GUIDELINES FOR
SUGARCANE STRAW REMOVAL IN BRAZIL

SUCRE PROJECT

APRIL 2020

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SUCRE

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ABOUT SUCRE PROJECT

The SUCRE (Sugarcane Renewable Electricity) Project is primarily designed to **increase the production of electricity with low greenhouse gases (GHG) emission using the sugarcane straw** made available during the crop harvest. SUCRE team has been working on identifying and solving issues that hinder partner mills from fully and systematically generating electricity. Beginning in June 2015, it is a total five years of Project, with funding of around US$ 7.5 million from Global Environment Facility (GEF) and a counterpart from the Brazilian Center for Research in Energy and Materials (CNPEM) of over US$ 3 million. The recovery and use of straw for electricity production in the private sector triggered an investment of approximately US$ 160 million by partner plants (a major part of which has already been done through the installation of dry cleaning systems, refurbishment or purchase of boilers, turbogenerators, balers and other pieces of equipment). The initiative is managed through a partnership with the United Nations Development Programme (UNDP) and is carried out by the Brazilian Biorenewables National Laboratory (LNBR), which is part of CNPEM.

ABOUT LNBR

The Brazilian Biorenewables National Laboratory (LNBR) is part of the Brazilian Center for Research in Energy and Materials (CNPEM), a non-profit private organization that operates under Contract Management with the Brazilian Ministry of Science, Technology, Innovations and Communications (MCTIC). LNBR uses Brazilian biomass and biodiversity to solve key scientific and technological challenges by employing high-performance biological platforms of industrial relevance for the sustainable development of advanced biofuels, biochemicals and biomaterials. The Laboratory has a history of technology development in partnership with companies, including start-ups. Among LNBR open-access facilities one finds a Pilot Plant for Process Development, a unique facility for scaling up of technologies.

ABOUT CNPEM

The Brazilian Center for Research in Energy and Materials (CNPEM) is a non-profit private organization under supervision of the Brazilian Ministry of Science, Technology, Innovation and Communications (MCTIC). Located in Campinas, São Paulo, the Center is comprised of four laboratories, worldwide references in their fields, which are open to the scientific and business communities. The Brazilian Synchrotron Light Laboratory (LNLS) is currently assembling Sirius, the new Brazilian electron accelerator. The Brazilian Biosciences National Laboratory (LNBio) is dedicated to solving challenges in the areas of health. The Brazilian Biorenewables National Laboratory (LNBR) is focused on biotechnological solutions for the sustainable development of advanced biofuels, biochemicals and biomaterials, using biomass and the Brazilian biodiversity. Finally, the Brazilian Nanotechnology National Laboratory (LNNano) conducts scientific research and technologic development into solutions based on nanotechnology. The four Laboratories also have their own research projects and participate in the transversal research agenda coordinated by CNPEM, which articulates scientific facilities and capabilities around strategic themes.

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SUGARCANE STRAW

From burning in the sugarcane fields to cogeneration

Over the last few decades, the sugar-energy industry has gone through a number of changes including the transition from manual harvesting of sugarcane to the mechanized harvesting without burning. In this new scenario, the straw became an important component of sugarcane agriculture system. With straw remaining on the soil surface, sugar-energy sector needed to adapt the sugarcane management in the Brazilian fields. At the time, a number of studies pointed out that maintaining straw in the field resulted in a series of agronomic and environmental benefits, while others suggested that straw would play a detrimental role under certain edaphoclimatic conditions, leading to losses in crop yield. But it should be noted that these pioneering studies mainly compared areas of green cane with those under the harvesting with previous burning.

Due to the abundance of straw in the field and the increasing demand for energy (which has minimal environmental, economic and social impacts), the sugar-energy sector has recently begun to show interest in using part of this biomass for cogenerate bioelectricity. Little is known, however, about the real impacts of straw removal on the soil-plant-atmosphere system, and there were no well-established methods for recommending straw removal without compromising soil quality and the sugarcane yield in the fields.

Aiming to understand the impacts of straw removal on the soil-plant-atmosphere system and to create a tool for the strategic straw removal, the SUCRE Project developed the ***Guidelines for Sugarcane Straw Removal in Brazil***.

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HTTP://BIT.LY/SUCREPROJECT

TO ACESS ALL PAPERS CITED IN THIS BROCHURE AND READ MORE ABOUT

SUCRE PROJECT

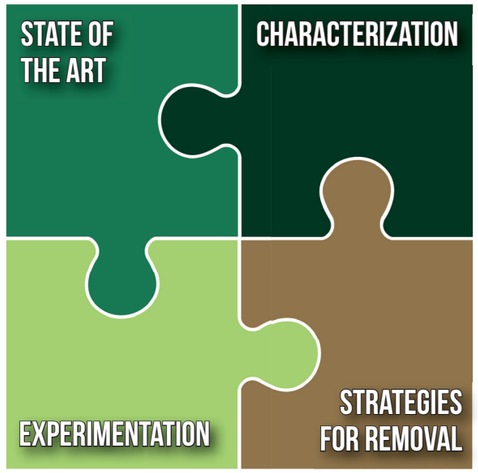
These Guidelines provides an overview of the key findings observed over the five years of SUCRE Project and is intended to offer instructions on the strategic sugarcane straw removal, supplying raw material to satisfy the Brazilian energy demand with lower emissions of greenhouse gases (GHG), maintaining the quality and conservation of the soil and sugarcane yield. The work plan for these ***Guidelines*** is based on the following pillars:

i) (State of the Art) the information available in the published studies on the impacts of straw removal on soil quality, GHG emissions and sugarcane yield was initially compiled;

ii) (Characterization) studies were also performed to characterize sugarcane straw and assess the potential of this biomass in industrial applications and/or maintenance in the field;

iii) (Experimentation) after these two steps, field experimentation and/or agro-environmental modeling activities were started in order to quantify the effects of straw removal in different climate and soil conditions in Center-South region of Brazil;

iv) (Strategies for Removal) for the final stage, a step-by-step guide was created including recommendations on straw removal, aiding in making decisions on how much, when and where to remove sugarcane straw in the sugarcane mills.



WHAT INFORMATION WAS AVAILABLE AT THE BEGINNING OF THE PROJECT?

The published literature was reviewed during the first stage of SUCRE Project and the results were summarized and published in an international scientific journal (Global Change Biology Bioenergy). At the beginning of the Project, most of information available in the literature assessed the impacts of the transition from the manual harvesting with previous burning of the sugarcane crop, not providing subsidies for the recommendation of straw removal. The review of the published literature evaluated topics related to the impact of straw removal on soil quality (chemical, physical and biological), in soil losses due to erosion, GHG emissions, pest and weed infestations and the productive potential of the crop. The review also examined the straw potential for bioenergy production (bioelectricity and cellulosic ethanol).

For more information on the literature review, search for:

CARVALHO, J. L. N. et al (2017). Agronomic and environmental implications of sugarcane straw removal: a major review. GCB Bioenergy 9, 1181–1195

SINCE THE LITERATURE LACKED SOME INFORMATION, A WIDE NETWORK OF FIELD EXPERIMENTS WOULD NEED TO BE ESTABLISHED

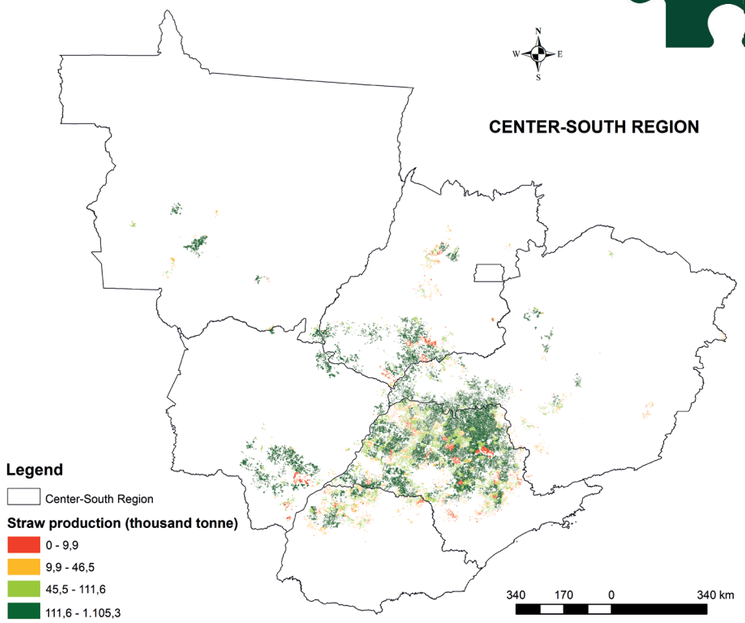
Based on the set available data, mainly information related to soil losses through erosion and weed infestation, SUCRE Project initially suggested maintaining at least 7 tonnes of straw (in dry basis) per hectare in the field. But the main conclusion from this study was that a network of field experiments would need to be established to propose more appropriated recommendations for removing straw with less impacts on sugarcane fields.

How much straw is produced in the sugarcane fields?

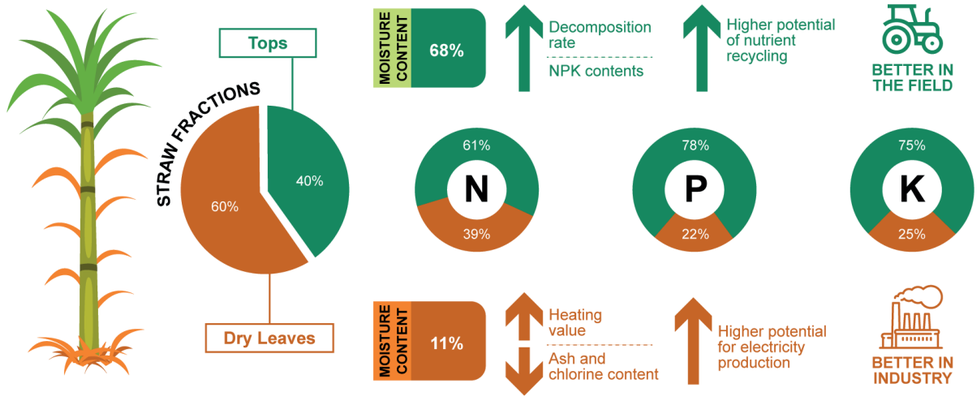
CHARACTERIZATION

The amount of straw produced varies according to the sugarcane yield, crop variety and age of the sugarcane field. Straw yield can vary from 4 to 30 t ha^{-1}, with an average range between 10 and 14 t ha^{-1} being the most common one seen in the fields. A ratio of 120 kg of straw (dry basis) per tonne of stalks (12%) can be used to estimate straw production in the sugarcane fields of Center-South Brazil.

Based on this ratio and on the production of sugarcane, it was estimated that 68.5 million tonnes of straw are produced annually in the sugarcane fields of the Brazilian-Center-South region.



Tops in the field and dry leaves in the industry



The optimization of the use of straw starts with biomass characterization. Straw is primarily composed of tops and dry leaves. Tops contain most of the nutrients found in the straw, making them preferable in the field to help in nutrients recycling to the soil. In turn, dry leaves exhibit more desirable characteristics for the use in industry, such as lower ash and nutrient content. This suggests that the total or partial removal of dry leaves may leverage bioelectricity cogeneration, with less impact on the boilers. These results pointed out the importance of separating the straw fractions in the field. However, the availability of equipment intended for separation during harvesting are still the biggest limitations in adopting this agricultural technology and, as such, represent a challenge that needs to be solved.

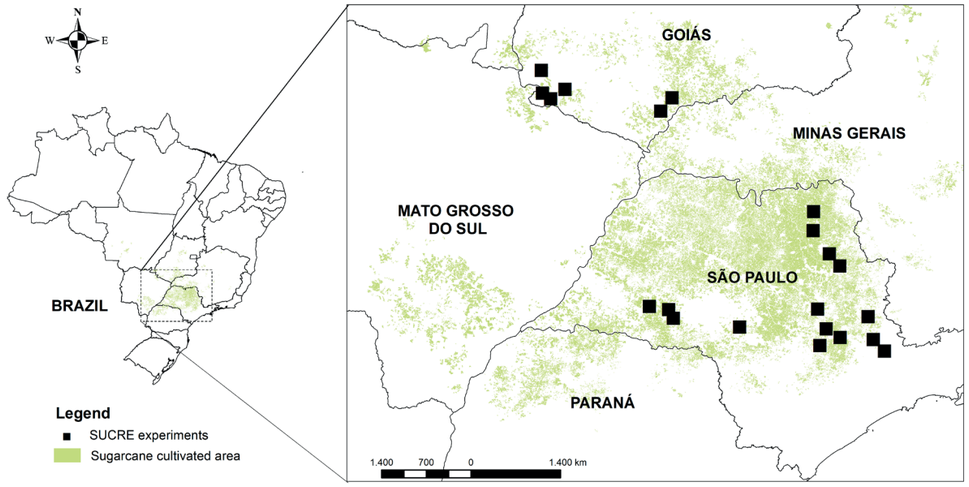
Further information on the characterization and potential use of tops and dry leaves can be found at:

MENANDRO, L. M. S. et al. (2017). Comprehensive assessment of sugarcane straw: implications for biomass and bioenergy production. Biofuels, Bioprod. Biorefining 11, 488–504

EXPERIMENTATION

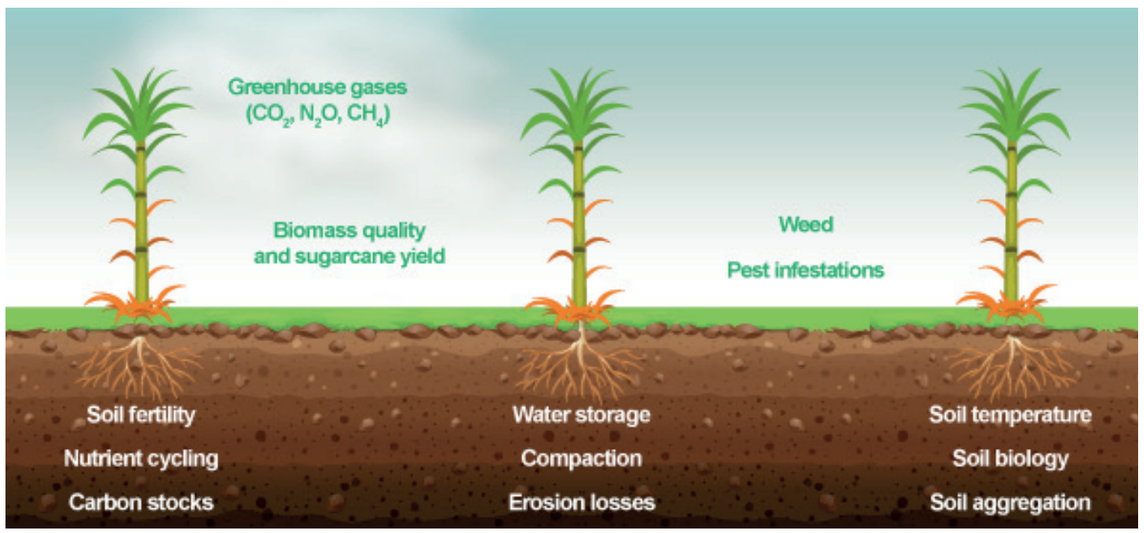
A measure is needed to recommend

EXPERIMENTATION



Throughout the five years of SUCRE Project, several field experiments were conducted to quantify the impacts of sugarcane straw removal on soil quality (chemical, physical and biological), on the sugarcane yield and GHG emissions. **The experimental areas were strategically selected representing climate and soil conditions of Center-South region of Brazil, along with the most planted sugarcane varieties in this region.** The experiments are based on setting up areas with different rates of straw removal, and the impacts of these processes on the soil-plant-atmosphere system were measured in subsequent years. The experiments were generally carried out with the following straw removal rates (on a dry basis): i) no removal (NR – maintaining 15 t ha^{-1} of straw on the soil surface); ii) low removal (LR – maintaining 10 t ha^{-1}); iii) high removal (HR– maintaining 5 t ha^{-1}); iv) total removal (TR – bare soil).

About soil quality, SUCRE Project evaluated: i) nutrient recycling and soil fertility; ii) soil and nutrient losses due to erosion; iii) compaction; iv) biological activity; v) carbon stocks and GHG emissions. The impacts of straw removal on the sugarcane yield, as well as levels of pest and weed infestation, were also studied over the years of the Project.



SOIL QUALITY

Maintaining the soil coverage with agricultural residues such as straw is a conservation practice that is recommended for most economic crops in various regions around the world. The total and high straw removal for industrial purposes can have a negative effect on the main soil quality indicators (chemical, physical and biological), and consequently affect the capacity of soils to sustain plant growth and provide food, fibers, biofuels and ecosystem services.

For more information on soil quality, search for:

CASTIONI, G. A. F. et al (2018). Soil physical quality response to sugarcane straw removal in Brazil: A multi-approach assessment. Soil and Tillage Research, 184, 301-309.

CASTIONI, G. A. F. et al. (2019). Straw removal affects soil physical quality and sugarcane yield in Brazil. BioEnergy Research.

MENANDRO, L. M. S. et al. (2019). Soil macrofauna responses to sugarcane straw removal for bioenergy production. BioEnergy Research.

RUIZ CORRÊA, S. T. et al. (2019). Straw removal effects on soil water dynamics, soil temperature, and sugarcane yield in south-central Brazil. BioEnergy Research.

EXPERIMENTATION

CHEMICAL

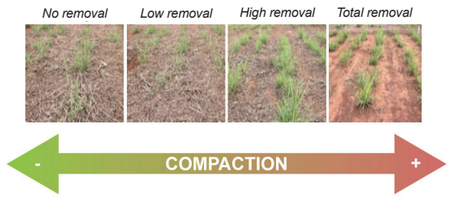
STRAW REMOVAL AFFECTS SOIL FERTILITY

Sugarcane straw is the largest source of organic matter and is also a source of nutrient recycling for sugarcane fields. Results from the SUCRE Project point out that the total straw removal can reduce soil fertility (specially macronutrients), but suggests that the effects on the nutrient stock may not be noticeable in the short term and may be more evident after four years of removal. The research also underlines the importance of adequate fertilization in the sugarcane fields, taking the management of straw into account, especially in places where the maintenance of straw promotes an increase in sugarcane yield and, consequently, the extraction of nutrients from the soil.

PHYSICAL

THE STRAW BLANKET REDUCES SOIL COMPACTION

The transition to mechanized sugarcane harvesting resulted in an increase in soil compaction, jeopardizing the crop's yield in later cycles. SUCRE Project's results demonstrate that the pronounced straw removal can exacerbate the effects of machine traffic on the levels of soil compaction. On the other hand, low straw removal does not intensify soil compaction and can thus be considered a viable alternative to fulfilling the demand for bioenergy without causing damage to the soil structure.



BIOLOGICAL

STRAW REMOVAL AND THE SOIL BIOLOGICAL ACTIVITY

Agricultural residue such as sugarcane straw plays a fundamental role in maintaining the soil biological activity. Results from SUCRE Project demonstrate, in a preliminary manner, that the indiscriminate straw removal can cause a reduction in microbiota, macrofauna and soil enzymatic activity, compromising soil quality. However, the magnitude of responses is highly associated with soil conditions, climate and the type of management adopted.

CONSERVATION

SUGARCANE STRAW ACTS IN SOIL CONSERVATION

Soil and nutrient losses due to erosion are recurrent problems in Brazilian sugarcane fields. Outcomes from SUCRE Project suggest that an accentuated straw removal increases soil and nutrient losses by erosion indicating that the maintenance of approximately 7 t ha^{-1} of straw (dry basis) in the field is needed to prevent these losses, mainly in areas that are more susceptible to erosion, such with high sloping and harvesting in rainy seasons.

WATER AND TEMPERATURE

IMPACTS OF STRAW REMOVAL ON SOIL MOISTURE AND TEMPERATURE

Maintaining straw in the sugarcane fields can lead to increased water storage and the maintenance of soil moisture, reducing water deficiencies. The straw also plays a role in controlling soil temperature, reducing soil daily thermal amplitude. Consequently, total straw and high removal increases the temperature and can reduce the storage of water in the soil. This can result in damage to the development and final crop yield, especially in areas with pronounced water deficits. On the other hand, in cold regions, partial removal can be strategic in helping the initial stage of sugarcane regrowth by providing higher thermal comfort for the plants.

GREENHOUSE GAS EMISSIONS AND SOIL CARBON STOCKS

EXPERIMENTATION

The use of sugarcane straw is a promising option for boosting electricity production with low GHG emissions. But removing sugarcane straw affects carbon stocks and the balance of GHG emissions from the soil. Results from SUCRE Project reveal a prevalence of the methane (CH_4) consumption in soils cultivated with sugarcane, regardless of straw removal. As far as nitrous oxide (N_2O) emissions, the results suggest that the removal of sugarcane straw minimizes N_2O emissions. The GHG measurements performed by SUCRE Project over a two year period pointed out that, regardless of the rates of removal, the N_2O emissions resulting from the application of nitrogen fertilizers and straw are approximately 50% lower compared to estimated values using the international standard factor proposed by the Intergovernmental Panel on Climate Change (IPCC).

If the straw removal tends to reduce N_2O emissions, the straw is the main component responsible for bringing carbon into the soil. Measurements carried out in field studies during five years of Project pointed out that, on average, 95 kg of C is stored in the soil for each tonne of straw that remains in the field. Data on GHG emissions (in addition to changes in soil carbon stocks) should be incorporated into more comprehensive Life Cycle Analysis (LCA) assessments to quantify pros and cons of using straw in the GHG balance of electricity production.

For more information on carbon stocks and greenhouse gases, search for:

BORDONAL, R. O. et. al. (2018). Sugarcane yield and soil carbon response to straw removal in south-central Brazil. Geoderma, 328, 79-90.

GONZAGA, L. C. et al. (2019). Implications of sugarcane straw removal for soil greenhouse gas emissions in São Paulo state, Brazil. BioEnergy Research.

TENELLI, S. et al. (2019). Can reduced tillage sustain sugarcane yield and soil carbon if straw is removed? BioEnergy Research.

Experiment for collecting greenhouse gas emissions

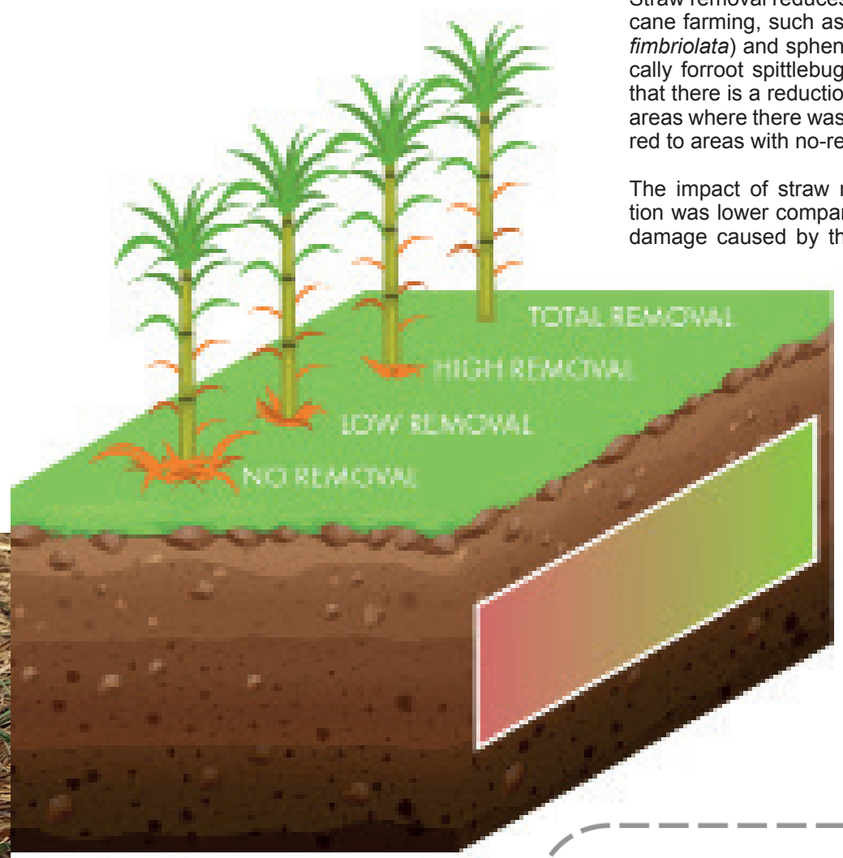
REMOVING SUGARCANE STRAW REDUCES SOME SOIL PESTS POPULATIONS

EXPERIMENTATION

Straw removal reduces the population of major pests in sugarcane farming, such as sugarcane root spittlebug (*Mahanarva fimbriolata*) and sphenophorus (*Sphenophorus levis*). Specifically forroot spittlebug, results from SUCRE Project suggest that there is a reduction of up to 45% in the pest population in areas where there was total or partial removal of straw compared to areas with no-removal.

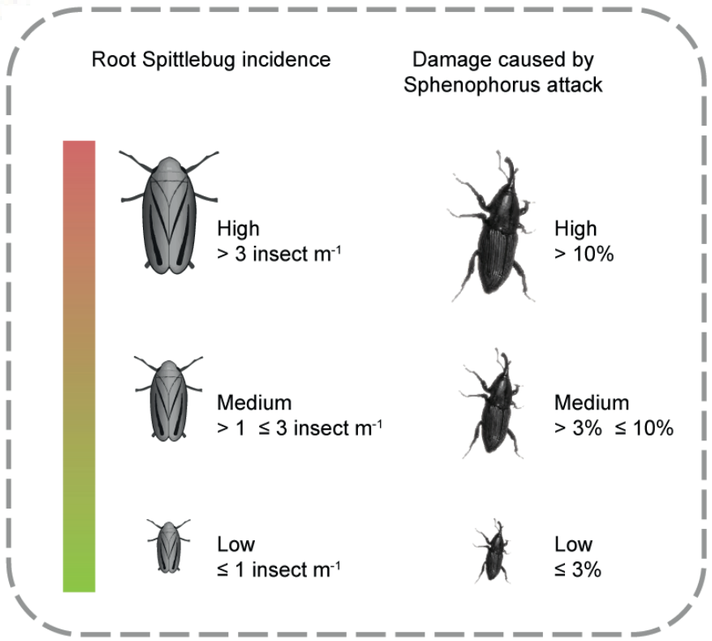
The impact of straw removal on the sphenophorus population was lower compared to the root spittlebug. However, the damage caused by the pest was more prominent in places where all straw was kept on the field. In areas where straw was removed, there was a tendency to reduce the damage caused by the pest, particularly in clayey soils.

Regardless of straw removal, the data suggests the need to adopt some additional control practices (chemical or biological) to these pests in the sugarcane fields. Therefore, straw removal mitigates the occurrence of root spittlebug and sphenophorus, but it does not exclude the need for alternative control practices so that there are no significant reductions in sugarcane yield.



For more information on the impact of straw removal on the incidence of soil pests, search for:

CASTRO, S. G. Q. et al. (2019) Changes in soil pest populations caused by sugarcane straw removal in Brazil. BioEnergy Research.



IMPACTS OF STRAW REMOVAL ON SUGARCANE YIELD

EXPERIMENTATION

At first glance, there is an impression that quantifying the effects of straw removal on sugarcane yield is relatively simple. But the association of factors such as soil types, climatic conditions, harvest times, age of the sugarcane field and crop management (such as irrigation), makes the responses of the crop to straw removal a complex equation and difficult to predict. In this context, SUCRE Project evaluated 28 field experiments located in the states of São Paulo and Goiás to assist in straw removal that less compromises sugarcane fields. In order to make it easier to interpret the results, the responses from sugarcane yield to straw removal were grouped into four macro-regions.

Overall, the results suggest that there is no single answer to recommend the straw removal in Center-South region of Brazil, and a removal strategy that takes the management performed in each site into account is needed because there are suitable and unsuitable locations for straw removal in the same macro-region.

For more information on productivity, search for:

CARVALHO, J. L. N. et al. (2019) Multilocation straw removal effects on sugarcane yield in South-Central Brazil. BioEnergy Research

SOUTHEAST REGION OF GOIÁS

Generally, the straw removal led to decreases sugarcane yield, varying from 2 to 13 t ha^{-1}, depending on the removal rate. However, under certain conditions, such as in irrigated areas or areas with hydromorphic soils, straw removal does not affect or can even increase sugarcane yields.

MID-WEST REGION OF SÃO PAULO

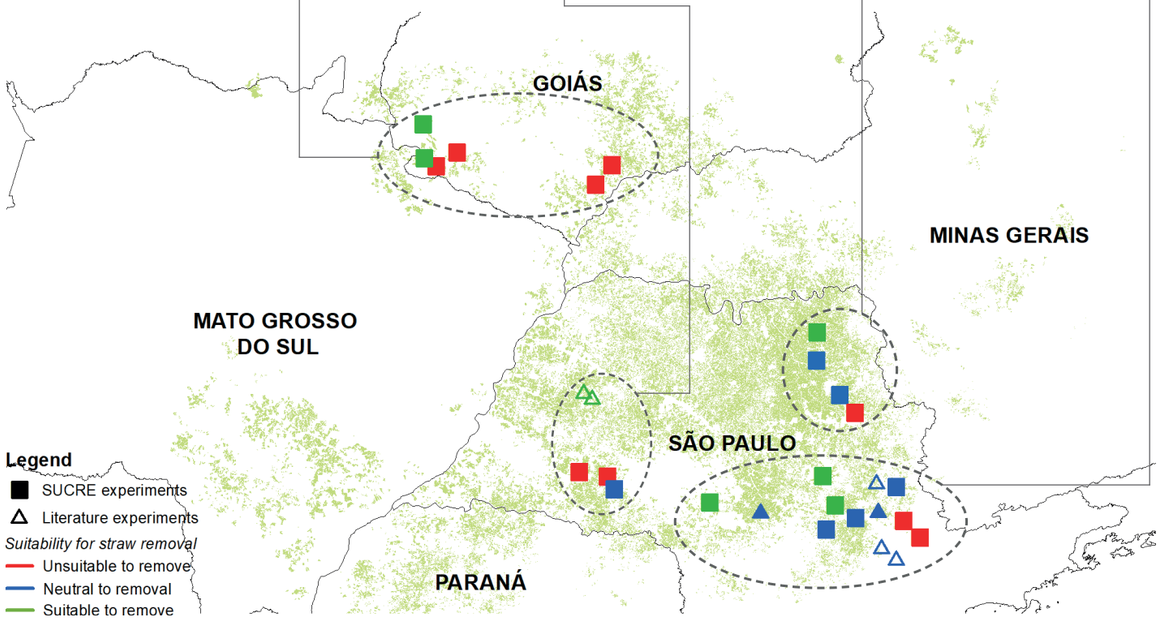
Straw removal resulted in decrease of 2 to 6 t ha^{-1}. But in some situations, such as harvest areas in dry and cold seasons, straw removal did not interfere with the sugarcane yield.

NORTHEAST REGION OF SÃO PAULO

The effects of straw removal on sugarcane yield did not follow any logical trend, and was totally associated with the sites that were evaluated. In some locations and evaluation years, straw removal has increased, reduced or had no effect on crop yields.

MID-EAST REGION OF SÃO PAULO

There was an overall perception that the region has potential for straw removal, considering that the total or partial removal did not affect the crop yield in most of the evaluated areas.

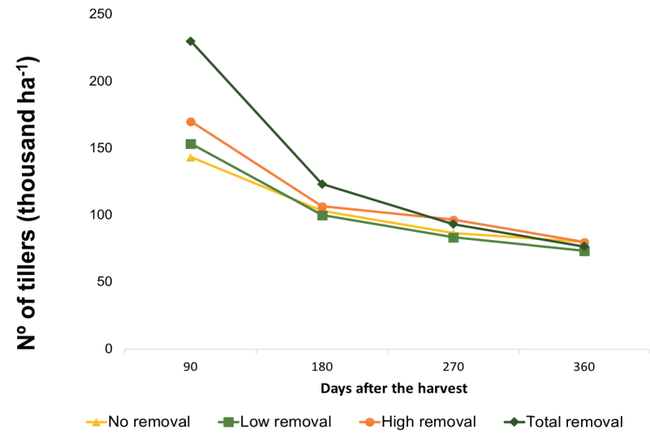


SUGARCANE TILLERING

EXPERIMENTATION

It is believed that maintaining straw in the field affects sugarcane sprouting and tillering, which could have negative impacts on sugarcane yields. SUCRE Project results underline a pattern of tillering and initial crop development in straw removal scenarios, allowing a broader view on this topic. In areas with total straw removal, high initial tillering is noted, followed by a great mortality of tillers during the crop cycle. On another hand, keeping the straw on soil surface (no removal and/or partial removal) reduces the initial tillers. But, the number of tillers remains constant throughout the crop cycle. This means that the number of tillers per hectare at harvest is similar regardless of the removal rate. Thus, data from SUCRE Project suggest that the evaluation of initial tillering is not a useful indicator for predicting the effects of straw removal on sugarcane yield. However, exceptions were in colder seasons (e.g. middle harvest) and regions with low temperatures, where the straw removal is recommended because, in this case, straw can negatively affect tillering and the final sugarcane yield.

Sugarcane tillering x Straw removal
Example of results in the Center-South region of Brazil



HOW, WHEN AND WHERE TO REMOVE STRAW?

Understanding the importance of straw in the soil and its energy potential as a feedstock for bioenergy production, the sugar-energy sector has been using the removal of 50% of straw in sugarcane fields as a standard. However, sugarcane yield and soil quality studies shown that responses to straw removal vary according to the quantity of straw, climatic conditions, soil types, harvest seasons, among other factors.

Based on the assumption that straw yield varies from 4 to 30 t ha^{-1}, it would not be meaningful to assume that maintaining 50% of the straw produced in different locations would have the same ecosystem function in sugarcane fields.

Now we provide Guidelines with step-by-step instructions for the strategic sugarcane straw removal. **These Guidelines will help in making decisions on how much, when and where to remove straw, matching increases in sugarcane yield, soil conservation and the availability of straw for bioenergy production.** This detailed manual was created in accordance with strategic principles based on the results of SUCRE Project, as well as expert's opinion. The step-by-step directions can be applied in any sugarcane mill through the use of a **planning and management tool** that was developed by SUCRE team and is combined with the use of geotechnologies (GIS). **This tool allows straw removal maps to be created based on soil conservation and sugarcane yield.**

Through the use of this map, mills will have the ability to adjust it to their particular operational conditions, including the economic feasibility, logistics and machinery available for harvesting, and other particularities (such as pest infestations) in order to generate customized straw removal maps for each year. In other words, the methodology provided here is applicable on a local scale and is designed to offer instructions on straw removal in the field according to the needs of the sugarcane mill.

This represents a significant advance in the optimization of straw management and use, which has had no similar tool up to this point. Now the challenge is the efficient implementation and validation of this tool within the sugarcane mills for this strategy to become an integral part of the agricultural annual planning in the mills. Devising plans for straw removal is as important as planning for fertilization, weed control, crop harvesting and others, which are generally performed by the production units. Finally, the straw management straw can interfere with the numerous factors that affect the production of sugarcane.

TAKE A LOOK AT THE TUTORIAL ON USING THE STRAW REMOVAL PLANNING AND MANAGEMENT TOOL:

HTTP://BIT.LY/FERRAMENTAS-SUCRE

STEP-BY-STEP FOR STRATEGIC STRAW REMOVAL

1 SURVEY AND ORGANIZATION OF INFORMATION FROM THE SUGARCANE MILLS

Basic information of the fields, such as slope, soil texture, harvest date, crop age (i.e., cane plant, ratoons, area for replanting), irrigation and yield per field plot, are usually readily known at the sugarcane mills. This information will serve as the basis for strategic straw removal.

2 CALCULATING THE PRODUCTION OF STRAW PER FIELD PLOTS

Straw production must be estimated per field plots in order to check the availability of straw in the area. The ratio of 12% straw (dry basis) per tonne of sugarcane stalk produced can be used in the Center-South region of Brazil. In addition, a more precise estimate can be made through biometric evaluations per field plot (or group of field plots) to measure the amount of straw produced.

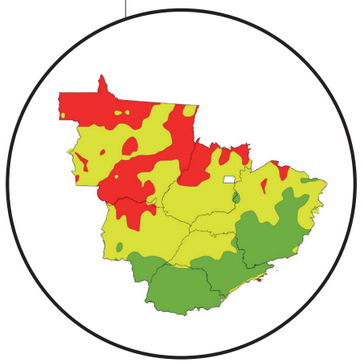
3 PRIORITIZING AREAS FOR STRAW REMOVAL

Planting areas with conventional soil tillage (plowing, harrowing, subsoiling, etc.) should be a top priority for straw removal. As the soil is prepared, straw will be incorporated into the soil, thereby forfeiting its role of offering protection against soil erosion. To this end, the use of straw in industry for bioenergy production becomes quite relevant. Areas under full irrigation and that show a low risk of soil erosion are also a priority for straw removal.

Scan the QRCode to access the tutorial in portuguese

4 WHAT IS THE CLIMATIC SUITABILITY FOR STRAW REMOVAL CONSIDERING THE COMBINED EFFECT OF CLIMATE AND STRAW BLANKET?

The climate's influence over sugarcane yield is well known. The outcomes from SUCRE Project indicate that solar radiation is the primary factor responsible for the potential sugarcane yield, while precipitation and temperature are decisive factors in the achievable yield. These parameters, combined with the effect of the straw blanket on the soil surface, are vitally important in making a better use of straw, ensuring high crop yields.



5 RESTRICTING AREAS WITH FAVORABLE SOIL EROSION CONDITIONS

Areas with a slope greater than 3% are susceptible to erosion processes. The maintenance of soil covered with straw plays a key role in controlling erosion, particularly in the initial months when the sugarcane canopy is not closed, exposing the soil to weather conditions. The recommendation is thus to maintain at least 7 t ha^{-1} (dry basis) of straw in order to control soil losses through erosion processes in areas with a declining slope over 3%.

6 INFLUENCE OF THE HARVEST TIME AND SOIL TEXTURE

The harvest time and soil texture are decisive factors in the strategy for removing straw because they affect soil conservation and sugarcane yield. Areas located in regions with lower temperatures and/or harvested in the winter time the straw removal should be recommended. However, in harvests done during the rainy season (early and end harvesting in Brazil) and/or in soils prone to erosion, at least 7 t ha^{-1} (dry basis) of straw maintained on the soil is recommended.

DECISION KEY

Based on these steps, SUCRE Project team developed a *Decision Key for Sugarcane Straw Removal* in the Center-South region of Brazil. The base removal map is obtained from this Key. See the Decision Key below.

SUBTITLE

1 At the end of the early harvest season, it is recommended to remove straw if the minimum temperature is critical and low rain intensity. In the presence of intense rains, it is recommended only to take away straw from the sugarcane line.

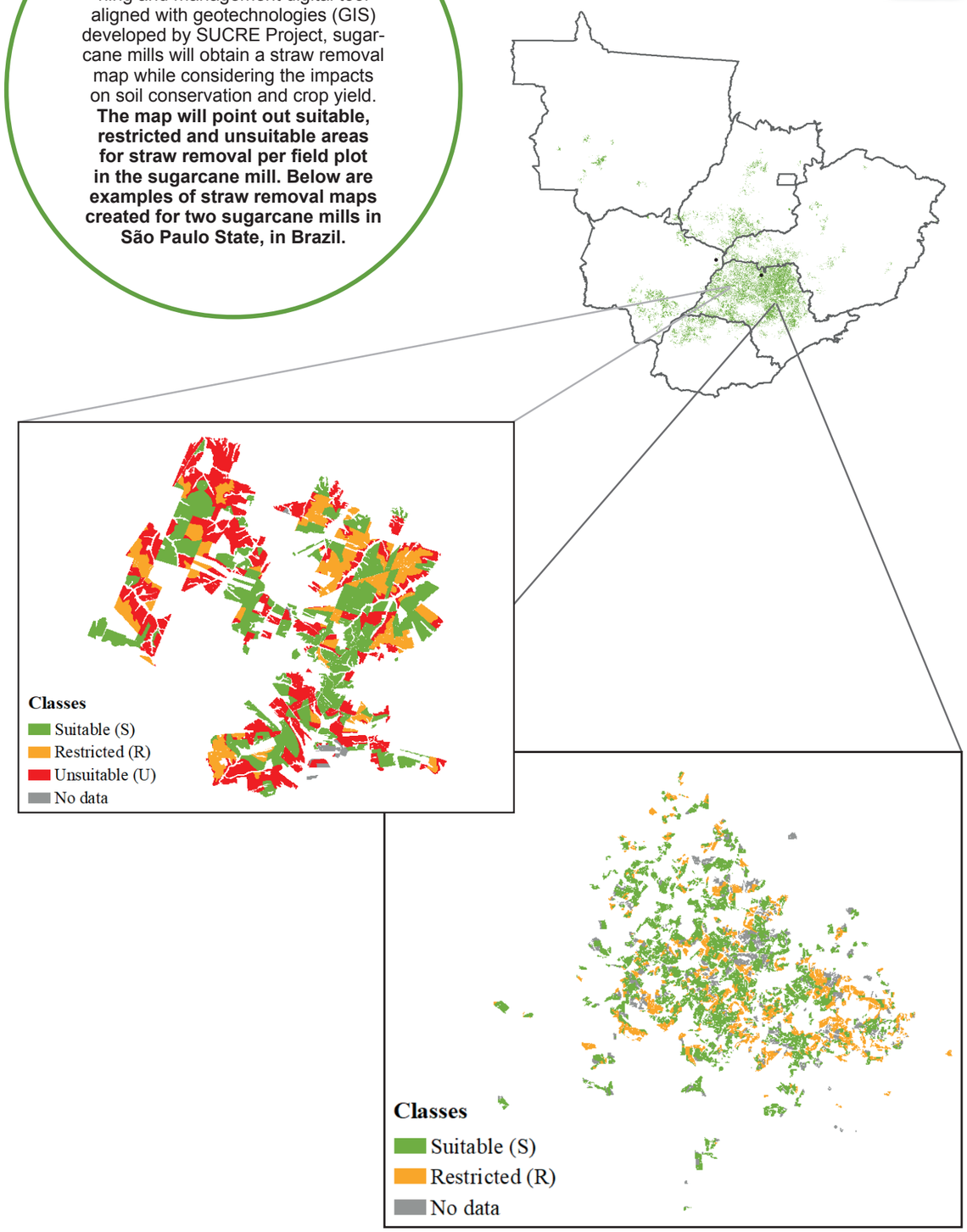
2 At the end of the middle harvest season, if there is an intensification of rains, it is recommended to restrict 7 Mg ha^{-1} for soil conservation and, take away straw from the sugarcane if the minimum temperature is critical.

3 No inflection point was found up to 17.2 Mg ha^{-1} of straw (dry basis).

4 No inflection point was found up to 12.4 Mg ha^{-1} of straw (dry basis).

5 There is no experimental evaluation in these areas and the suitability was based on the response of the potential of sugarcane yield.

Based on the step-by-step thus far, using the decision key in the planning and management digital tool aligned with geotechnologies (GIS) developed by SUCRE Project, sugarcane mills will obtain a straw removal map while considering the impacts on soil conservation and crop yield. **The map will point out suitable, restricted and unsuitable areas for straw removal per field plot in the sugarcane mill. Below are examples of straw removal maps created for two sugarcane mills in São Paulo State, in Brazil.**



NEXT STEPS TOWARDS STRATEGIC STRAW REMOVAL

STRATEGIES FOR REMOVAL

7 OTHER RELEVANT FACTORS AFFECTING THE SUGARCANE YIELD AND SOIL QUALITY

Pests, weeds, among other factors, affect the sugarcane yield. Based on the evidence presented in these Guidelines, the manager could decide to remove the straw in specific conditions. These factors are not included in the base map but should be considered in preparing the final straw removal map through specific filters, created by each sugarcane mill. The digital tool developed by SUCRE's team is compatible with these adjustments.

8 STRAW RECOVERY

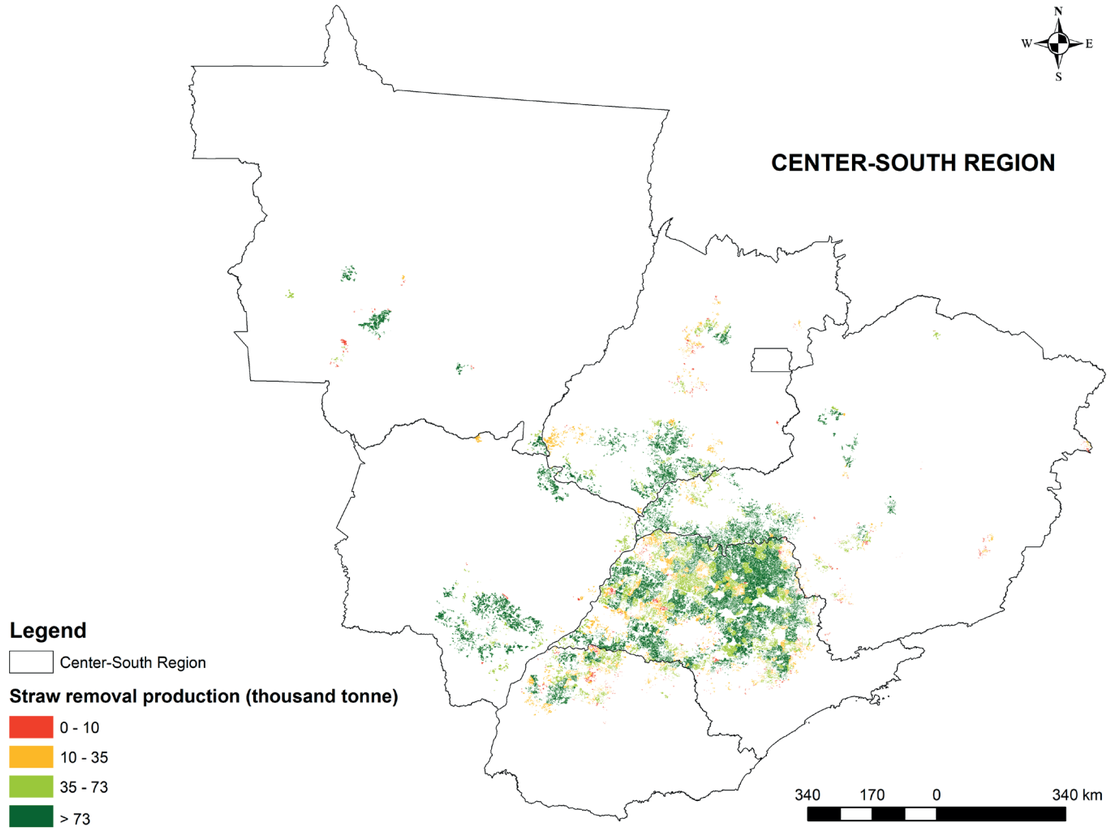
Once the suitable areas for straw removal have been defined, it is time to consider logistics, routes and recovery costs. Each sugarcane mill should match the removal according to its operational condition to create custom maps. Information on routes and recovery costs can be obtained at SUCRE Project's website.

NOTE:

The suitability categories defined account for the fact that straw recovery does not affect the quality of sugarcane ratoons. It is therefore necessary that straw recovery operations are carried out according to the following technical specifications:
- opening the gauges of tractors and implements in order to avoid the trampling on sugarcane rows;
- proper adjustment of the height of baler rake, avoiding the uprooting of stumps;
- homogeneous distribution of residual straw providing full soil coverage and not only in the sugarcane line.

WE WILL ONLY OPTIMIZE THE USE OF STRAW THROUGH STRATEGIC REMOVAL, MEETING THE DEMANDS FOR BIOENERGY, WITHOUT COMPROMISING THE SUGARCANE FIELDS QUALITY!

POTENTIAL FOR STRAW REMOVAL IN CENTER-SOUTH BRAZIL, CONSIDERING SOIL CONSERVATION AND SUGARCANE YIELD



Even though an average of 68.5 million tonnes of straw are produced every year in the Center-South region of Brazil, a total of approximately 43 million tonnes of straw can be removed. This value accounts for the minimum amounts of straw to be left on the field in order to keep soil conservation, with the control of soil loss through erosion, and the productivity of the sugarcane fields. The minimum quantities of straw were allocated according to a climatic suitability in which the sugarcane field is located, and the quantities to be removed were estimated through the sugarcane areas mapped to the Center-South region and the municipal yield provided by the Brazilian Institute of Geography and Statistics (IBGE). On average, considering the evaluated year 63% of the straw produced in Center-South of Brazil can be removed for bioenergy purposes, ranging from 19% in areas with low suitability for removal, 57% in areas of medium suitability, to 77% in areas with high climate suitability for straw removal.

CNPEM
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MINISTRY OF
SCIENCE, TECHNOLOGY,
INNOVATION AND COMMUNICATION

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