Natural fertilizer

Using leguminous plants as fertilizer can increase sugarcane production by 35%

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Although farmers throughout the world have long used so-called 'green manure'– making use of the biomass of one type of plant as a fertilizer for another type of plant – few scientific studies have investigated how this approach functions and quantified its results. The search for those answers inspired agronomist Edmilson José Ambrosano, a researcher at the São Paulo Agency for Agribusiness Technology (APTA), affiliated with the São Paulo State Department of Agriculture and Supply, to conduct two projects supported by FAPESP. The research showed that sunn hemp (*Crotalaria juncea*) can completely replace chemical nitrogen fertilization in sugarcane fields, resulting in a 35% increase in productivity and a financial gain of approximately 150%.

Originally from Asia, sunn hemp grows very quickly and vigorously. This species produces a high volume of biomass in a short period of time. In addition, sunn hemp is a fibrous plant that is also use in the manufacture of special types of paper.

One of the principal advantages of using sunn hemp as a fertilizer is the fact that it is leguminous. Legumes are members of a family whose species are able to fix nitrogen, i.e., incorporate nitrogen from the air into organic molecules. "With rare exceptions, legumes are the only plants in the vegetable kingdom that can accomplish such fixation from atmospheric air. They do it with the help of bacteria found in their roots," Ambrosano explains. "Sunn hemp not only supplies nitrogen but can be used to restore degraded soils as well."

Sugarcane is one of Brazil's most important crops. This semi-perennial plant can be grown from four to eight years on the same tract of land and can be harvested every year. At the end of that period, the cane field is renewed by destroying the old plants and planting new ones. In Brazil, 1.9 million hectares of cane fields are renewed each year. "It is in those areas, or in new fields, that green manure is sown to restore the soil by incorporating nitrogen," Ambrosano says. "We have been doing this in Brazil since 1934."

Plots planted with sunn hemp yield more biomass in less time than plots without sunn hemp (*left*)

Experiment conducted at CENA, in Piracicaba, where ^{15}N compounds were applied to sunn hemp (*below*)

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The purpose of the study, which began in 2003 and continued until very recently, was to study the effect of green manure on sugarcane. "We already knew that sunn hemp was a good fertilizer that functioned well as a source of nitrogen," he recalls. "What we wanted to determine was how much of that element comes out of the plant and enters the sugarcane. We used the opportunity to verify the transfer of nitrogen found in ammonium sulfate, a very popular type of chemical fertilizer. Our idea was to compare the efficiency of the two types of fertilizer, the green one and the chemical one."

NUCLEAR METHOD

To conduct the study, Ambrosano designed an experiment using a technique known as isotopic labeling of nitrogen. Nitrogen is the most abundant element in the Earth's atmosphere, accounting for approximately 78% of all of the gas that surrounds our planet, whereas oxygen accounts for 21% of this gas. In air, nitrogen is present in the form of N_2 molecules that are composed of two atoms in an extremely strong triple covalent (electron-sharing) bond. For this reason, animals and plants are unable to metabolize nitrogen.

Nature uses nitrogen through leguminous plants with the aid of bacteria, especially bacteria of the genus *Rhizobium*. These microorganisms associate with plants in a symbiotic relationship, forming nodules on their roots where they capture gas from the air through the porous soil and convert it into nitrogenous compounds such as amino acids that plants can use in their metabolism. Fertilizer manufacturing represents another way to convert nitrogen into a form that plants can exploit. However, the manufacturing process uses a large amount of energy, making manufactured fertilizer expensive for farmers.

In nature, nitrogen is found as two isotopes, nitrogen-14 (^{14}N), which accounts for 99.634% of all nitrogen in the atmosphere, and nitrogen-15 (^{15}N), which accounts for the remaining 0.366% of all nitrogen in the atmosphere. Isotopes are variants of a single chemical element that have the same properties and the same number of protons but a different number of neutrons. And so ^{14}N has seven protons and seven neutrons, and ^{15}N has an extra neutron, making it heavier. "That is why we had to think of a way to label what is present in sunn hemp so that we could verify how much of it would be used by the cane," Ambrosano explains.

The study, conducted at the Center for Nuclear Energy in Agriculture (CENA) at the University of São Paulo (USP), produced a nitrogen compound that contained 70% ^{15}N and 30% ^{14}N. The next step was to prepare two plots of land, one measuring 2.80 m by 2.0 m and the other measuring 1.40 m by 1 m. Sunn hemp was planted in both plots. The first plot was sprayed with urea rich in ^{15}N. The crop in the second plot received ammonium sulfate, also rich in ^{15}N. The plants were then allowed to grow to a height of approximately 2 m, after which they were cut down and sugarcane was planted in their place. The cane was cultivated for five years and harvested three times. The amount of ^{15}N recovered was measured at the time of the first two harvests.

To carry out the assessment, Ambrosano collected leaves from the experimental sugarcane plots and took them to the laboratory, where he used a mass spectrometer to determine the amount of labeled nitrogen, i.e., the amount of ^{15}N from the sunn hemp. "The transfer of those elements from the sunn hemp to the cane in the first two (consecutive) harvests varied from 19% to 21%, and the transfer of nitrogen applied with ammonium sulfate was 46% to 49%," says Ambrosano. "We concluded that the nitrogen from the application of fertilizer met the needs of the sugarcane, equivalent to using 70 kg of that element per hectare."

Although the ammonium sulfate transferred more nitrogen to the sugarcane, the green manure has other benefits that make up for the difference. "In addition to being cheaper, sunn hemp protects the soil from heavy rains and decompacts it, thereby improving the infiltration of water," says Ambrosano. ■

Projects

1. Dynamics of nitrogen in sugarcane after green manure fertilization with *Crotalaria juncea* (Nº. 2006/59705-0); **Grant mechanism** Regular Line of Research Project Award; **Principal Investigator** Edmilson José Ambrosano (APTA); **Investment** R$36,860.00 (FAPESP).

2. Dynamics of nitrogen in sugarcane after green manure fertilization with *Crotalaria juncea* (Nº. 1998/16446-6); **Grant mechanism** Regular Line of Research Project Award; **Principal investigator** Edmilson José Ambrosano (APTA); **Investment** R$26,309.10 and US$701.02 (FAPESP).

Scientific article

Ambrosano, E. J. *et al.* ^{15}N-labeled nitrogen from green manure and ammonium sulfate utilization by the sugarcane ratoon. **Scientia Agricola**. V. 68, n. 3, p. 361-8. June 2011.

PHOTOS 1 FABIO COLOMBINI 2 EDMILSON AMBROSANO / APTA