# Custom Services for Forage Conservation Services

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## 1. Introduction

In Brazil, specialization in the beef and dairy cattle industry has lead to significant growth in sales of related products and services. Until recently, the hay market has been the only reference for the forage conservation segment, and even then data is only available for a few elite herds of animals or for critical situations when forage is insufficient for herd production. Currently, custom services or product purchasing including large volumes from specialized producers is a good alternative for ranchers. The process of outsourcing can begin with services related to crop implantation, fertilization (receiving the chemical fertilizer in the field or periodically distributing organic fertilizer) and all phytosanitation management, as well as transportation and storage processes involved in forage harvest.

The producer has the advantage of specializing property use, which focuses their efforts and investment into the area in which they are strongest, resulting in better crop quality, a quicker harvest, lower investment in machinery, higher feed quality and especially more careful planning of their activities (Pereira et al., 2008).

## 2. Custom services for forage in Brazil

According to Pereira & Barros (2004), custom services were first used by the milk volume partnership system during the mid 90's in the Campos Gerais region of Paraná state. This program primarily involved milk producers from the Batavo and Castrolanda cooperatives. It arose from beef and dairy cattle producers need to grow or at least continue in an area that was undergoing great changes. Some of these changes can be summarized as follows:

a) Small dairy producers: Areas destined for milk production were reduced due to family divisions, and acquisition of new areas was not viable due to rising property values. Production increases were needed to enable new investments or even to pay old ones off in addition to stimulating the market by offering differential payment for greater volumes of milk delivered. The high cost and relatively low number of hours forage equipment is utilized during the year impede acquisition of new machines. In addition, the need for consistent milk production throughout the year and the offer of adequate feed for more productive animals make the use of conserved forage fundamental.

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b) Large milk producers: need to invest in forage equipment (greater fixed cost) for large scale silage production, high maintenance costs of equipment, production of high quality silage, and dairy and agricultural integration (integrated planning of activities).

c) Farmers: need to find new income options, to integrate this activity in their planning or even offer services with their machinery (reduced fixed costs), to amortize part of the cost of winter crops that were seeded as cover for direct planting.

Nowadays custom services, has become increasingly common in different regions of Brazil. This practice has been stimulated by significant growth in the beef and dairy cattle industry. It should be stressed that custom forage conservation production is not only associated with self-propelled forage harvesters, but also with all forms that involve cash payment and/or exchange of services for the use of machinery, equipment and vehicles during production and harvesting forage destined for conservation.

Kruppa (2009) in a joint study with one of the largest dairy coops in Rio Grande do Sul, the Santa Clara Coop, reported that 62% of producers (municipal or private) that customized the harvesting of corn or sorghum for silage, 21% utilized group owned equipment and only 17% owned their own machinery. Private harvesting equipment was primarily one row choppers with some two-row choppers. In the Campos Gerais region of Paraná state, it is estimated that more than 70% of the corn for silage is harvested by custom self-propelled forage harvesters.

In 2010, approximately 7,000 with one or two-row harvesters were sold in Brazil (information gathered from manufacturers). Together, the two leading brands of self-propelled harvesters in Brazil sold over 100 machines over the last three years.

## 3. Forage crops and custom harvesting

Currently, harvesting corn for silage is the most common type of custom service. The fact that corn silage provides high yields dry matter (DM) per area with a high energy concentration make it an indispensible ingredient in most dairy herds, as well as much of the beef cattle feedlots.

Marketing research studies in Brazil estimate the area of corn grown for silage to be approximately 980,000 hectares at 2009/2010 summer harvest and about 450,000 hectares for the winter harvest, the area of corn grown for silage is estimated to represent about 14 to 18% of all the certified corn seed sold in the country.

Cultivation of winter corn has shown great technological advances over the last few years. Until the mid 90’s, the off-season harvest occupied a little over 1.5 million hectares, representing a modest 10% of all domestic corn production. Today winter corn accounts for more than 35% of all domestic corn production, occupying more than 4.5 million hectares with an average yield of 3500 kg/ha. The area of winter corn planted has increased by more than 3 million hectares over the last 15 years, and average yield has practically doubled over this same period (Seleme, 2011).

Some technical aspects were decisive in increasing the productivity during professionalization of the off-season. Among these are the following: selecting and seeding early-maturing soybean cultivars seeking to anticipate off season planting and minimize some effects of stress, such as drought in Mato Grosso, Goiás and São Paulo as well as thermal inversion and frosts that occur in Paraná and southern Mato Grosso do Sul; selecting hybrids suitable for the planting season by combining different hybrids with complementary characteristics of yield potential, early maturity and defense; adapting the plant population so that it presents the best overall results in a final population ranging between 55,000 and 62,000 plants/ha; reducing the space between rows from 90 to 45 cm in order to improve the spatial distribution of plants in the field seeking to increase exposure to solar radiation and reduce water evaporation from the soil by closing the culture more quickly (Seleme, 2011).

Thus, it is increasingly evident that agility in harvesting corn for silage is a key factor in guaranteeing the quality of the produced silage. High temperatures in the summer accelerate culture maturity, and when associated with frequent rain, harvest is more difficult and often delayed. On the other hand, the off season harvest should be quick given the early culture cycle and the higher risks of loss due to disease or frost. Another important factor is that, off season crops, or even summer ones, seeded with reduced space between the rows, require appropriate cutting platforms with rotating disks that are independent of the orientation of the plant line. Regarding this aspect, only self-propelled harvesters have a high performance cutting system even in sloped areas.

Sorghum is the second most common culture in area intended for silage production in Brazil. It is mostly planted during the off season. Despite its greater resistance to pests and disease, sorghum is at risk for hydric stress and frost; consequently, it faces the same challenges to accelerate harvest as winter corn crops.

## 4. Silage production costs

Tables 1 and 2 present the production costs of two corn silage crop yields. Winter corn yield presents productivity of 25 tons/ha, while a summer crop presents productivity of 50 tons/ha. Fertilizer costs are in agreement with the extraction of nutrients for crop yields without considering any residual fertility. For respective productivities of 25 and 50 t/ha for winter and summer crops, machine costs for seeding and cultivating represent 7 and 8% of total costs, while harvesting costs involving cutting, transportation and packing represent 22% and 20%.

Table 3 presents production costs of off season sorghum silage in which machine costs for seeding and cultivation represent 13% and harvesting 27% of total costs.  To produce oat haylage, machine costs in seeding and cultivation represent 15% and harvesting 23% of total costs (Table 4).

**Table 1 – Production cost of corn silage crop yield of 25 tons/hectare.**

| | | | | |
|---|---|---|---|---|
| Production of fresh forage | 25000 kg/ha | | | |
| Dry matter (%) | 30 | | | |
| Production of forage dry matter | 7500 kg/ha | | | |
| Annual return of capital | 8.75 % | | | |
| Annual interest loan(bank loan) | 8.75 % | | | |
| Financial cycle | 5 months | | | |
| **Items** | **R$ /unit** | **quantity/ha** | **R$/ha** | **%** |
| **Seeds** | | | **436.76** | **16** |
| P 30R50 | 286.09 /bag | 1.30 | 371.92 | 14 |
| Crop Star | 162.10 /L | 0.40 | 64.84 | 2 |
| **Fertilizers** | | | **498.49** | **19** |
| NPK 10-20-20 + Zn | 0.95 /kg | 300 | 285.15 | 11 |
| Urea | 0.79 /kg | 240 | 189.84 | 7 |
| Potassium Chloride | 0.96 /kg | 0 | 0.00 | 0 |
| Simple Superphosphate | 0.52 /kg | 0 | 0.00 | 0 |
| Limestone | 0.02 /kg | 500 | 7.90 | 0 |
| Fertilizer transportation | 15.00 /ton | 1.04 | 15.60 | 1 |
| **Herbicides** | | | **89.36** | **3** |
| **Insecticides** | | | **59.87** | **2** |
| **Fungicides** | | | **37.92** | **1** |
| **Machinery** | | | **210.5** | **8** |

| | | | | | |
|---|---|---|---|---|---|
| | | | | **0** | |
| Sprayer – 2000L | 10.00 | /ha | 4.00 | 40.00 | 1 |
| Dual-disk fertilizer spreader | 9.00 | /ha | 2.00 | 18.00 | 1 |
| Seeder or – 8 rows (40 cm) | 75.00 | /ha | 1.00 | 75.00 | 3 |
| Manure spreader | 72.00 | /ha | 1.00 | 72.00 | 3 |
| Limestone spreader – 5000 kg | 22.00 | /ha | 0.25 | 5.50 | 0 |
| **Direct Costs** | | | | **1332.90** | **50** |
| **Financing Cost** | | | | **48.60** | **2** |
| **Administration** | | | | **480.25** | **18** |
| **Indirect Costs** | | | | **528.85** | **20** |
| Harvesting (self-propelled harvester) | 320.00 | R$/h | 0.9 | 288.00 | 11 |
| Transportation | 35.00 | R$/h | 3.6 | 126.00 | 5 |
| Packing | 50.00 | R$/h | 0.9 | 45.00 | 2 |
| Labor | 41.00 | R$/day | 0.2 | 8.20 | 0 |
| Plastic Film | 1.27 | R$/m2 | 25 | 31.75 | 1 |
| Bunker Silo | 2.85 | R$/m3 | 30 | 85.50 | 3 |
| Diesel fuel | 1.89 | R$/L | 60.3 | 113.97 | 4 |
| **Silage** | | | | **698.42** | **26** |
| **Interest on inventory** | **19.20** | **R$/month** | **6** | **115.21** | |
| | | | **Silage** | **With** | **Without** |
| **Total costs** | **R$/ha** | | | **2,675.3** | **1,861.7** |
| **Dry matter cost** | **R$/kg** | | | **0.357** | **0.248** |
| **Fresh forage cost** | **R$/kg** | | | **0.107** | **0.074** |

Costs estimated for 2010/2011 harvest. Harvested with self-propelled harvesters (6m platform) and transported with dump trucks (cost approximately R$ 35/hour for the forager).
Source: Fundação ABC (2011).

**Table 2 – Production cost of corn silage – crop yield of 50 tons/hectare**

| | | | | |
|---|---|---|---|---|
| Production of fresh forage | 50000 kg/ha | | | |
| Dry matter (%) | 30 | | | |
| Production of forage dry matter | 15000 kg/ha | | | |
| Annual return of capital | 8.75 % | | | |
| Annual interest loan(bank loan) | 8.75 % | | | |
| Financial cycle | 5 months | | | |
| **Items** | **R$ /unit** | **quantity/ha** | **R$/ha** | **%** |
| **Seeds** | | | **436.76** | **15** |
| P 30R50 | 286.09 / bag | 1.30 | 371.92 | 13 |
| Crop Star | 162.10 /L | 0.40 | 64.84 | 2 |
| **Fertilizers** | | | **666.48** | **23** |
| NPK 10-20-20 + Zn | 0.95 /kg | 300 | 285.15 | 10 |
| Urea | 0.79 /kg | 240 | 189.84 | 7 |
| Potassium chloride | 0.96 /kg | 158 | 151.93 | 5 |
| Simple superphosphate | 0.52 /kg | 26 | 13.32 | 0 |
| Limestone | 0.02 /kg | 500 | 7.90 | 0 |
| Fertilizer transportation | 15.00 /ton | 1.22 | 18.35 | 1 |
| **Herbicides** | | | **89.36** | **3** |
| **Insecticides** | | | **59.87** | **2** |

| | | | | |
|---|---|---|---|---|
| **Fungicides** | | | **37.92** | **1** |
| **Machinery** | | | **210.50** | **7** |
| Sprayer – 2000L | 10.00 /ha | 4.00 | 40.00 | 1 |
| Dual-disk fertilizer spreader | 9.00 /ha | 2.00 | 18.00 | 1 |
| Seeder or – 8 rows (40 cm) | 75.00 /ha | 1.00 | 75.00 | 3 |
| Manure spreader | 72.00 /ha | 1.00 | 72.00 | 2 |
| Limestone spreader – 5000 kg | 22.00 /ha | 0.25 | 5.50 | 0 |
| **Direct Costs** | | | **1500.89** | **52** |
| **Financing Cost** | | | **54.72** | **2** |
| **Administration** | | | **480.25** | **17** |
| **Indirect Costs** | | | **534.97** | **19** |
| Harvesting (self-propelled harvester) | 320.00 R$/h | 0.9 | 288.00 | 10 |
| Transportation | 35.00 R$/h | 3.6 | 126.00 | 4 |
| Packing | 50.00 R$/h | 0.9 | 45.00 | 2 |
| Labor | 41.00 R$/day | 0.2 | 8.20 | 0 |
| Plastic Film | 1.27 R$/m2 | 50 | 63.50 | 2 |
| Bunker Silo | 2.85 R$/m3 | 30 | 85.50 | 3 |
| Diesel fuel | 1.89 R$/l | 60.3 | 113.97 | 4 |
| **Silage** | | | **730.17** | **25** |
| Interest on Inventory | 20.75 R$/month | 6 | 124.47 | |
| | | **Silage** | **With** | **Without** |
| **Total costs** | **R$/ha** | | **2,890.5** | **2,035.8** |
| **Dry matter cost** | **R$/kg** | | **0.193** | **0.136** |

| | | | | |
|---|---|---|---|---|
| **Fresh forage cost** | **R$/kg** | | **0.058** | **0.041** |

Costs estimated for 2010/2011 harvest. Harvested with auto-propelled forager (6m platform) and transported with dump trucks (cost approximately R$ 35/hour for the forager).

Source: Fundação ABC (2011).

**Table 3 – Production cost of off season sorghum silage – Crop yield of 30 tons/hectare.**

| | | | | | |
|---|---|---|---|---|---|
| Production of fresh forage | 30000 | kg/ha | | | |
| Dry matter (%) | 30 | | | | |
| Production of forage dry matter | 9000 | kg/ha | | | |
| Annual Return of capital | 8.75 | % | | | |
| Annual interest loan(bank loan) | 8.75 | % | | | |
| Financial cycle | 4 | months | | | |
| **Items** | **R$** | **/unit** | **quantity/ha** | **R$/ha** | **%** |
| **Seeds** | | | | **197.83** | **1<br>4** |
| AG 2005E | 14.92 | /kg | 10.00 | 149.20 | 1<br>1 |
| Crop Star | 162.10 | /L | 0.30 | 48.63 | 3 |
| **Fertilizers** | | | | **418.90** | **3<br>0** |
| **Herbicides** | | | | **46.42** | **3** |
| **Insecticides** | | | | **40.90** | **3** |
| **Machinery** | | | | **186.00** | **1<br>3** |
| Sprayer – 2000L | 10.00 | /ha | 3.00 | 30.00 | 2 |
| Dual-disk fertilizer spreader | 9.00 | /ha | 1.00 | 9.00 | 1 |
| Seeder or – 8 rows (40 cm) | 75.00 | /ha | 1.00 | 75.00 | 5 |
| Manure spreader | 72.00 | /ha | 1.00 | 72.00 | 5 |
| Limestone spreader - 5000 kg | 22.00 | /ha | 0.00 | 0.00 | 0 |
| **Direct Costs** | | | | **890.05** | **6<br>3** |
| **Financing Cost** | | | | **25.96** | **2** |

| | | | | | |
|---|---|---|---|---|---|
| **Administration** | | | | **0.00** | **0** |
| **Indirect Costs** | | | | **25.96** | **2** |
| Harvesting (self-propelled harvester) | 320.00 | R$/h | 0.6 | 192.00 | 1<br>4 |
| Transportation | 35.00 | R$/h | 2.4 | 84.00 | 6 |
| Packing | 50.00 | R$/h | 0.6 | 30.00 | 2 |
| Labor | 41.00 | R$/day | 0.2 | 8.20 | 1 |
| Plastic Film | 1.27 | R$/m2 | 30 | 38.10 | 3 |
| Diesel fuel | 1.89 | R$/l | 40.2 | 75.98 | 5 |
| **Silage** | | | | **428.28** | **3**<br>**0** |
| Interest on inventory | 10.08 | R$/month | 6 | 60.49 | |
| | | | **Silage** | **With** | **Without** |
| **Total Cost** | **R$/ha** | | | **1,404.**<br>**78** | **916.0**<br>**1** |
| **Dry matter cost** | **R$/kg** | | | **0.156** | **0.102** |
| **Fresh forage cost** | **R$/kg** | | | **0.047** | **0.031** |

Costs estimated for 2010/2011 harvest. Harvested with auto-propelled forager (6m platform) and transported with dump trucks (cost approximately R$ 35/hour for the forager).

Source: Fundação ABC (2011).

**Table 4 – Production cost of oat haylage.**

| | | | | | |
|---|---|---|---|---|---|
| Number of cuts | 1 | Cut | | | |
| Dry matter yield | 4000 | kg/ha | | | |
| Harvesting stage | Initial Panicle Emission | | | | |
| Annual return on capital | 8.75 | % | | | |
| Annual interest loan (bank loan) | 8.75 | % | | | |
| Financial cycle | 5 | months | | | |
| **Ítems** | **R$** | **/unit** | **quantity/ha** | **R$/ha** | **%** |
| **Seeds** | | | | **101.64** | **9** |
| Common black | 1.09 | /kg | 80 | 87.20 | 8 |
| Cruiser 350 FS | 180.50 | /L | 0.08 | 14.44 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **Fertilizers** | | | | **441.61** | **40** |
| **Herbicides** | | | | **25.62** | **2** |
| **Machinery** | | | | **161.50** | **15** |
| Sprayer – 2000L | 10.00 | /ha | 2.00 | 20.00 | 2 |
| Dual-disk fertilizer spreader | 9.00 | /ha | 1.00 | 9.00 | 1 |
| Planter – 19 rows | 55.00 | /ha | 1.00 | 55.00 | 5 |
| Manure spreader | 72.00 | /ha | 1.00 | 72.00 | 7 |
| Limestone spreader – 5000 kg | 22.00 | /ha | 0.25 | 5.50 | 0 |
| **Direct Costs** | | | | **730.37** | **66** |
| **Financing Costs** | | | | **26.63** | **2** |
| **Administration** | | | | **0.00** | **0** |
| **Indirect Costs** | | | | **26.63** | **2** |
| Mower conditioner | 107.00 | R$/h | 0.5 | 53.50 | 5 |
| Hay tedder | 29.00 | R$/h | 0.5 | 14.50 | 1 |
| Hay rake | 32.00 | R$/h | 0.5 | 16.00 | 1 |
| Collection | 320.00 | R$/h | 0.3 | 96.00 | 9 |
| Transportation | 35.00 | R$/h | 0.9 | 31.50 | 3 |
| Packing | 50.00 | R$/h | 0.3 | 15.00 | 1 |
| Labor | 41.00 | R$/day | 0.2 | 8.20 | 1 |
| Plastic Film | 1.27 | R$/m2 | 25 | 31.75 | 3 |
| Diesel fuel | 1.89 | R$/l | 17.7 | 33.45 | 3 |
| **Silage** | | | | **299.90** | **27** |
| **Interest on Inventory** | 7.93 | R$/month | 6 | **47.56** | |
| | | | **Silage** | **With** | **Without** |
| **Total Costs** | **R$/ha** | | | **1,104.46** | **757.00** |
| **Dry Matter Cost** | **R$/kg** | | | **0.276** | **0.189** |

Costs estimated for 2010/2011 harvest. Harvested with auto-propelled forager (6m platform) and transported with dump trucks (cost approximately R$ 35/hour for the forager).
Source: Fundação ABC (2011).

Table 5 presents operational costs of machinery and forage equipment as a reference price for services and production costs in the Campos Gerais region. Note that fuel cost, which is often considered a primary cost component, did not exceed 50% of total costs of tractor hours. Depreciation of forage equipment was considered to be 40% of the hourly cost.

As for the value charged by companies hired to harvest with auto-propelled foragers, the mean value charged in the region was about R$ 420 to R$ 460. Due to the large supply of this service in the region, its cost has decreased over the last few years. Companies offset investments in machinery and equipment by offering services in other regions or states. The harvest season begins with cutting corn from December (early planting) to July in off season areas (from western Paraná to the central western region of Brazil).

Table 5 – Machinery and equipment costs for conserved forage production.

| Equipment | Cost Components – R$/hour | | | | | | |
|---|---|---|---|---|---|---|---|
| | Depret. | Insurance | Interest | Maint. | Comb. | Total/hour | Total/ha. |
| Tractor 70- 90cv 4x4 | 6.90 | 0.80 | 6.10 | 6.50 | 18.90 | 39.20 | - |
| Tractor 90 –110cv 4x4 | 8.60 | 1.00 | 7.50 | 8.10 | 24.60 | 49.80 | - |
| John Deere7350/New Holland 9050 | 89.50 | 10.00 | 72.70 | 76.70 | 104.00 | 352.90 | 90.80[1] |
| Single row forage harvester | 6.10 | 0.20 | 3.30 | 5.50 | - | 15.10 | 107.50[1] |
| Dual row forage harvester[*] | 12.20 | 0.40 | 6.50 | 10.80 | - | 29.90 | 100.00[1] |
| Harvester (cas./silt) | 8.40 | 0.30 | 4.50 | 7.50 | - | 20.70 | 36.90 |
| 4-wheel trailer | 2.00 | 0.60 | 1.30 | 1.00 | - | 4.00 | - |
| Mower Conditioner | 27.90 | 1.00 | 14.90 | 18.60 | - | 62.50 | 55.90 |
| Tedder – 3m | 4.80 | 0.20 | 2.60 | 2.70 | - | 10.10 | 29.80 |
| Baler - rectangular | 7.00 | 0.30 | 4.60 | 4.40 | - | 16.40 | 5.50 |
| Baler – cylindrical | 14.60 | 0.70 | 9.60 | 9.10 | - | 33.90 | 6.90 |

Source: Fundação ABC (2011). [1] For corn silage; *Attached to a tractor with 110 cv. Remaining pull type equipment attached to tractors with 90cv.

## 5. Impact of harvest efficiency on conserved forage quality

A comparison of harvest costs per area of corn crop for silage production (Table 5) verified that harvest with self-propelled forager costs approximately 15% less than a single row harvester and 9% less than one with two rows. However, the primary benefit to harvesting with self-propelled machines is the possibility of obtaining better quality forage.

The ideal moment to harvesting the corn, expressed by the dry matter content of the whole plant and the maturity stage of the kernel, has a significant impact on silage quality. This point occurs when the plant accumulates the greatest quantity of dry matter with high nutritional quality. In general, it happens when the kernel attain the hard-floury stage, and the whole plant reach 32 to 38% of dry matter. Meanwhile, the difficulty in harvesting within this ideal range is evident if one considers problems such as frequent rain and accelerated maturity in the summer and precociousness and risk of loss due to disease or frost during the off season.

Forms to lessen these risks basically consist of good agricultural planning to create the widest harvest window possible for cutting associated with practices such as combining hybrids with different cycles with staggered seeding so that the ideal moments for cutting appear in a sequenced way. A second phase includes all the steps in silage such as cutting, transportation and packing in a quick efficient manner which will certainly have a positive effect on the quality of the silage produced.

As few producers consider these variables during crop planning for silage production, the most common practice is to anticipate the harvest. Research conducted on the 2010 harvest in Carambeí, PR with the P30F36 hybrid indicate that early cutting significantly reduces the quality of corn silage, and consequently, its potential to be transformed into the milk or meat (Table 6).

Table 6. Field productivity and nutritional quality of corn silage at different harvesting periods

| | Dry matter content at harvesting | | | |
|---|---|---|---|---|
| | 27% | 31% | 35% | 39% |
| DM yield, kg/ha | 14,680 | 16,180 | 17,660 | 21,050 |
| NDF, % | 53.7 | 49.1 | 46.6 | 41.2 |
| TDN, % | 67.6 | 68.3 | 66.5 | 70.2 |

| | | | | |
|---|---|---|---|---|
| Milk, kg/ton of DM | 1,358 | 1,394 | 1,362 | 1,484 |
| *Milk kg/ha | 19,930 | 22,552 | 24,045 | 31,238 |
| *Meat kg/ha | 1,900 | 2,159 | 2,171 | 3,042 |

Source: Pereira et al. (2010) – ongoing study. *estimates

Studies made by Marquardt (2007) and Kruppa (2009) on silage quality in two Brazilian regions indicate that early cutting of corn for silage is the most common error made regardless of the form of harvest. Even in regions with elevated use of auto-propelled harvesters, denominated region A, more than 40% of the sample evaluated presented dry matter values below 30%, while in regions that mainly use single row harvesters, denominated region B, this occurs in more than 50% of the samples (Table 7).

Table 7 – Dry matter content of silage samples collected from two Brazilian regions.

| Dry matter% | Region A (% samples) | | Region B (% samples) |
|---|---|---|---|
| | 2006 | 2007 | 2008 |
| 20 - 25 | 4 | 6 | - |
| 25 - 30 | 41 | 40 | 58 |
| 30 - 35 | 34 | 33 | 36 |
| 35 - 40 | 21 | 21 | 6 |

Adapted from Marquardt (2007) and Kruppa (2009).

Corn harvesting with dry matter content higher than 35-37% associated with greater participation of forage grains demand greater efficiency in the quality of cutting and kernel processing. Removal of air from the silo mass is fundamental to reduce the respiration process and increase the temperature, whose main consequence is the energy losses as heat. Thus, uniform chopping of the particles allows packing to be more intense, increasing the silage density and the storage capacity of the silo, which significantly reduces forage losses.

Furthermore, it is possible to produce good quality silage with single or double row harvesters. Aware of the lower harvest efficiency, the farmer should have a good seeding strategy for a staggered harvest, daily equipment maintenance and division of forage stored in lower capacity silos that can be closed more quickly during ensiling and larger portions removed during the silage feedout.

## 6. Final considerations

Custom harvesting services is a very interesting option that has grown significantly in Brazil. From a financial point of view, the advantage for the producer who hires these services is reduced investment in acquisitions as well as lower depreciation costs and maintenance.

Large scale harvesters (self-propelled) have greater operational efficiency, allowing for a quicker harvesting within the ideal time for cutting, less time for filling and closing the silo and, eventually greater availability of tractors for packing, which all contribute to the quality of the silage produced. However, producers do not take advantage of a significant part of these benefits. This fact could be due to lack of a planting strategy, unavailability of machinery at the time of harvest or even a lack of knowledge of the machine's resources.

Use of single or dual row forage harvesters does not impede the production of high quality silage as long as some seeding strategy and silage plan are involved.

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