COLHEITA DA ÁGUA DA CHUVA E IRRIGAÇÃO DE SALVAÇÃO PARA O CULTIVO DE ALGODÃO COMO MEDIDA DE RESILIÊNCIA À SECA EM MINAS GERAIS, BRASIL

RAINWATER HARVESTING AND SALVATION IRRIGATION FOR COTTON CULTIVATION AS A DROUGHT RESILIENCE MEASURE IN MINAS GERAIS, BRAZIL

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Resumo
O Norte de Minas Gerais no Brasil está passando pela pior seca dos últimos oitenta anos, comparado somente com a seca que ocorreu nos anos 30, especificamente de 1934 a 1940, quando houve uma devastação geral no setor agrícola e pecuário. Entretanto, a cultura do algodão continua a se destacar na região como uma das poucas alternativas agrícolas capazes de gerar renda e emprego devido a sua característica de resistência aos efeitos da seca, o que não ocorre com outras culturas tradicionais. Entretanto, devido não somente à baixa pluviosidade, mas também pela forma de distribuição intercalada das chuvas, a produção de algodão tem sido afetada frequentemente, o que torna indispensável a introdução e adaptação de sistemas de produção de algodão a esta realidade. Para este fim, a COOPERATIVA DOS PRODUTORES RURAIS DE CATUTI LTDA - COOPERCAT instalou oito "Unidades Demonstrativas" de algodão sob "irrigação de salvação" através da captação de água da chuva nos municípios de Catuti, Mato Verde, Monte Azul e Pai Pedro. Este estudo visa demonstrar que a adaptação dos sistemas de produção de algodão através de este método em períodos críticos proporciona e garante aos agricultores familiares uma produção de algodão sustentável e, por outro lado, avaliar um modelo de produção adequado à realidade climática do norte de Minas. Desde a implementação desta tecnologia em 2015, a produção de fibras de algodão aumentou 72% em uma área 19% menor; por outro lado, a produção total de algodão aumentou em 58%. A partir de 2022, os produtores de algodão continuam a utilizar esta metodologia suplementar de irrigação, demonstrando que a tecnologia é viável, tem impacto positivo na produção de algodão e é eficaz como medida de resiliência às mudanças climáticas e à seca. Esta experiência é considerada uma boa pratica agrícola a ser difundida nos 6 países latino-americanos parceiros do Projeto +Algodao de ABC/MRE e FAO.

Palavras-chave: Algodão, irrigação, colheita de água, Minas Gerais.

Abstract
The North of Minas Gerais in Brazil is going through the worst drought in the last eighty years, only compared to the drought that occurred in the 1930s, specifically from 1934 to 1940, when there was general devastation in the agricultural and livestock sector. Nevertheless, the cotton crop continues to stand out in the region as one of the few agricultural alternatives capable of generating income and employment due to its characteristic resistance to the effects of drought, which is not the case with other traditional crops. However, due not only the low rainfall but also the form of intercalated distribution has led to the consecutive affectation of cotton production, which makes the introduction and adaptation of cotton production systems indispensable. To this end, the COOPERATIVA DOS PRODUTORES RURAIS DE CATUTI LTDA - COOPERCAT installed eight "Demonstration Units" of cotton under salvation irrigation through rainwater capture in the municipalities of Catuti, Mato Verde, Monte Azul, and Pai Pedro. This study aims to demonstrate that the adaptation of cotton production systems through the "Salvation Irrigation" method in critical periods provides and guarantees family farmers sustainable cotton production and, on the other hand, to evaluate a production model suitable to the climatic reality of Northern Minas. Since the implementation of this technology, cotton fiber production has increased by 72% from 2015 to date in a 19% smaller area; on the other hand, the total cotton production

increased by 58%. As of 2022, cotton producers continue to use this supplemental irrigation methodology, demonstrating that the technology is viable, impacts cotton production, and is effective as a resilience measure to climate change and drought.
***Keywords**: Cotton, irrigation, rainwater harvesting, Minas Gerais,*

1. Introdução

The development of a region is directly related to the production capacity of goods and services of its population and the capacity to generate surplus for export or savings. For regions inserted in the semi-arid region, like the micro-region of Serra Geral, where the productive limitations are great, adequate alternatives to the edaphoclimatic conditions must be sought to foment the local economy. Thus, it is necessary to adapt the production technologies in a way that traditional activities, such as cotton, can overcome climatic adversities and produce sustainably, based on a production system adapted to the local reality, capable of providing economic and social dividends. For this to happen, the adaptation/adaptation of production technologies is necessary to bring to the extensionist actions' beneficiary public the methods and techniques capable of changing the group's technological profile. The proposal of setting up "Cotton Demonstration Units" under a salvation irrigation system called "Salvation Coated Excavated Tank" and the use of water from tubular wells in the municipalities of Catuti and Mato Verde create conditions for storing rainwater in the months of abundant rainfall like December and using it in the summer months as a salvation irrigation system (Brito & Cavalcanti, 2013). Therefore, the proposed "Demonstration Units" serve as support for the production systems, constituting physical bases to be set up in the communities, in agreement with the selected producers, for evaluating and comparing technologies for coping with drought based on the process of building and rebuilding a practice, to produce within the recommended technical standards and in a sustainable way.

The North of Minas Gerais, as well as other regions of the state, is going through the worst drought of the last eighty years compared only to the drought that occurred in the 1930s, specifically from 1934 to 1940, when there was general devastation in the agricultural sector caused by low levels of rainfall, reduction, and cutting of the flows of rivers and streams, causing serious economic and social losses to the population (Marengo et al, 2017). Paradoxically, eighty years later, the region is facing one of the most tragic droughts with worse effects than the ones that occurred in the 1930s due to man's interventions in the environment, increasing, even more, the environmental, economic, and social damages. The cotton crop still stands out in the region as one of the few agricultural alternatives capable of generating income and employment for the population due to its characteristic resistance to the effects of drought, which does not happen with other traditional crops (Carvalho et al, 2019). However, due not only to the low rainfall that has been occurring lately but also to the distribution of rainfall interspersed with systematic Indian summers, especially in January and February, it has led to consecutive frustration of cotton production in the region, which makes it essential to introduce and/or adapt the cotton production systems so that the remaining activity can provide economically viable for family farmers. In this regard, Drip irrigation has been found to be the most effective water-saving system. It can conserve soil, aggregate structure, successfully prevent deep water loss and surface water loss, and therefore, decrease exposure of the soil to degradation and salinization (Koudahe et al, 2021).

The test with 08 "Demonstration Units" of cotton under salvation irrigation in the municipalities of Catuti, Mato Verde, Monte Azul, and Pai Pedro aims to demonstrate that the adaptation of cotton production systems through the "Salvation Irrigation" method in critical

periods of Indian Summer[1] occurrence will provide and guarantee to the family farmers a sustainable cotton production and evaluation of a production model adequate to the climatic reality of the North of Minas Gerais.

2. Methodology

The initiative of rainwater harvesting and salvation irrigation for cotton cultivation in Minas Gerais is part of the good practices and experiences identified and disseminated by the south-south cooperation +Cotton Project, implemented jointly by the Brazilian Government through the Brazilian Cooperation Agency (ABC/MRE), the Food and Agriculture Organization (FAO) and seven partner countries in LAC Region. This experience has been shared through cooperation mechanisms including technical visits to farmers' fields by international delegations of public-private actors in the regional cotton sector.

The management of the DUs from soil preparation to commercialization was based on the Participatory Methodology and the exchange of knowledge between technicians and farmers mediated by specific practices, through problematizing dialogue, necessary at each moment of the cotton cycle within the new technological paradigm of salvation irrigation. The used technique was the Demonstration Unit (DU), considered a space where technicians and farmers deconstruct and reconstruct a new technology or practice to produce cotton within the required technical standards in a sustainable way.

The Demonstrative Units are an opportunity for the participants to reflect and make comparisons between the practices and technologies of dryland planting known up to now and the ones being proposed. In the implementation and conduction of the DUs, the farmer groups, structured according to their interests, must be responsible for conducting the DUs, which will be accompanied, evaluated, and validated as a model to be adopted and implanted with other producers with the National Program for the Strengthening of Family Agriculture (PRONAF) resources.

Technical Details of the "Salvation Irrigation" Model

The proposed model of "Salvation Irrigation" (Silva, 2007) consists of the adaptation of rainfed production systems with complementary irrigation in the critical periods of Indian Summer occurrence in the North of Minas Gerais. Traditionally, cotton planting in the region starts with the rainy season which normally happens in the period October/March, and the months of November and December are when the highest rainfall volumes occur, whose historical average precipitations are 190 mm and 230 mm, respectively, and are normally followed by small 15- day Indian Summer in January and/or February. Thus, adding together the average rainfall of the region October 139 mm; November 190 mm; December 230 mm; January 197 mm; February 156 mm we have an average accumulated volume of 912 mm, which represents a cumulative volume of 9,120 m3/hectare water sufficient to develop agriculture if rationally used. Thus, the sources of water supply for the proposed saving irrigation can be from the use and retention of rainwater through the capture by the system of "Excavated Tanks Coated" and/or also the use of water from tubular wells existing on the properties of the six candidates whose average flow rate is 5100 liters/hour and equipped with reservoirs built of canvas and cement with an average capacity of 75,000 liters. The "Demonstration Units" will have 01 hectares to be planted with cotton using the drip irrigation system and supplied by a

[1] An Indian summer is a period of unseasonably warm, dry weather that sometimes occurs in autumn in temperate regions of the northern hemisphere.

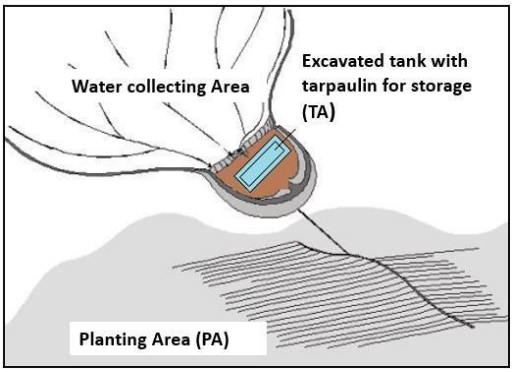
rainwater harvesting system "Excavated Tanks" and/or tube wells whose costs are the following:

- DU with Excavated Tank R$ 18.301,89 (Brazilian currency)
- DU with Tubular Well R$ 18.000,00 (Brazilian currency)

a) Excavated Tank Covered with Salvage

Historically, the exploitation systems in the small rural properties of the semi-arid region of the North of Minas live in unbalance with the natural resources. This imbalance is directly associated with two factors, climatic irregularity, and environmental degradation, making agricultural and cattle-raising activities risky. The region of the municipality and surrounding area of Catuti is culturally distinguished by the planting of rain-fed cotton by family farmers, which has caused successive crop frustrations due to the constant Indian Summer in the rainy season that has intensely affected the crops and decimated production. The purpose of this "Excavated Covered Salvage Tank" technology is to take advantage of the water that comes from surface runoff, storing it for later use in the summer periods during the cotton harvest. The system consists of a (figure 1) Catchment Area (CA), the construction of a barrier tank covered with plastic canvas for storage (TA) of this runoff, and a planting area (AP).

Figure 1. Map showing the planting area, tank and water collecting area

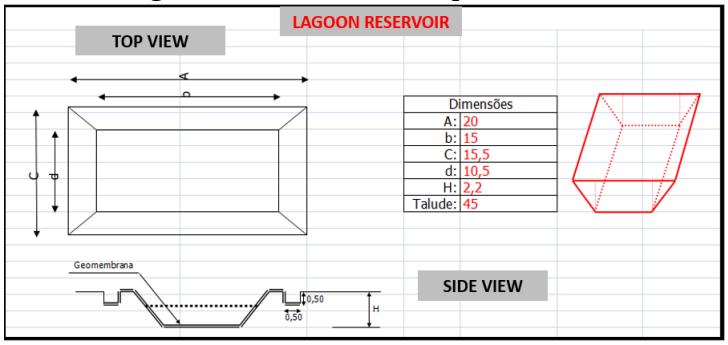


Source: COOPERCAT

Water collecting Area: Formed by a nano hydrographic basin, to collect rainwater, so that all water precipitated in this area is directed to the tank excavated. According to Embrapa, this area should have a minimum slope of 2%, and drains should be built in contour curves to prevent erosion, spaced 15 to 20 meters apart, directed to the storage tank, placing stones at the end of the drain to slow down the speed and reduce silting.

Excavated tank with tarpaulin for storage (TA) - An earth tank excavated and protected with a plastic tarpaulin, destined to store the water that falls and runs off, to be later used in irrigation during the cotton growing summer period. In the proposed model the tank should be dug in a trapezoidal shape, and its dimensions in meters will be according to the amount of water to be used (figure 2).

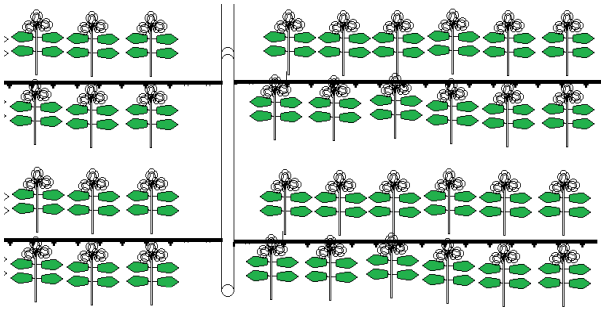
Figure 2. Reservoir tank specifications



Source: COOPERCAT

Planting Area (PA) - is the area that will be destined for cotton cultivation consisting of the installation of equipment with a dripping hose (figure 3). The drippers with 0.40 cm spacing and the streets with 0.60 cm spacing will be used during Indian summer during the crop cycle. Planting Area (PA) - is the area that will be destined for cotton cultivation consisting of the installation of equipment with a dripping hose. The drippers with 0.40 cm spacing and the streets with 0.60 cm spacing will be used during Indian Summer during the crop cycle.

Figure 3. Plant area scheme with irrigation infrastructure details



Source: COOPERCAT

Use of water from existing tube wells for irrigation

The great majority of the rural properties are endowed with alternative sources of water supply and/or rainwater harvesting systems. The properties that are the object of the "Demonstrative Units" have tube wells equipped with reservoirs whose storage capacity tied to the flow of the wells is sufficient for the supply of water for salvation irrigation of the proposed irrigated area. Thus, the six proposed units were supplied with water from these wells.

3. Results and Discussion

In the 2015/16 season, the rainfed cotton area exceeded the irrigated area by more than 90%; in the seasons following the implementation of this initiative, the rainfed cotton area increased until started to decline in the 2017/2018 campaign. On the other hand, the irrigated area increased to almost 150% in 2018/2019 season in comparison to 2015 area. In this regard, the irrigated cotton area was superior to rainfed by 28% in the 2018/2019 season. In addition, there was an increase in the total planted area of 265% by 2019. This allows understanding how water is a limiting factor for cotton production in Minas Gerais. Table 1 below details the dynamics of cotton area from the 2015/2016 campaign to the estimate for 2019/2020.

Table 1.- New cotton planted area in rainfed and irrigated cotton between the 2015 and 2019 seasons in Minas Gerais

Season	Rainfed cotton (h)	Irrigated cotton (h)	Total area
2015/2016	138	15	153
2016/2017	369.5	60.5	430
2017/2018	215	177	392
2018/2019	178	228	406
2019/2020 (Estimated area)	96	119	215

Source: COOPERCAT

In terms of cottonseed cotton production, there was an increase in production that is consistent with the increase in the area due to greater availability for irrigation and water use. In the 2015/2016 season, rainfed cotton production was 400% higher than irrigated cotton production, compared to the 2018/2019 season where irrigated cotton production exceeded rainfed cotton production by 500%. On the other hand, total cotton production reached 978 tons, an amount 320% higher than that of the 2015/2016 season. This dynamic responds to the area increase for irrigated cotton and because of the use the irrigation technology, as it is stated by Almeida et al (2015), the use of irrigation and soil cover increases the Graviola production in Brazil, and the yields of beans and corn in 54,5% and 237,3% (Brito et al, 2012). Table 2 below shows the details of cotton production from the 2015/2016 campaign to the estimate for 2019/2020.

Table 2: Cotton seed production between 2015 and 2019 seasons in Minas Gerais

Season	Production		
	Rainfed production	Irrigated production	Cottonseed
2015/2016	248.4	54	302.4
2016/2017	561.6	254.1	815.7
2017/2018	129	442.5	571.5
2018/2019	160.2	818.5	978.7
2019/2020	182.4	499.8	682.2

Source: COOPERCAT

As to produce cotton fiber, it presents similar dynamics to that of cottonseed, since the fiber is obtained after the cotton fiber ginning process. In this case, cotton ginning has a performance of between 35% and 40% in rainfed and irrigated cotton areas, respectively. This is aligned with the Masasi et al study (2020) which found that irrigated cotton fiber had better yield and quality than non-irrigated cotton. This management model facilitates access to income for farmers belonging to the cooperative since the increase in production and the greater irrigation infrastructure allows for increased production and ginning in facilities belonging to the cooperative itself. Table 3 shows information on the production of fiber cotton in irrigated and rainfed areas.

Table 3. Cotton fiber production between the 2015 and 2019 seasons in Minas Gerais

Season	Cotton fiber Production (t)		Total Production
	Rainfed production	Irrigated production	Cotton fiber
2015/2016	89.4	22.6	112.1
2016/2017	202.1	106.7	308.8
2017/2018	46.4	185.8	232.2
2018/2019	57.6	343.7	401.3
2019/2020 (Estimated ton)	65.6	209.9	275.5

This increase in cotton fiber production is reflected in the income received by the cooperative's farmers; since the 2015/2016 season, there was a 350% increase in total cotton fiber production by the cooperative. Which translated into profits of up to 1 million Brazilian reais (Brazilian currency) from the selling of cotton fiber. At the same time, profits from fiber sales increased by 400% from the 2015/16 season to 2019 mostly because of the production increase and good prices for cotton fiber. Table 4 shows the detail of income obtained per season from the sale of total cotton fiber.

Table 4. Revenue from the sale of cotton fiber between 2015 and 2019 in Minas Gerais

Season	Cotton fiber	Price/ Ton	Value (R$)
	112.1	2534.00	Cotton fiber
2016/2017	308.8	2979.00	919915
2017/2018	232.2	3031.00	703798
2018/2019	401.3	2913.00	1168987

Although Irrigation and water storage technologies are acceptable technology, their adoption by the farmers is slow which is mainly attributed to the high initial installation cost of the system. Cotton is the preferred crop over other commercial crops in many water-scarce farms, as it could be raised successfully by providing 2-3 protective irrigations at critical stages. Thus, water-saving irrigation practices must be refined to the farmers' preference and need to be popularized for wider adoption (Sankaranarayanan et al, 2012). In this regard, cooperative work and management can lead to faster adoption and benefit from the use of this technology or any kind of precision tool used as new information (Lambert et al, 2022).

4. Conclusion

The use of irrigation and water storage technology in the framework of the cooperative gave positive results in relation to cotton production, planted area and income generation from the sale of the fiber.

This technology proves to be beneficial and sustainable over time for farmers in Brazil and the region if this initiative is replicated. Cotton is widely distributed in the Latin American

and Caribbean region and in countries that depend on irrigation to grow cotton, this technology is useful for crop continuity and resilience of cotton and food production systems.

With proper management and participation, this technology allows producer organizations to strengthen their management capabilities, crop management, cotton sales and reinvestment to strengthen the cooperative and the production capabilities of each of its associated producers.

For the +Cotton Project (Brazilian cooperation with FAO and 6 countries in the Latin American region), this experience in Catuti is a good practice that is being disseminated to cotton producing countries, especially to producers of cotton family farming.

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