Benefits of Integrating Crops and Tropical Pastures as Systems of Production

By Carlos A.C. Crusciol, Rogério P. Soratto, Emerson Borghi, and Gustavo P. Mateus

Dry winter seasons prevent farmers from successful adoption of sustainable no-till systems. The consortium (intercropping) of cereals with tropical forages has been successfully adopted in several regions of Brazil as a means to protect the soil and obtain higher yields and higher economic return. This article discusses the main conditions of this consortium and its advantages, including improvement of nutrient use efficiency.

Obtaining more sustainable agricultural production systems is facilitated when utilizing effective crop rotations adapted to the region. In Brazil, no-till has been successfully used as a means to obtain more sustainable systems due mainly to its benefits to the soil and at the same time because it provides conditions for higher crop yields with time.

The correct implementation and evolution of no-till in tropical areas should follow certain basic principles. Two of the most important are to avoid tilling the soil and to establish crop sequences leading to higher amounts of straw at the surface for soil protection. The first principle is farmer dependent. The second is difficult to achieve in several regions of Brazil, and also the world, where the winter season is unfavorable in terms of climatic conditions. This is because the low temperature and low water availability does not favor good plant development and, consequently, good dry matter production.

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Figure 1. *Brachiaria brizantha* cv. Marandú seeded with corn in different stages of the consortium: (A) before corn harvesting time, (B) at corn harvesting, (C) soon after corn harvesting, and (D) some days after corn harvesting.

In recent years, an alternative has been implemented to increase dry matter production and straw at the soil surface in these areas. It consists of a consortium of grain crops with tropical pastures, especially *Brachiaria brizantha* or *Panicum maximum*, during the summer, with the forages evolving to produce good dry-matter yield during the winter. These pastures have vigorous and deep roots and high tolerance to water stress, developing well in climatic conditions where the great majority of other cover crops would fail. In this system the pasture is managed with the annual crop until the main crop is harvested, at which time it continues to grow for good forage production **(Figure 1)**. The inclusion of tropical forages in the cropping system, besides leading to higher amounts of straw at the soil surface all year long, creates conditions for improved soil properties (physical, chemical, and biological) and also for more favorable nutrient cycling, resulting in better plant nutrition, development, and yield.

The consortium of annual crops, especially corn or sorghum, with tropical forages is possibly due to the relevant difference in the rate of biomass accumulation among cereals and forage crops, with forages presenting lower rates of accumulation in early stages of development. Consequently, the crops of corn and sorghum become established with no necessity, in most cases, to use herbicides to retard the forage development.

Advantages to the Soil and Plant Development of Integrating Crops and Pastures

Research has already shown many agronomic advantages in the consortium of annual crops and tropical pastures. There are proven positive impacts related to straw production, nutrient cycling and removal, weed development, and soil physical, chemical, and biological quality. Average yields of up to 12 metric tons/ha (t/ha) of pasture straw, 7 months after harvesting, are frequently obtained leading to favorable soil protection, especially when corn is included in the crop sequence. These

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; CEC = cation exchange capacity; H = hydrogen; Al = aluminum; AN = ammonium nitrate.

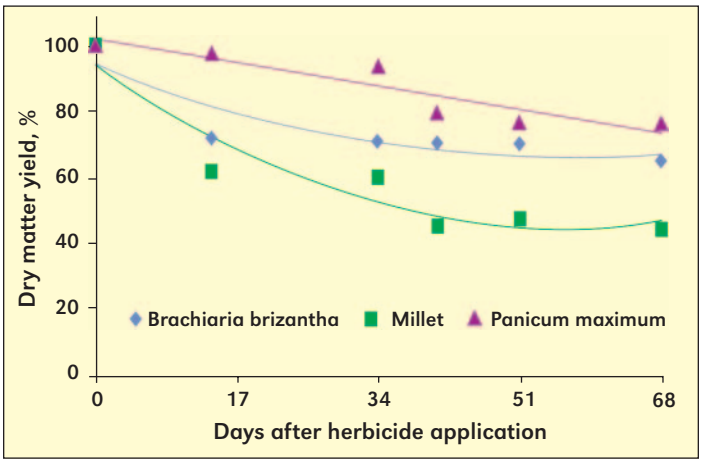

Figure 2. Persistence of forage grasses in no-till system in Botucatu, São Paulo (Crusciol, 2007).

values are much higher than the average 2.5 t/ha obtained in the same 7 months with a single corn crop.

Besides high dry-matter yield, one of the main characteristics conferring success to the use of perennial forages in grain production systems under no-till, in regions of dry winter, is its higher persistence in the soil. As an example, **Figure 2** shows that 51 days after herbicide application, only 50% of the straw from millet remained in the soil, while around 70% to 80% remained when using *Brachiaria brizantha* or *Panicum maximum* (Crusciol, 2007). In the same study, it was observed that these two tropical forages retained similar amounts of nutrients, preventing them from natural losses. These amounts were always higher than the amounts retained by millet. For example, 68 days after herbicide application the amount of N in the straw remaining in the soil was 43%, 22%, and 48% for the systems including *Brachiaria*, millet, and *Panicum*, respectively.

The higher and more resistant amounts of straw provided by the tropical forages also control the development of weeds that can negatively interfere with the plant development and final yield. Borghi et al. (2008) evaluated the occurrence of weeds before desiccation in an area, as a function of cropping system, and noticed that the control of weeds was much higher (up to 99% of control) when using *Brachiaria* in consortium with corn, as compared to corn cultivation only.

In terms of soil quality, a study by Crusciol et al. (2006) showed that the cultivation of *Brachiaria* in consortium with corn improved the soil fertility with higher final values of organic matter, soil pH, P, K, Ca, Mg, CEC, and base saturation and lower values of H + Al and P adsorption. The soil physical quality is also improved with the use of forages in these production systems, with studies showing more structured soil particles, higher soil aeration, lower levels of soil resistance, lower temperature at soil surface and more water availability to the plants. All these changes are favorable to plant growth.

One of the main advantages of utilizing these cropping system relays is the higher nutrient use efficiency with time. With more adequate soil conditions, and with improved soil nutrient cycling, plants are able to capture and utilize nutrients more efficiently. **Figure 3** shows an example. In this study, corn partial factor productivity (amount of grain produced per unit of fertilizer applied) was up to 20% higher when utilizing *Brachiaria* or *Panicum* in the cropping system.

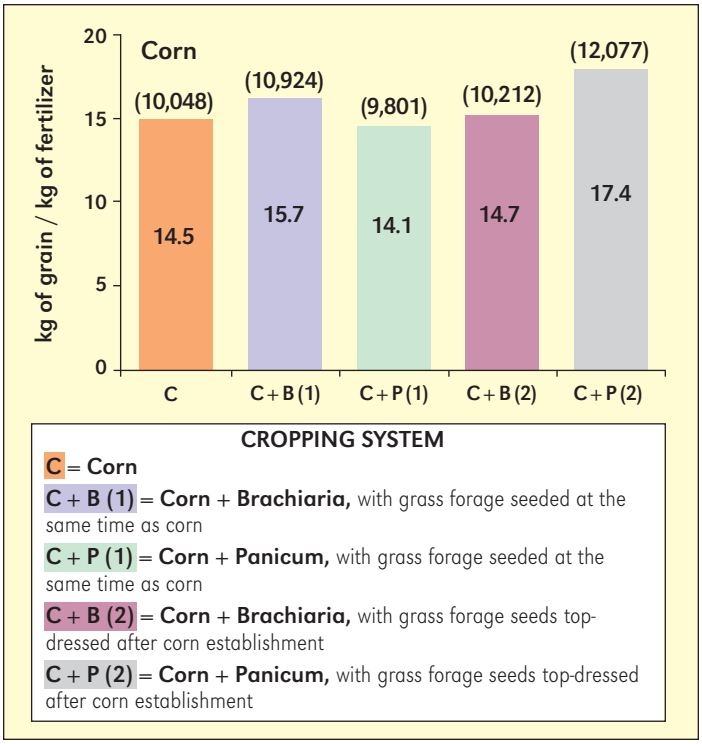

Figure 3. Corn partial factor productivity as influenced by grass forages (*Brachiaria brizantha* cv. Marandú or *Panicum maximum* cv. Mombaça) and time of consortium establishment (Crusciol, 2009). Fertilizer was 320 kg/ha 8-28-16 for corn, applied at seeding, plus 375 kg/ha AN applied as top-dressing. Yields (kg/ha) appear in parentheses above bars. Data are average of 3 years.

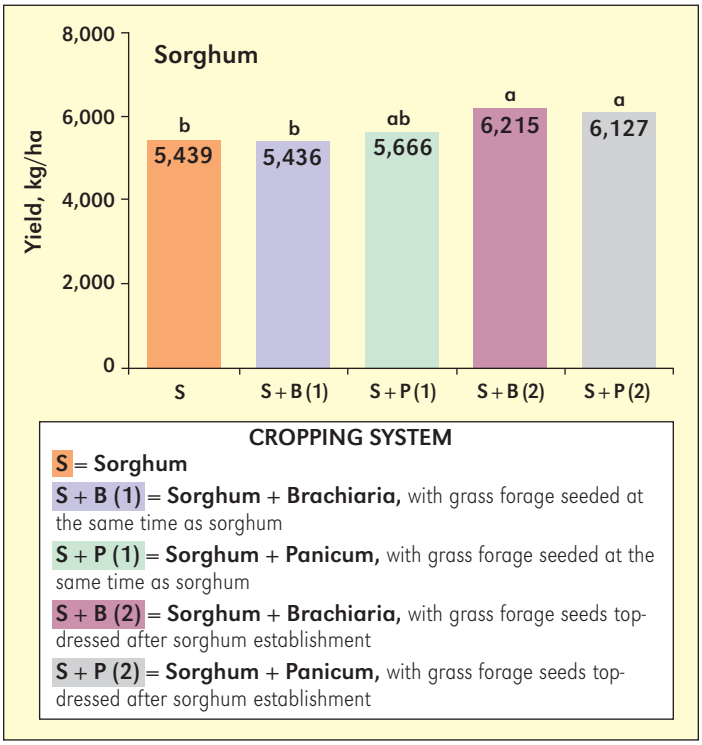

Figure 4. Yields of sorghum influenced by grass forages (*Brachiaria brizantha* cv. Marandú or *Panicum maximum* cv. Mombaça) and timing of consortium establishment (3-year average). Averages followed by the same letter do not statistically differ at 5% probability (Sousa et al., 2006).

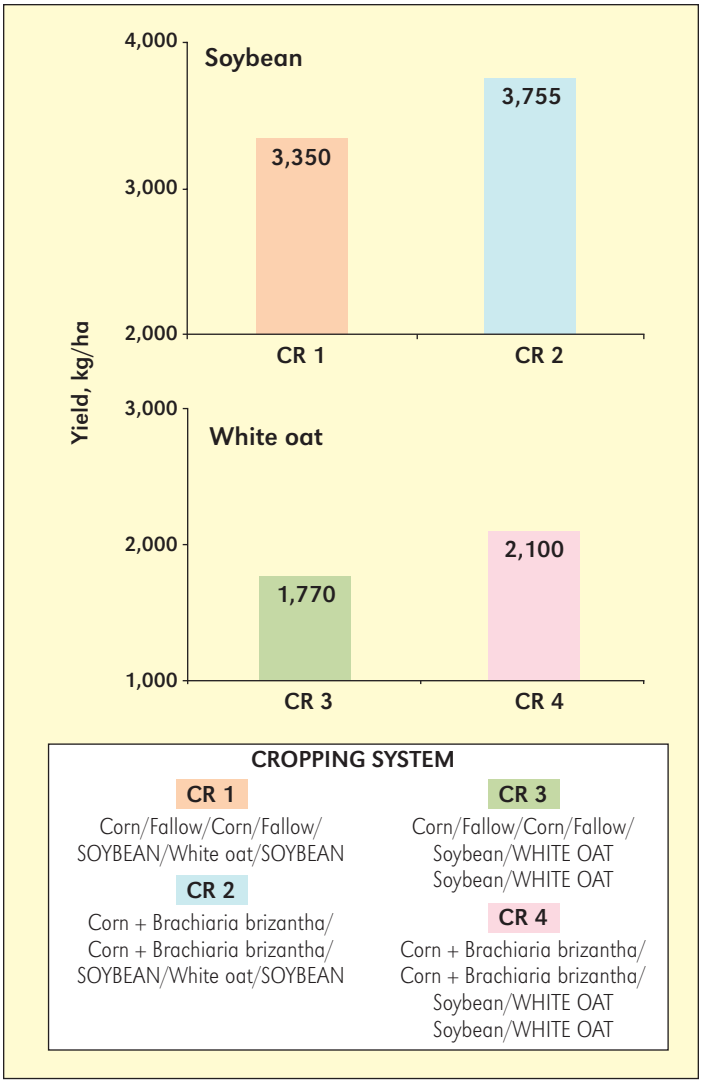

Figure 5. Yield of soybean and white oats with or without the addition of *Brachiaria brizantha* cv. Marandú in the cropping system; 2-year average (Crusciol, 2009).

Important Agronomic Aspects to be Considered

The success of these cropping systems depends greatly on several interactions with other factors affecting plant development. Some of the most important aspects that farmers have to consider follow.

Seed and Herbicide There is a clear interaction between the time to add forage seeds to the soil and the need for herbicide to control the forage development. Simultaneous seeding of forage in the corn furrow and also at the soil surface between furrows can reduce the grain yield when not utilizing the herbicide to retard forage development. However, when forage seeds are added in only one place, such as furrow or soil surface, the pasture does not interfere with final cereal yields.

Variety Cycle An important decision is related to the type of cereal variety regarding the crop cycle (very early, early, medium or long). Research has shown that very early and early cereal cycle seeds should be utilized to increase the cereal yields. It seems that the short cereal cycle leads to less impact in yields by diminishing the period of competition among both plant species. New specific varieties of cereals and tropical pastures are in development for these cropping systems.

Nitrogen Recommendation Due to the higher amounts of straw at soil surface, and also a possible competition between crops, it may be necessary to increase the amounts of N applied as compared to local official recommendations.

Consortium with Soybean The consortium between forage and soybean has to be carefully planned. Seeding this legume and the forage too close in time may lead to an aggressive development of the pasture, which can reduce the final soybean yield. For this type of consortium, it is necessary to adopt one of these two options: (1) apply herbicide in sub rates as to decrease the forage development or (2) seed the forage when the soybean crop is at stage R5 - R6. The first option may lead to soybean developing much faster, interfering with later light availability to the forage. Consequently, the sub rates have to be carefully planned.

Cereal Yield Increases by Integrating Crop and Forage Production

As a consequence of soil and plant amelioration by the consortium of tropical forages with annual crops, the yields have been improving when the system of production is established and managed properly. The increase in yields can be noticed early during the consortium (example in **Figure 4**) but are remarkably higher in future annual crops (example in **Figure 5**). **Figure 4** shows a positive effect in sorghum yield in consortium with *Brachiaria* or *Panicum*, with, in this case, the forage seeds top dressed to the soil surface only when the plants of sorghum had already established. **Figure 5** shows the effect of previous crop rotations in the yields of soybean and white oats, with a clear trend for higher yields with the inclusion of *Brachiaria* in the cropping system.

Differences in yield are economical and attest that these systems should be considered as an alternative in no-till areas with dry winter seasons. As an example of economic feasibility, in one of the farms of Peeters' agro company, there was 100% increase in profit due to the adoption of a cropping system alternating soybean, corn second crop, and *Brachiaria* grass in one year with cotton in the other year, as opposed to cotton every year. It is believed that similar cropping systems can be expanded to other areas of the world. BC

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