Crop-Livestock Integration Options

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Introduction

From a Brazilian viewpoint the recuperation of lands degraded by cropping or livestock production, environmental conservation and better returns constitute the background for sustainable crop and livestock production. The basic premises for sustainability for the smallholder in livestock production in the Brazilian Cerrados are; the reduction of production costs, increased added value and intensive all year round land use while maintaining high productivity. One of the best alternatives, without doubt, to achieve all these objectives, is the integration of crop and livestock production.

Innumerable options of integrating agriculture and livestock have already been available to smallholders and large farmers alike; whether crop or animal producers. Similarly, since the 1960s, smallholders and large farmers established the integration of upland rice with some *Brachiaria* species with the objective of increasing the land use efficiency and reducing the cost of pasture establishment in the Cerrados.

Regions with developed and efficient crop and livestock production, as in the case of most European countries, already have the basic premise of sustainability in the integration of crops and animal production.

The more common options of integration of crops and animal production will be discussed in this chapter.

Alternatives for the integration of crop and animal production

In the past, the integration of grain and animal production was limited to restricted options. Today, however, innumerable technologies are available which are applicable to the producers' most diverse aspirations and socio-economic conditions. The integration may be achieved through consortium; either as succession or rotation with annual crops such as forages. Also, the objectives of integration are various. In livestock production they vary from the rehabilitation of degraded pastures, the maintenance of high pasture production and, mainly, sequential crop/pasture production. The objectives of crop production include; the break in pest, disease and weed cycles, reduction (by physical suppression or allelopathy) of soil-borne pathogens, improved soil water conservation, reduced soil-temperature fluctuations and the possibility to aggregate these values to the system in general. There's practically no limitation in the integrated use of any forage species, which are actually grown in the Cerrados, as long as one opts for the best way of integrating them. Also, farm size or farmers' social-economic conditions do not restrict farmers' opportunities from family, with small machinery and equipment, to commercial agriculture, with the most modern equipment, to decide on the most appropriate manner of integration. The main alternatives, considering the edaphic conditions,

for the integration of crop and animal production in the Cerrados, are described as follows.

Areas with degraded soils and pastures

Mixed cropping, rotations and crop-forage successions in areas with these characteristics are possible with the main objective of recuperating degraded soils and pastures. In principal, grain production fundamentally envisages the partial or total recuperation of investments of inputs and services.

Integration of annual crops with forages

The consortia of tropical forages are possible thanks to the differences in time and space of biomass accumulation during the species' cycles. While the tropical forage grasses, especially the brachiarias, are known for their slow accumulation of aerial dry matter up to about 50 days after germination, most annual crops are subject to competition during the same period . Also, cultural practices, such as spacing (Oliveira *et al*., 1996) or the use of growth regulators (Kluthcouski *et al*., 2000), assist in further reduction of forage biomass accumulation during the period of inter-specific competition.

Degraded pastures in degraded soils (less fertile and more acid) can be recuperated by intercropping with rice using appropriate technology for the annual crop and with the forages *Brachiaria sp., Andropogon gayanus* and forage legumes (Kluthcouski *et al*., 1991 and Sanz *et al*., 1993). The rice production has been sufficient to recuperate the expenses involved in the cost of recuperation/renovation of the pastures (Yokoyama *et al*., 1995). In soils that have previously been treated with lime, particularly after 6 months, maize, sorghum, sunflower or pearl millet can be intercropped with forages of the genera *Brachiaria sp., Andropogon gayanus, Panicum sp.* and forage legumes (Oliveira *et al*., 1996 and Kluthcouski *et al*., 1999). In such cases it has been seen that the yield of crops that require high soil fertility, such as maize, do not reflect the yield potential of earlier soil correction with lime. Nevertheless, production has been sufficient to pay most of the inputs and overheads (Yokoyama *et al*., 1995).

Annual succession - crop with annual and/or perennial pasture

Annual succession, with annual crops such as soybean, with annual forages has been practiced by some Cerrados farmers with a view to use the forage for silage or pasture, especially between harvests.

The major area used for grain production in the Cerrados remains as fallow for about 8 months; generally starting from February to March. Grain production in many Cerrado micro-regions is unproductive due to moisture stress in early autumn. The succession option foresees forage production in the fallow period. It refers mainly to the summer crop, generally soybean, followed by the annual forage species, mainly millet or forage sorghum, which are adapted to dry conditions, sown in February to March.

The annual crops are sown from October to November with harvest usually from February to March. Considering that the rains usually continue up to April-May, it is valid use the land to plant annual forages during these months. Due to their drought tolerance and adaptation to the inter-harvest edapho-climatic Cerrado conditions both millet (Kichel & Macedo, 1994) as well as forage sorghum (Embrapa Milho e Sorgo, 2000) have proven to be the best alternative annual succession forage crops. In the colder Cerrado areas such as Southern Mato Grosso, species such as oats can be used as an alternative (Salton, 2000). The great advantage of annual forage succession planting at the start of the dry season is that it allows field meat production in the season of greatest lack of animal feed. (Kichel & Macedo, 1994).

At the establishment of the annual forages, perennial forages such as the brachiarias can be sown simultaneously as intercrops. This system allows for the extension of the pasture period as well as the formation of crop residues for direct sowing (no-till) in the following rains.

Rotation annual crops/forages

It is also possible to establish the rotation crop/pasture in areas with degraded soil and pasture, principally with rice and soybean (Gilioli, 2000 and Pitol *et al*., 2001). Also, in this case, the land should have been limed and the annual crop fertilized. In the case of soybean, production has been average as soils have been in the process of acidity correction, but in practice it is possible to achieve at least 1 800 kg/ha (Zimmer *et al*., 1999).

The strategy of lime spreading for the correction of soil acidity has been recommended for the end of the rains, up to the latest in May of the same crop year, followed by incorporation by ploughing at the start of the following rainy season. In the case of soils that are very deficient in phosphorus the application of 300 kg/ha of activated phosphorus incorporated with discs just before planting soybeans is recommended. Soybean cultivars most locally adapted to soils for the first year of planting of this leguminous crop should be used. The use of major fertilizers, based on soil analysis, should be complete and include recommended macro and micronutrients. Other inputs should follow established recommendations for the crop.

With the 'no till' hypothesis for soil recuperation Broch (2000) recommended that the physical and chemical restrictions, such as termites and other regional pests should be controlled 6 months before sowing the annual crop. In this case the pasture re-growth that occurs from autumn to winter can be consumed by animals up to about 15 days before sowing soybeans the next summer. Should controlled desiccation be the case the plants should be about 20 cm tall. It is also recommended that this type of rotation should be for at least 2 years in order that a significant accumulation of soil nutrients occurs for the use of forage crops in subsequent years. The rotation is based on the establishment of perennial pastures in the next rains; for example the brachiarias or *Panicum maximum*, either alone or in the 'Santa Fé'[1] system (Kluthcouski *et al*., 2000).

Gilioli (2000), using data from Monsanto, proposed the following procedures for the implantation of the system for the integration of agriculture and livestock in rotation in areas with degraded pastures and soil in tropical regions: divide the area into plots; physical elimination of termites; soil sampling; spreading of lime; phosphate application; cut old re-growths; desiccation at the beginning of the rains and planting of soybean or black beans in October to November, then seed the preferred pasture using minimum tillage immediately after the bean harvest. According to the author the most important facts about this system of integration are - the increased capacity of the pasture to support up to 5 head of cattle/ha, production of 'green meat' and the production of 40-50 and 35-45 sacks of soybeans and black beans/ha respectively.

Areas with degraded pastures

In this situation areas that had already been corrected, principally in relation to soil acidity, and which had previously been transformed into pastures where, in time, one or more nutrient reserves had been exhausted are included. The main objective of this area of integration is to re-establish a good pasture productivity index. Here, it is assumed that soils with degraded pastures do not have problems related to excessive acidity and general low soil fertility (Broch 2000). Under these conditions the pasture recuperation, especially regarding soil fertility, can be achieved using the 'Santa Fé' system with maize, sorghum or soybean (Kluthcouski *et al*., 2000), in the rotation or the succession soybean-forage. In case the soil has some physical impediment, for example compaction, this can be alleviated by the drill disc or by using the

'Barreirão system', which recommends deep ploughing (Oliveira *et al*, 1966), preferably with a maize crop.

Intercropping of annual crops with forages

If the soil profile has no physical or chemical problems related to acidity, calcium and magnesium deficiency and compaction, the degraded pastures can be recuperated through intercropping annual crops and forages. The operations of desiccation and sowing should be done at the beginning of the rains with harvest in February to March. From thereon, the forage will still have sufficient rain for its full establishment and dry matter accumulation for autumn to winter. The biggest threat to the establishment of tropical forages sown from February on is the lack of rain during the period of greatest biomass accumulation which normally occurs 70 to 80 days after germination and which coincides with the so-called 'pasture formation'. The great advantage of the 'Santa Fé' system is the anticipation of forage sowing in order that it completes its growth cycle with good soil water availability, as well as offering the possibility of good annual crop harvests, allowing profit from both grain production and, later, with a renovated/recuperated pasture.

Rotation/succession of annual crops with forages

Pitol *et al*. (2001) proposed that degraded pastures established in non-degraded soils be recovered through rotation with soybean. The method involves (if needed) re-liming for acidity correction and direct drilling of the soybean into the brachiaria straw. With this methodology, Broch *et al*. (1997) obtained 2.4 to 3.6 t/ha of soybean and the meat production reached 375 kg/ha in the first year of grazing.

In another study, Broch (2000) observed the behaviour of soybean in *B. decumbens* straw in large plots originating from degraded pasture used by the pastoralists for 15 to 20 years. The non-degraded soils had levels of Ca+Mg of 3.5 $cmol_c dm^{-3}$, P less than 1 mg/kg, no sub-superficial compaction problems, but up to 10 cm of superficial compaction by the animals' hooves. The soybean production varied from 2 125 kg/ha (due to lack of inoculation) to 3 060 kg/ha. The author emphasized that, in cases where liming was needed, it should be done at the end of the rains in the same year. It was also emphasized that the drill's fertilizer furrow should penetrate below the animal hoof compaction zone.

As seen, in areas previously occupied by annual crops or naturally fertile, it is possible to get high soybean yields; especially if adequate nutrient levels were maintained and soil acidity corrected. With this alternative, as well as the possibility of nutrient reposition so that the forages come in succession through mineral fertilizers, one has the additional advantage of atmospheric nitrogen fixation by the legume.

In case it is necessary to continue the rotation for more than one year, with a view to a better soil fertility, annual forages can be established at each inter-harvest period in the area as well as the natural seeding which usually occurs in this situation; making autumn/winter grazing possible.

Cropping areas with corrected soils

In cropped limed soils with medium to high fertility the integration alternatives mainly consider inter-harvest forage production. As these areas are destined for grain production, the integration options - under these soil conditions - should not interfere with the annual summer crop production chronogram. In this case one has the options of annual succession and intercropping of annuals with forages as follows in this section. If the farmer wishes to introduce pasture in the area, to make the most of a differential rotation, then this option can

also be considered.

Succession annual crop with annual forage

The temporary objective of this succession is the inter-harvest production of forage in the dry period. It involves sowing annual forage such as pasture sorghum (Embrapa Milho e Sorgo 2000) or millet (Netto, 1998) after the summer grain crop (mainly soybean). The two forage species are recommended for sowing up to March and develop well with the residual rains, probably thanks to their deep rooting systems. Forage species for silage such as forage maize and sorghum can also be considered in the inter-harvest period. Under medium to high soil fertility conditions, that are commonly seen in crop areas, a better development and production of these forage species is expected.

Intercropping of annual crops with forages

This integration option also has the objective of inter-harvest production and dry matter cover for direct sowing. There are more than 10 million hectares of soils that are partially or well corrected in the Cerrados which are cultivated only once per year and mostly in a regime of soybean monoculture. As well as the 7 to 8 months fallow period that include periods of residual rains, these areas serve as a habitat for the preservation and multiplication of crop pests. As a way of reducing this problem many farmers plant millet at the end or the beginning of the rains with a view to straw production for minimum tillage. This minimises the damaging monoculture effect but increases production costs as well as bringing no economic benefit to the farmer.

Intercropping annual crops with forages in areas mainly destined for the production of major grain crops; the so-called 'Santa Fé' system (Kluthcouski *et al*., 2000), makes the intercropping of maize and sorghum (grain and forage) with *Brachiaria* and *Panicum sp*. and soybean with *Brachiaria sp*. possible. In some cases a small reduction in yield of annual grains may occur with this system, which as a rule, has been compensated through herbicide economy. In the case of intercropping with maize and grain sorghum the area is available for pasture or silage about 30 to 40 days after harvest. In intercrops using forages and soybean, the time needed for the post-harvest reestablishment of the post-harvest grain forage practically doubles to about 60 days.

Rotation annual crop/perennial forage

This option unites all the inherent advantages of crop and livestock production with the objectives of maintaining high pasture as well as grain productivity. The principal components are maize and soybean rotated mainly with forages of the genera *Brachiaria* and *Panicum*. This method of integration is especially recommended for the direct planting system. The pastures produced, especially in sequence to soybean, are of high quality and make high yields of meat per unit area possible. Broch *et al*. (1997) and Roos (2000) report that, after one and two years of soybean cultivation, it is possible to obtain 375 and 300 kg/ha/year of meat respectively. Better grain yields, principally of soybean and black beans, when direct drilled into brachiaria straw are reported by Broch *et al*. (1997), Aidar *et al*. (2000) and Kluthcouski *et al*. (2000).

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[1] The Santa Fé system is based on the intercropping of grains (mainly maize, sorghum, millet, rice and soybean) with tropical forages mainly of the genus *Brachiaria*; whether through the minimum till or conventional planting systems.