Economic Analysis of Storing Grain in Silobags Through a Web Application

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ABSTRACT

Storing grain in hermetic plastic bags (silobags) is a frequent storage alternative for farmers, grain elevators and the grain processing industry in Argentina. During the last 5 years, about 40% of the grain production in Argentina was stored in silobags, and this technology is being adopted in several countries around the world. The silobags can store about 200 tones of grain, and it can be placed in the same production field, in a case of a farm, or in a field specially dedicated right next to the elevator.

In Argentina, some farmers own their own silobag equipment, and for them is critical to know what is the real cost of bagging the grain in comparison with sending the grain to the elevator. On the other hand, other farmers use custom operation. For silobag contractors is also critical to know the real cost of the service, so they can charge a profitable rate.

The main goals of this work were: 1) to present a web based application for computing the cost of storing grain in silobags, 2) to show the use of the application for determining the cost of storing grain in silobags for a typical system configuration in Argentina.

The cost per tone decreases as the number of silobags increases, from 5.9 US$/tone for 15 bags per year to 5.03 US$/tone for 503 bags per year. The cost did not changed substantially as the number of bags increased due to the high proportion of variable costs. For a medium size operation (126 bags per year), the bags accounts for 59% of the total cost, labor 13% and fuel 24%, meaning that the variable costs accounts for 96% of the total costs, while the ownership costs represents only 4% (maintenance 1%, interest 1% and amortization 2%).

Keywords: Storage, Grain, Cost, Logistic, Web application, Silobag, Argentina.

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1. INTRODUCTION

The silobag is a hermetic type of storage. Grain, associated microorganisms and insects consume O2 and generate CO2 through the respiration process creating a modified atmosphere inside the hermetic bag which has some advantages for grain storage.
Storing grain in silobags is a frequent storage alternative for farmers, grain elevators and the grain processing industry in Argentina. During the last 5 years, about 40% of the grain production in Argentina was stored in silobags, and this technology is being adopted in several countries around the world. The silobags are made with a plastic bag, with the shape of a tube, of 60 m long and 2.74 m diameter. The plastic cover is made of three layers (white outside and black inside) with 235 micrometers of thickness. Each bag can hold approximately 200 tones of grain and with the available handling equipment is very easy to fill and unload. The bag can be set up in the same production field, or in a field specially dedicated next to the elevator or the processing industry.
INTA has conducted extensive research in the silobag storage technology. The effect of grain MC and storage time on the quality of wheat, corn, sunflower and soybean and barley (Bartosik, 2012) was extensively analyzed. Cardoso et al. (2009) studied the change in phosphine concentration during fumigation of silobags, and Cardoso et al. (2012) applied a pressure decay test to determine the initial air-tightness level of silobags and its evolution after four months of storage in the field.
Logistic studies were performed showing the advantage and flexibility of the silobags in the harvest operation (Busato et al., 2011). Recently Bartosik (2012) presented a summary of the investigations carried out so far in Argentina.
In Argentina, some farmers have their own silobag equipment, and for them is critical to know what is the real cost of bagging the grain in comparison with sending the grain to the elevator. On the other hand, other farmers use custom operation. For silobag contractors is also critical to know the real cost of the service, so they can charge a profitable rate.
Computing the cost of storing grain in silobags requires some considerations. For the silobag systems the following equipment is needed: bagging machine, unloading machine, grain wagon with an unloading auger and, at least, two tractors (one for the bagging or unloading machine, and other for the grain wagon). In addition to the ownership cost of the equipment there are other expenses, mostly related to the fuel and the labor involved in the operation. The bag is not reusable, so users need to buy the bag each time the grain is bagged. Obtaining the real cost of storing grain in silobags can be confusing because part of the equipment is not fully dedicated to the bagging operation, such as the tractor which is shared with other operations (i.e. planting).
The National Institute of Agricultural Technology (INTA) of Argentina develops web based applications for helping farmers and the grain industry to size and select aeration fans, size aeration ducts, calculate phosphine dosage during fumigation, estimate weight reduction of grain during storage, to calculate storage capacity of different storage structures, among other applications. This applications are free (users only need to register) and are presented with the name of AireAr (Bartosik et al., 2009).

In spite of the extensive research related to silobag technology presented above, little effort has been done for studying the economics of the system. The main goals of this work were: 1) to develop a web based application for computing the cost of storing grain in silobags, 2) to use the application for determining the cost of storing grain in silobags for a typical system configuration in Argentina.

2. METHODOLOGY

A typical silobag operation was analyzed for Argentina conditions, including the sub operations of 1) transportation from the field (combine) to the bagging machine, 2) bagging, and 3) unloading the bag. The transportation from the silobag to the grain elevator, port or industry was not considered, since this operation has to be done regardless the use of the silobag system.

The equipment required for the operation consists of a bagging machine, an unloading machine, a grain cart with unloading auger, one tractor dedicated to the grain cart and other tractor dedicated to the bagging machine. The same tractor used for the bagging machine is used, in time, for the unloading machine. The bagging machine has a loading capacity of 400 t/h, and requires a power of, at least, 60HP. The unloading machine has a capacity of 80-110 t/h (depending on grain type and condition), and requires a power of 90 HP. The grain cart has a holding capacity of 14 t, and it is equipped with an unloading auger of 360 t/h capacity. Two tractors of 90 HP were considered, which could be used either for the grain cart, the unloading machine or the bagging machine. This is a typical equipment configuration for a contractor that offers the bagging service for farmers and elevators. The cost of the equipment was the market price in Argentina of the new machines, taken from dealer's information and from a specialized magazine for agricultural costs in Argentina (Agromercado). The useful life was set in 10 year for all the equipment, with the exception of the tractors (20 years). The residual value was considered in 25%, and the annual maintenance cost was 3% of the price (Table 1).

Table 1. Characteristics, price, useful life, residual value and maintenance cost of the equipment considered for the silobag operation

Equipment	Characteristics	Price (US$)	Useful life	Residual value (%)	Interest rate (%/year)	Maintenance cost (%)
Bagging machine	400 t/h capacity	3842	10	25	15	3
Unloading machine	80-110 t/h capacity	10105	10	25	15	3
Grain cart	14 tones capacity, with unloading auger 360 t/h	15378	10	25	15	3
Tractor 1	90 HP	50000	20	25	15	3
Tractor 2	90 HP	50000	20	25	15	3

The price of the standard bag (2.74 m diameter and 60 m long) was US$ 500 and, according to the volumetric density of the grain, different amount of tones can be stored in each bag (200 tones of wheat, corn, soybean and sorghum, 180 tones of barley and 120 tones of sunflower and rice).

2.1. Dedicated Time to the Bagging Operation

Part of the equipment if fully dedicated to the bagging operation, such as the bagging and unloading machine. Thus, 100% of the amortization and interest cost was assigned to this operation. However, the grain cart and the tractors are used in other operations as well, so a proportional amortization and interest cost was assigned to the bagging operation.

Based on practical experience, it was assumed that during the bagging operation the equipment is used 10 hours per day, and that 4 bags could be made per day (2.5 hours per bag). During the unloading operation the equipment is also used during 10 hours per day, but only 2.5 bags can be unloaded per day (4 hours per bag).

Bagging machine tractor: the tractor dedicated to the bagging machine is working every time that the grain cart is unloading grain into the bagging machine. Assuming and average discharge rate of the grain cart of 300 tones per hour, and adding 20% of working time to compensate for some inefficiency, the working time of this tractor was computed as following:

$$Tractor\ Bagging\ Machine\ (h) = \frac{Total\ grain\ (t)}{Grain\ cart\ unloading\ capacity\ (\frac{t}{h})}\ x\ 1.2 \qquad \text{Eq. 1}$$

Bagging machine: The working time of the bagging machine was set the same as the working time of the dedicated tractor.

Unloading machine tractor: the tractor dedicated to the unloading machine is working every time that the unloading machine is working. Assuming an average capacity of 90 tones per hour, and adding 20% of working time to compensate for some inefficiency, the working time of this tractor was computed as following:

$$Tractor\ Unloading\ Machine\ (h) = \frac{Total\ grain\ (t)}{Unloading\ machine\ capacity\ (\frac{t}{h})}\ x\ 1.2 \qquad \text{Eq. 2}$$

Unloading machine: The working time of the unloading machine was set the same as the working time of the dedicated tractor.

Grain Cart Tractor: the tractor dedicated to the grain cart is working during the transportation of the grain from the field (or bin) to the silobag, during the unloading operation of the grain cart, and during the trip (empty) to the field. The number of trips that the tractor should make depends on the amount of grain and the capacity of the grain cart (14 t). The average distance from the field to the silobag was set in 1.5 km (3 km round trip), the average velocity of the tractor in 15 km/h and the unloading capacity of the grain cart in 300 t/h. In order to compensate for some inefficiency, 20% of the time was added. The working time of this tractor was computed as following:

$$Tractor\ Grain\ Cart\ (h) = \left(\frac{Total\ grain\ (t) x\ Distance\ (km)}{Grain\ cart\ capacity\ (t)\ x\ Velocity\ (\frac{km}{h})} + \frac{Total\ grain\ (t)}{Grain\ cart\ unloading\ capacity\ (\frac{t}{h})}\right) x\ 1.2$$

Eq. 3

Grain Cart: the working time of the grain cart was the same as the working time of the tractor dedicated to the grain cart.

The dedication of the equipment to the bagging operation was as indicated in table 2.

Table 2. Overall annual use of the equipment (hours) and dedication (%) to the bagging operation.

Equipment	Total annual use (hours)	Dedication to the silobag operation (%)
Bagging Machine	Eq. 1	100
Unloading Machine	Eq. 2	100
Grain Cart*	2000	Eq. 3/2000 x 100
Tractor Bagging Machine*	2000	Eq. 1/2000 x 100
Tractor Unloading Machine*	2000	Eq. 2/2000 x 100
Tractor Grain Cart	2000	Eq. 3/2000 x 100

* considering the hours used for the silobag operations and the hours used in other activities

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2.2. Equipment depreciation

The yearly depreciation of the equipment was computed as following (Ghida Daza et al., 2009):

$$Amortization = \frac{Value\ New - Residual\ Value}{Useful\ life}\ x\ Dedication\ (\%)$$ Eq. 4

2.3. Interest

To account for the opportunity cost of capital invested in the silobag related machinery a yearly interest rate of 3% was considered as follows (Ghida Daza et al., 2009):

$$Interest = \left(\frac{Value\ New}{2}\right) x\ Interest\ Rate\ X\ Dedication\ (\%)$$ Eq. 5

2.4. Fuel cost

It was estimated that each tractor has, in average, a fuel consumption of 20 l/h, and the price of the diesel oil was set in 1.3 US$/l. For each tractor, the fuel consumption was computed as follows:

$$Fuel\ cost\ (US\$) = Time\ dedicated\ to\ silobag\ operation\ (hs)\ x\ Fuel\ Consumption\ \left(\frac{l}{h}\right)\ x\ Diesel\ oil\ price\ \left(\frac{US\$}{l}\right)$$ Eq.6

Where: Time dedicated to the silobag operation is computed from equations 1, 2 and 3.

2.5. Labor

The labor dedicated to the silobag operation was divided in three sub operations: 1) bagging (same working hours as the grain cart tractor), 2) transportation (same working hours as the grain cart tractor), 3) unloading (same working hours as the unloading machine tractor). A salary of 2000 US$/month and 200 net working hours per month were considered. The labor cost for each sub operation was computed as follows:

$$Labor\ cost\ (US\$) = \frac{Time\ of\ the\ sub\ operation\ (hs)}{200\ \left(\frac{hs}{month}\right)}\ x\ Salary\ \left(\frac{US\$}{month}\right)$$ Eq. 7

2.6. Operation size

The economic analysis was performed for a variable number of silobags, from 15 to 503 per year with the same equipment configuration. It was considered a mix of different grains to be bagged (Table 2).

The Silobag Calculator Cost was first developed as an Excel spreadsheet and is currently being programmed into a web application that will be soon available at the INTA web site.

3. RESULTS AND DISCUSSION

Figure 1 shows the cost per tone of storing grain in silobags. The cost per tone decreases as the number of silobags increases, from 5.9 US$/tone for 15 bags per year to 5.03 US$/tone for 503 bags per year. This effect is expected and due to spreading fixed cost over an increasing number of tons. The cost reduction is more significant up to 100 bags approximately, after that, increasing the number of bags did not result in a substantial cost reduction per tone. This could be explained due to the small ownership cost (fixed costs) in comparison with the variable costs.

Figure 2 shows the cost composition of a silobag operation of 126 bags per year (23 300 tones). The bags accounts for 59% of the total cost, labor 13% and fuel 24%, meaning that the variable costs accounts for 96% of the total costs, while the ownership costs represents only 4% (maintenance 1%, interest 1% and amortization 2%).

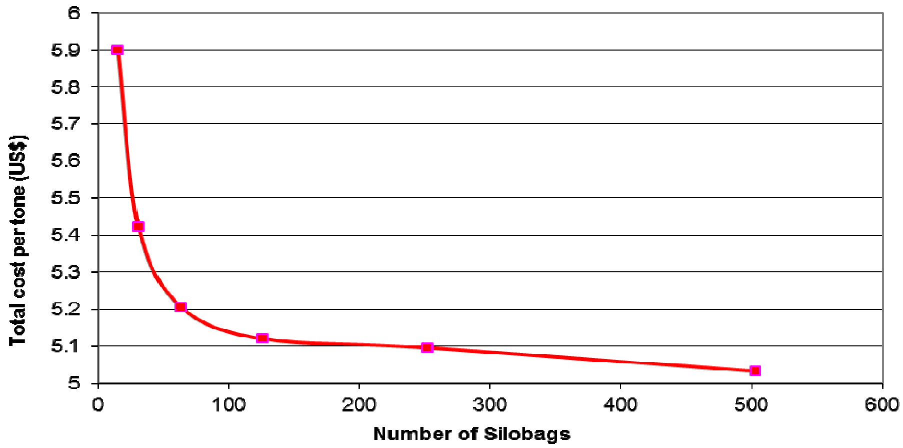

Figure 1. Cost of storing grain in silobag (US$/tone) for different numbers of bags.

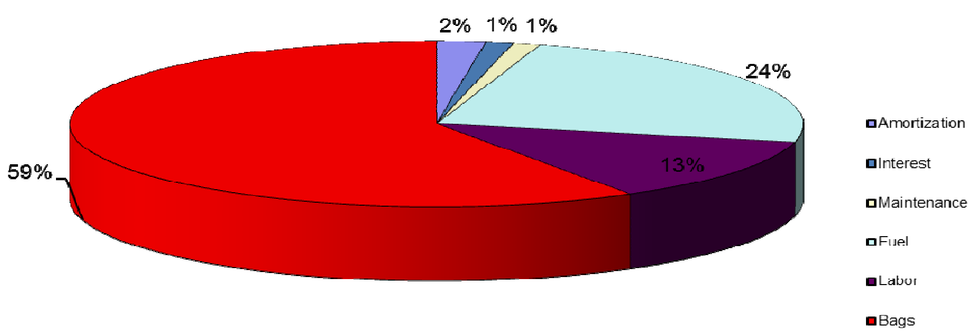

Figure 2. Cost composition for a silobag operation of 126 bags per year (23 300 tones).

It is important to consider that, in order to make a comparison between storing grain in silobags and sending the grain to the elevator, other cost components should be taken into account, including transportation cost from the field to the elevator, commercialization, quality control, etc. It is also worth noting that the current article does not evaluate the economic convenience of investing in silobag specific machinery, which should be done through an investment analysis.

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4. CONCLUSIONS

An application was developed for estimating the cost of storing grains in silobags. A typical silobag operation was proposed, which includes a bagging machine, an unloading machine, a grain cart and two tractors. As expected, the cost per tone decreases as the number of silobags increases, from 5.9 US$/tone for 15 bags per year to 5.03 US$/tone for 503 bags per year. The cost did not changed substantially as the number of bags increased due to the high proportion of variable costs. For a medium size operation (126 bags per year), the bags accounts for 59% of the total cost, labor 13% and fuel 24%, meaning that the variable costs accounts for 96% of the total costs, while the ownership costs represents only 4% (maintenance 1%, interest 1% and depreciation 2%).

This application is a useful tool for easily computing the cost involved in the operation of storing grain in silobag and it will be soon available at INTA website (http://online.inta.gov.ar:8080/aireAr/)

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