addition to renewing the capacity of that environment to increase its production potential, a greater sequestration of atmospheric carbon, as well as minimizing the need to deforest new areas.

5.7 Other practices collected in the survey.

Collective monitoring. Effective pest control is one of the most important aspects of sustainable cotton farming, especially with a view to controlling weevils, the most traditional and one of the most pernicious pests in the history of cotton farming in Brazil, which, when out of control, are extremely devastating. Collective initiatives promote intensive monitoring of all producing micro-regions, involving the eradication of food sources for the boll weevil, controlling voluntary cotton plants in other crops, roadsides, near cotton gins. This work involves awareness campaigns, constant inspections of the cotton and crop rotation areas, diagnostic meetings and analysis of the results measured in boll weevil “traps” using pheromones. Also, with the same objectives, it is legally prohibited to grow cotton in a 90 day period of the year, called “vazio sanitário”, the practice aims to restrict the food source for insects in a coordinated way during a 90 day period in the off season. These programs certainly contribute to a lower quantity of pesticides applied to the cotton crop and a lower number of sprayings, contributing in this way to climate mitigation and adaptation.

Registered pesticides. Use only of registered pesticides, and not falsified ones, so it does not compromise the fauna in agricultural areas, reducing the chance of using products that may cause harm to people and animals.

Boll weevil control in smallholder cotton farming. Farmers use cotton crop residues as a form of grazing for their cattle, which causes a 100% reduction in the weevil pest in the reproductive parts of cotton plants. Less use of pesticides and less sprayings.

5.8 Major climate-smart practices implemented by the Better Cotton – ABR licensed producers in Brazil.

The major climate smart practices, the factors affecting the adoption of these practices and the effects do those practices have on climate change mitigation are described in chapter 5.2 – 5.7.

The agricultural production systems are consolidated and ranked in the table below. As can be seen, the NTS – No Tillage System is not widely used by the respondents.

Agricultural production systems	% of responses			
	Uses in 100% of the cotton area	Uses in part of the cotton area	Does not use the tecnology	Average years in use
Crop rotation	50%	37%	13%	20
Mulch and cover crops	50%	33%	17%	16
No till planting system	43%	40%	17%	16
Reduced tillage system	43%	40%	17%	13
Crop livestock integration	23%		77%	5

The survey detected that of the farms using reduced tillage 60% responded using cover crops on 100% of the cotton area and 40% uses on part of the cotton area. The same answers were collected for crop rotation.

The next table shows the survey results for **soil fertility and fertilization**.
Note: the biological nitrogen fixation shown is used in soy, not in cotton, as cotton is **not** a legume plant and does not fix nitrogen from the atmosphere.

Soil fertility and fertilization	% of responses			
	Uses in 100% of the cotton area	Uses in part of the cotton area	Does not use the tecnology	Average years in use
Agricultural machinery steering systems	90%	3%	7%	13
Fertilizers	70%	23%	7%	22
Precision agriculture	57%	13%	30%	10
Liming and gypsum	53%	43%	4%	23
Fertilization of the system	54%	23%	23%	17
Biological nitrogen fixation (soy)	93%	4%	3%	21

The survey results show that for **Fuel and energy,** 93% of the respondents stated that there is a strategy for the use of fuel, while only 7% do not have a strategy. For the use of energy, the numbers are 76% and 24% respectively.

The survey results for the uses of **seeds and phytosanitary products** are consolidated and ranked in the next table.

Seeds and phytosanitary products	% of responses			
	Uses in 100% of the cotton area	Uses in part of the cotton area	Does not use the tecnology	Average years in use
Superior seeds	97%	0%	3%	22
Use of integrated pest management	97%	*	3%	*
Phytosanitary products	93%	7%	0%	21
Biofactory on the farm	48%	*	52%	*
Remote sensing	45%	14%	41%	4
Biological and microbiological control	44%	44%	12%	4
Smart traps	24%	14%	62%	*

The survey results for the uses of **other climate smart practices** are consolidated and ranked in the next table.

Other climate smart practices	% of responses		
	Has the practice on the farm	Does not have the practice on the farm	Average years in use
Climate managing and meteorological monitoring	93%	7%	4
Byproduct and waste management	93%	7%	9
Income diversification	52%	48%	16
Recovery of degraded areas and pastures	41%	59%	7
Rural insurance	24%	76%	*
Water and irrigation	18%	82%	*

The adoption of practices by regions/states was not assessed as the distribution of the sample in some states was too small.

The practices have direct effects on mitigating the effects of climate change and on the causes of some factors that lead to global warming. Product traceability, certification audits and monitoring and guidance practices for reducing fertilizers and phytosanitary products contribute positively to reducing the effects and causes of climate change.

Soil conservation practices, water conservation and native forests are closely linked to carbon sequestration and natural preservation, which generates a considerable impact on reducing climate change, while good cultivation practices (planting, harvesting and processing) help in emissions reduction.

5.9 Initiatives from Better Cotton and ABRAPA supporting the adoption of climate smart practices.

The following contributions were collected during interviews and questionnaire responses.

- The main initiative is the benchmark made by the institution in relation to the raw material production chain, granting a certificate of compliance with these sustainable practices. The quest to implement these practices through follow-up and audits has attracted the attention and attention of all people involved in these activities, recognizing the work of the entire corporation.
- The cotton sector, under the leadership of ABRAPA, is among the most active in the cause of sustainability in Brazil. The association focuses its efforts on several fronts. It maintains a national sustainable cotton production program, operates a benchmarking agreement with the Better Cotton Initiative (BCI), encourages regional initiatives related to good socio-environmental practices, and supports sustainable government programs. The main initiatives are the on-farm audits that are carried out, and the support to events on cotton farming showing the importance of sustainable cotton.
- The stock of carbon in the soil could compensate for anthropogenic emissions, benefiting agricultural productivity and mitigating the increase in temperature. For carbon sequestration to occur in the soil, management systems must seek to maintain high amounts of biomass, cause minimal disturbance to the structure, in addition to promoting soil and water conservation. These practices also increase the activity and diversity of the edaphic fauna, strengthening the elements cycling mechanisms. All these recommendations are contemplated in the ABR protocol, in criteria 07 and 08, in this context, ABRAPA encourages dialogue and mechanisms to propagate these good practices, making the sector make a great contribution to the reduction of soil emissions and higher carbon sequestration. In addition to techniques aimed at soil conservation, other actions that contribute to the reduction of emissions are the implementation of an integrated pest management supported by innovative technologies, like remote sensing and precision agriculture, that will provide subsidies to farmers in making decisions about applications of pesticides, the reduction in these applications reflects directly on emissions, since operations with diesel oil will be reduced. The use of fertilizer with fixative and solubilizing microorganisms also acts as a mechanism to reduce emissions, since with their use it is possible to reduce the need for fertilizer application. In addition to the items contained in the certification protocol, state associations and ABRAPA show great concern with the preservation and maintenance of water quality from springs and water bodies, making large investments in research and implementation of practical actions together with the community. In order to preserve this natural resource, there are also several studies carried out jointly with Embrapa on carbon sequestration in a tropical environment and the methodology for calculating the carbon balance, which will guide more accurate actions on the subject for cotton cultivation.
- Thinking that the consequences of climate change directly affect rural production activity (productivity, profitability, etc.), it is in the interest of the sector to always be looking for new techniques that support climate alerts, productive efficiency and carbon sequestration, at all stages of cotton production.

5.10 Adaptation of Better Cotton - ABR producers and their communities to the consequences of climate change.

The concern and views regarding climate change and all the effects caused by its oscillation are not recent. The communities are committed to recognizing the main points of improvement that directly impact our environment and that are extremely important to minimize these effects. The challenges are increasing for companies in the midst of the market and the variables that interfere, where a more profitable business with less impact on the environment is sought and, consequently, bringing a better condition for all the people involved.

From the moment the farms join the Better Cotton – ABR program, they are already committing themselves to the good practices described in the standard, so that they can be approved in audits and receive the certificate. These practices are efficient in reducing GHG emissions, improving processes and ensuring the continuity of natural resources in the region, not only for their owners but also for the entire community. In this way, producers will be more resilient to the effects of climate change.

These practices, when done correctly and with commitment, bring a lot of confidence to the community, since the benefits are visible to everyone. And this facilitates the adaptation of these new cultivation methods. Currently, these producers and their communities are already familiar with these changes, once everyone is aware of their responsibilities. And that these changes, and the way of management and production, is in line with the preservation of the environment, thinking about the next generations, and taking care of today's people, taking care of the community, so that those people who are involved in cotton production, have a dignified life, with well-defined rights and duties.

Nowadays, the topic of climate change has been discussed with great incidence within many organizations, seeking to develop and implement pertinent actions in a constant and precise manner, seeking to optimize cotton production and also contribute to the mitigation of climate change. There is a search for the necessary information, training of teams and a change in the vision of indicators that were not effectively monitored before and have impact changing habits to reduce the adversities of climate change.

5.11 Factors influencing climate change adoption among Brazilian producers.

- Main factor that influences climate change adoption is the awareness of producers that they are responsible for the future, that everything sown now will reap tomorrow. Many of the climate-smart practices adopted serve to improve production, reduce production costs, in short, analyzing and looking at nature, and learn to produce more and more sustainable. Another factor is to overcome producers' resistance to changes and adaptation to new management technologies.
- Considering that the consequences of climate change directly affect rural production activity (productivity, profitability), it is in the interest of the sector to always be looking for new techniques that support climate alerts, productive efficiency and carbon sequestration, at all stages of production.
- Important is to have access to information and education on the use of climate-smart practices, with training and technical assistance. Investment lines, certifications and the use of low-cost technology are also factors to be considered.

5.12 Effects of climate smart practices on climate change mitigation.

The practices have direct effects on mitigating the effects of climate change and on the causes of some factors that lead to global warming. Product traceability, certification audits and monitoring and

guidance practices for reducing fertilizers and phytosanitary products contribute positively to reducing the effects and causes of climate change.
Soil conservation practices, water conservation and native forests are closely linked to carbon sequestration and natural preservation, which generates a considerable impact on reducing climate change, while good cultivation practices (planting, harvesting and processing) help in emissions reduction.
The practice of soil covers increases the accumulation of carbon and also increases the sequestration of GHG in the atmosphere, keeping the soil hydrated, directly affecting and altering the nearby climate with temperature variation and rainfall.
The effects are many, first of all it improves production, with a decrease in the use of fuel, and a decrease in the use of chemical fertilizers and pesticides. Produce with more quality and maintain life in the soil.
And the choice of varieties with high productive capacity, resistant to diseases, pests and adversities, can provided a healthier and more productive crop. This has a direct impact on the intensive use of machinery and products to control these adversities. Therefore, the management of these areas becomes easier and at lower costs and with less impact on nature.

5.13. Key lessons learned from climate change efforts in Brazil.

The sector needs to build metrics and methodologies to measure the carbon balance in a tropical environment in the activities inherent to the production of lint, in order to improve its processes if necessary. Reducing the use of chemical fertilizers is a challenge. Plants well nourished by chemical fertilizers can be more resilient to climate problems.
The knowledge of the Brazilian producer today is very advanced, because with the pandemic that occurred, young people returned to the properties, bringing innovative ideas, new insights and rules, firming the commitment to their families and taking actions respecting good practices. Today Brazil has several successful experiences that are an example for the world.
It has been noted that working in groups with the coordination of the associations amplifies the effects of the efforts made, and it is possible to see the result in some regions. Working in groups and associations favors actions and amplifies results.
The great lesson is that Brazilian farmers are capable of producing more and more, with greater quality and competitiveness, using technologies available on the market at a lower cost and with the lowest possible environmental impact.

5.14 What has worked well and what could be scaled up.

Practices that have worked well are product traceability, questionnaires for monitoring the use of fertilizers and pesticides, Better Cotton – ABR certification with all requirements related to reducing impacts on the climate, use of biological products, adoption of no-tillage and its variations according to the reality of each productive micro-region, Integrated Pest management, crop rotation, mulch and cover crops and precision agriculture.
The use of inputs can have its use positioned more assertively, with the new technologies available on the market, such as soil conditioners, fertilization, pesticides, bio-defensives, among others. For this, precision agriculture has helped a lot in the correct use of these resources at the right time with the right intensity.

5.15 Major challenges for the implementation of climate-smart practices.

Climate change is undoubtedly one of the greatest challenges facing society today. The impacts of climate change are significant and affect everything from our health to food production.

The major challenges are the implementation of new technologies and adapting them to the large-scale production scenario, this can be a challenge to be achieved in the short term, requiring trained people and equipment. Produce more with less costs, using available resources more intensively through the use of new tools and technologies. More use of regenerative agriculture, more studies and incentives for agriculture with less use of pesticides and use of biological products on a large scale, use of soil health management, creation of root rotation alternatives and cover crops for different purposes.

A challenge can also be to maintain support from producers, generate information and seek awareness and commitment to sustainable agriculture among young producers. Reducing the use of chemical fertilizers is a challenge, as well nourished plants by use of chemical fertilizers are more resilient to climate problems. Producer awareness towards the implementation of climate smart practices.

5.16 Unintended positive or negative outcomes of the climate-smart practices promoted by the program.

No unintended outcomes were mentioned, only positive effects, as it is necessary to make farmers available to carry out the activities of the program. Also, a positive outcome related to facilitating the understanding of the need for culture change among farmers.

5.17 Interviews.

5.17.1 Interviews with producers. The interviews with producers were limited, due to the lack of contact details which had to be provided by the state organizations.

5.17.2 Interviews with stakeholders. Stakeholder interview was conducted with a number of people; however, feedback was very limited, probably due to available time in this time of the year.

5.17.3 Focus groups results. No focus groups meetings were held, as the state organizations were reluctant to share contact details, and due to the difficulties in bringing producers together, being the period of the year soy harvest time, cotton crop care, and many farms were involved in the audits for Better Cotton – ABR certification. Also, the very tight timespan of the study to be able to organize these meetings.

5.18 Climate awareness survey - perception of rural producers on climate change.

Agriculture is one of the sectors most vulnerable to climate change, due to its intrinsic dependence on climatic factors and natural resources. Concerns about the reaction of cotton producers towards the theme, which farmers may see as issues that have been guided mistakenly and restricted by ideological, political, economic and academic motivations, moving away, not only from the basic principles of the practice science, have led the consultancy to conduct a small survey aimed to identify their perception of the matter. For this a small questionnaire was composed, and the results of the participating group are as follows.

Description	Answer	%
Summer temperature	Increased	36
	Stayed the same	60
	Diminished	4
Winter / dry period tempreratue	Increased	44
	Stayed the same	44
	Diminished	12
Dry spells during crop seazon "veranicos"	Increased	42
	Stayed the same	58
	Diminished	0
Annual rain	Increased	8
	Stayed the same	72
	Diminished	20

Part 1. The first part of this survey tries to capture the farmers perception of climate change, asking what the perception of climate change in the last 10 years on their farm(s) is, regarding four indicators – summer temperature, winter / dry period temperature, dry spells during the crop season called "veranicos" and annual rainfall.
See table: Farmers perception of climate change on the farm in the last 10 years (% of respondents).

Part 2. The next part of the survey aimed at capturing farmers concerns about climate-related risks and the future impact they may have on the farming operations, what is the probability that this event could occur and, if the event occurs, what would be the consequences.

Description	How concerned are you about the following climate-related risks.		What is the probability that these events could occur?		If the event occurs, what would be the consequences?	
	Answer	%	Answer	%	Answer	%
More severe droughts	Not at all concerned	0%	Not likely	0%	No impact	0%
	Concerned	50%	Likely	29%	Some impact	13%
	Very Concerned	50%	Very likely	71%	High impact	88%
Change of the weather, intensity and frequency of rainfall events	Not at all concerned	8%	Not likely	8%	No impact	0%
	Concerned	50%	Likely	17%	Some impact	38%
	Very Concerned	42%	Very likely	75%	High impact	63%
Higher temperatures	Not at all concerned	17%	Not likely	21%	No impact	17%
	Concerned	58%	Likely	42%	Some impact	46%
	Very Concerned	25%	Very likely	38%	High impact	38%
More frequent heat waves / dry spell in critical periods in crop seazon (veranicos)	Not at all concerned	17%	Not likely	13%	No impact	13%
	Concerned	21%	Likely	29%	Some impact	21%
	Very Concerned	63%	Very likely	58%	High impact	67%
Increase in weeds/invasive species, pests, diseases	Not at all concerned	4%	Not likely	4%	No impact	8%
	Concerned	25%	Likely	13%	Some impact	17%
	Very Concerned	71%	Very likely	83%	High impact	75%

Description	How concerned are you about the following climate-related risks.		What is the probability that these events could occur?		If the event occurs, what would be the consequences?	
	Answer	%	Answer	%	Answer	%
Fewer/more cold hours in winter	Not at all concerned	63%	Not likely	42%	No impact	42%
	Concerned	33%	Likely	38%	Some impact	29%
	Very Concerned	4%	Very likely	21%	High impact	29%
Increased frequency or intensity of hail/frost	Not at all concerned	46%	Not likely	42%	No impact	38%
	Concerned	29%	Likely	17%	Some impact	13%
	Very Concerned	25%	Very likely	42%	High impact	50%
Less reliable surface water supply	Not at all concerned	32%	Not likely	23%	No impact	27%
	Concerned	50%	Likely	45%	Some impact	50%
	Very Concerned	18%	Very likely	32%	High impact	23%
Increased frequency or intensity of flooding	Not at all concerned	58%	Not likely	58%	No impact	54%
	Concerned	29%	Likely	33%	Some impact	13%
	Very Concerned	13%	Very likely	8%	High impact	33%
Increased frequency or intensity of erosion	Not at all concerned	42%	Not likely	46%	No impact	38%
	Concerned	25%	Likely	29%	Some impact	29%
	Very Concerned	33%	Very likely	25%	High impact	33%

Overall, respondents are concerned about climate-related risks and the future impact they may have on their farming operations, as 73% stated that they are worried / very worried about these impacts, and 27% say they are not very concerned about the surveyed risks.

6. Recommendations and Institutional Strategies

The following recommendations and institutional strategies were collected during the study.

- Provide awareness and tools so farmers have a better understanding of their farm's performance including greenhouse gas emissions and carbon capture accounting.
- As the concept of regenerative farming is still under construction, it is important to ensure that consolidated conservationist practices – such as no tillage farming, in which Brazil is a global leader and knowledge frontrunner – remain duly recognized and accounted for within regenerative agriculture.
- Develop farmer-friendly tools to improve Climate-Smart Agriculture (CSA) for cotton, and step by step approach for farmers, as some are not so open to big changes, and all the farmers must be reached.
- Establish a network of model farms working with CSA to cover different areas, to help the initiatives to better disseminate the results and connect to each other training of the trainers (advisers), because there are knowledge gaps that need to be further fed with new knowledge.
- There is a necessity to create production systems which are more diversified, as, besides the already mentioned results like the carbon stock potential, healthy living soils break down pesticide molecules more easily.
- Develop crops and markets for crop rotation produce, which would facilitate the implementation of cotton rotation with crops with greater carbon sequestration potential. Exploring these markets and developing these products, cover crops begin to bring a greater return to the farmer, no longer being used only for straw.
- There is a necessity to evaluate, with more scientific data, soil tillage used in cotton production, especially develop better understanding on compaction level of soil and appropriate indicators, evaluate what really is happening. And evaluate soil sampling methods with soil density, sampling depth and the relation with the soil carbon stock and microorganisms.
- The cotton sector is getting used to certification to 'guarantee' sustainable farming, but these certifications (as the bare minimum) are complicated and expensive. Farmers pay for audit services, and are also responsible for covering all costs associated with compliance with standards, although costs associated with national law compliance cannot be attributed to compliance costs. Producers have to make significant extra investments in establishing adequate internal controls in order to monitor a range of Better Cotton / ABR KPIs, including input application, working conditions and biodiversity management. Most farms have already a rigorous information management system, leading to improvements in operational efficiency, however, it is difficult to quantify the extra costs associated to the compliance with all principles and criteria contained in the standard. Good agricultural practices can provide significant benefits in the form of increased productivity, reduced input costs, etc., however, this particularly does not apply for larger farms (>500 Ha) as they already are at optimal levels of productivity. Key potential benefits can be a price premium, input discounts, a discount on financing, being the most important benefit a healthy price premium.
- More investments are needed in the development of faster and more specific methods for soil organic matter assessment and determination of soil health. The work carried out by Embrapa, with metagenomics and its application in the study of plant diversity and functions of microorganisms from Cerrado soils, is a good example.

- Encourage the creation of soil health departments among the different cotton producers' associations, establishing a network to help the initiatives to better disseminate the CSA practices and connect to each other, with training of the trainers (advisers) to overcome the knowledge gaps that need to be further fed with access to most recent knowledge.
- Support research on species and varieties of cover crops in cotton production, and their use in different regions.
- Organize long-term economic studies on the use of crop rotation and cover crops in cotton production, in order to monetize these practices and point out to producers also in this way the gains of these practices.
- Considering the potential damage caused by cotton pests and diseases and the indiscriminate use of chemical agents in an attempt to control them, support research on the use of biological products in an alternative pest management system, combining biological and chemical management strategies in the control of pests and diseases in the cotton crop cultivated in the different regions of Brazil.
- Develop and provide farmers with region-specific data to adjust the use of pesticides which have impact on soil fauna communities in fiber and grains cropping systems, to find out pesticides accumulation rate for no-till fields and impact to soil fauna.
- Promote adoption of NTS (No Tillage System) among cotton producers by influencing the curricula of agriculture universities and federal institutes, give visibility to farms with good results from the adoption of the system, organize field days and develop financial incentives for farmers engaging in good agricultural practices, resulting in carbon preservation.
- Raise awareness among cotton producers of the importance of the most direct consequences of climate change; in the short-term, focus more on the inevitable consequences of extreme events like heat waves and droughts, with changes in temperatures and precipitation regimes that have a huge impact on agriculture.

7. Exhibits – Interview questionnaires / **data sets**

a. Producer questionnaires.

b. Producer organisation questionnaire.

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