Study of the Effect of Shade Cloth Cover on Quality of Soybean Seeds (*Glycine max* (L.) Merr.) Stored in Plastic Bags.

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ABSTRACT

Storage of grains and oilseeds in plastic bags in Argentina has expanded steadily in the last years; indeed, in the 2007/08 crop year 35 million tons (t) have been stored using this system. The use of this type of storage spread mainly among small-scale producers, extending to farming cooperatives, middlemen, and industries. Later, several high-quality seed companies adopted storage in plastic bags and obtained diverse results; a number of specific problems remain unsolved. The aim of this work was to study the effect of shadow cloth cover on the quality of soybeans stored in plastic bags, by comparing different cultivars and grains with different moisture content. Several soybean cultivars with 10.8% (dry) and 15.7 % (moist) grain moisture content (m.c.) were used. In July 2003 shadow cloth was placed longitudinally on half of the bags. Grain samples were taken from the top, middle, and bottom sectors of both parts (covered and not covered by the shadow cloth) of the bags, every 60 days up to December 2003. The shadow cloth cover was effective in maintaining quality of moist seeds until October, without variation in seed germination (SG). Quality of seeds under the shadow cloth cover was also high in December, but SG decreased to 80%, whereas seeds exposed to ambient conditions (without cover) only reached 60% of SG. In dry seeds, no significant differences were observed between seeds covered by the shadow cloth and seeds stored in bags exposed to ambient conditions.

Key words: Silo bag, shadow cloth, soybean seed, quality, Argentina.

1. INTRODUCTION

In the area encompassing northwest of the province of Buenos Aires, east of La Pampa and southwest of Santa Fe soybean agriculture has expanded noticeably in the last crop years, with the consequent replacement of other traditional crops. Such increase in the cultivated area, along with the incorporation of new varieties, requires a higher number of seeds. As a consequence,

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seed companies must develop strategies to produce soybean seeds of maximum quality so that they can offer certified seed in the market at competitive costs.
To avoid mechanical damage and minimize possible pre and postharvest losses, seeds are collected with high moisture content (m.c.). By contrast, when harvest is anticipated, a high grain volume is obtained in the short term that cannot be conditioned and must be stored temporarily until it can be dried and cooled using the suitable methods.
On the other hand, results of a survey conducted among 42 seed companies in 2008 showed that 4% of these companies store seeds exclusively in plastic bags before processing; however, there is an increasing tendency to implement this system (CONAPRE, 2008). The use of plastic bags is likely to increase in the coming years because it contributes to cost reduction and allows greater material segregation than the use of other storage systems. However, there is no accurate information on the adequate seed m.c. for storing seeds using this system.
It is important to consider that, as all living organisms, seeds obtain the energy necessary for the metabolic processes from respiration. Moisture and temperature are the two variables that most affect the behaviour of such biological functions.
Inside the silo these two variables combine in different ways that may affect adequate grain conservation because they may generate an environment suitable for the development of pests and diseases. For example, temperatures above 18 ºC are suitable for insect development; if, in addition to high temperatures, m.c. in grains is higher than 13.5%, risks of fungal development and attack increase (Rodríguez and Bartosik, 2006). Therefore, maintaining grains at low and constant temperatures is the best method for their long-term conservation, because the higher the temperature, the lower the grain moisture for a given relative humidity of the intergranular air.
The use of shade cloth has been one of the most efficient methods to maintain intergranular air temperature below ambient temperature. However, this technique has not been tested in soybean storage in plastic bags (Casini et al., 2006).

2. OBJECTIVES

This work aims at evaluating the effect of shade cloth cover on physiological quality of soybean seeds with different seed m.c. during storage in plastic bags. Also it aims at gathering information about m.c. and storage time in plastic bags for storing soybean seed without risk of seed deterioration.

3. MATERIALS AND METHODS

Silo bags were located in the locality of Lincoln, northwest of the province of Buenos Aires, Argentina, (34º 52’3.70’’S, 61º 32’ 08.50’’ W, 80 m a.s.l.).
Two soybean cultivars were employed: A-3770 RG (Nidera seeds) maturity group 3 (stored in two bags, with seed m.c. of 10.4% and 15.5%, respectively), and A-4910 (Nidera seeds) maturity group 4.9 (stored in one bag, with seed m.c. of 15.7%). Both cultivars were stored in April.
Seeds were stored in plastic bags that were 6 ft in diameter, 60 m in length and about 152 m^3 in volume. Bags had a capacity of approximately 110 tons (t). The sheet was 250 μm thick,
In July, shade cloth (80%) cover was installed over half of each plastic bag; the shade cloth was 30 m long and was suspended 50 cm above the plastic bag, allowing the passage of air between the cloth and the bag (fig. 1) to reduce the effects of solar radiation (Casini, 2002).

Figure 1. Shade cloth cover suspended on plastic bag.

Each bag was divided into two parts: one part with shade cloth cover (with SCC) and the other without shade cloth cover (without SCC). Within each part sampling was conducted in three sectors, which were defined according to their relative position inside the bag: Top, from the grain surface in contact with the plastic down to 0.1 m; Middle, from 0.1 m to 0.6 m; Bottom, from 0.6 to 1.2 m.

Seed Germination (SG) (ISTA, 1999) was estimated from the grain samples. This is the most sensitive variable to any alteration in the seed during storage and is the most important variable in the production of seeds for commercialization.

Also, data were recorded at different moments during seed storage. Temperature and relative humidity of intergranular air were recorded with a probe provided by Stagtron; seed moisture was determined with the automatic humidimeter Tesma A-79.

4. RESULTS AND DISCUSSION

4.1 Seed Germination

Data obtained throughout the assay from the different parts (with and without SCC) and the three sectors defined according their position with respect to the plastic surface for the varieties A-4910 and A-3770 RG (stored with seed m.c. of 15.5 and 15.7%, respectively) showed a different behaviour between varieties. At the start of the assay both varieties had a similar SG (between 95 and 96%). As storage period progressed, however, the variety A-3770 RG showed a better behaviour, regardless of the parts or sectors inside the bag (fig. 2 , 3, 4), reaching a SG value of 87% in October, at the end of the assay (minimum value recorded in the Top sector without SCC). It should be noted that in October seeds are usually processed for further commercial sale and sowing.

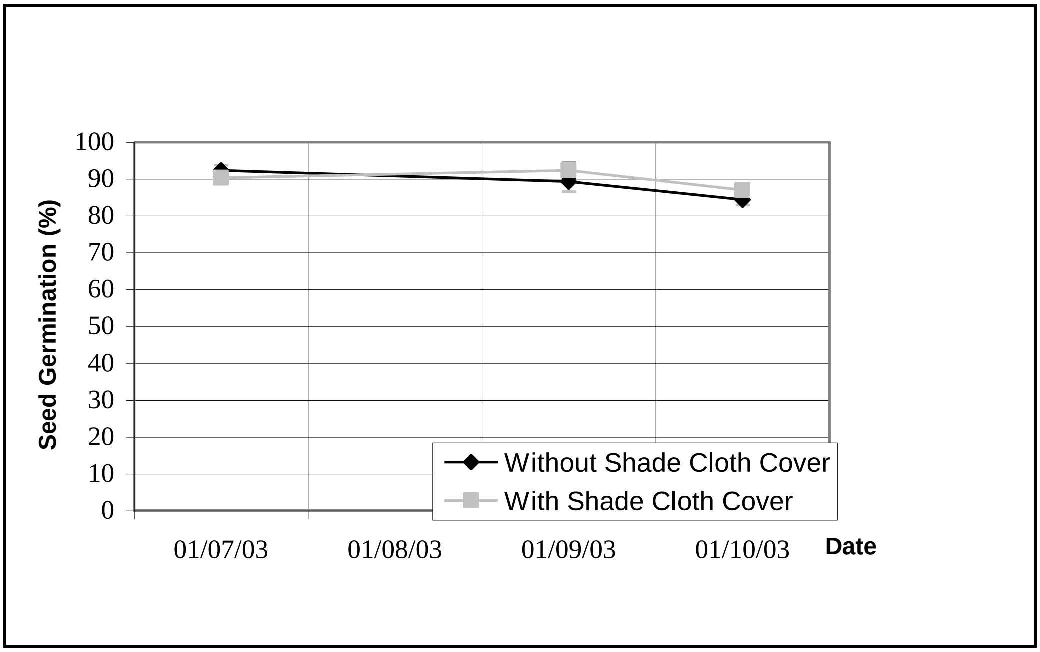

Figure 2. Seed germination of the variety A-3770 RG (initial moisture content of 15.5%). Top sector.

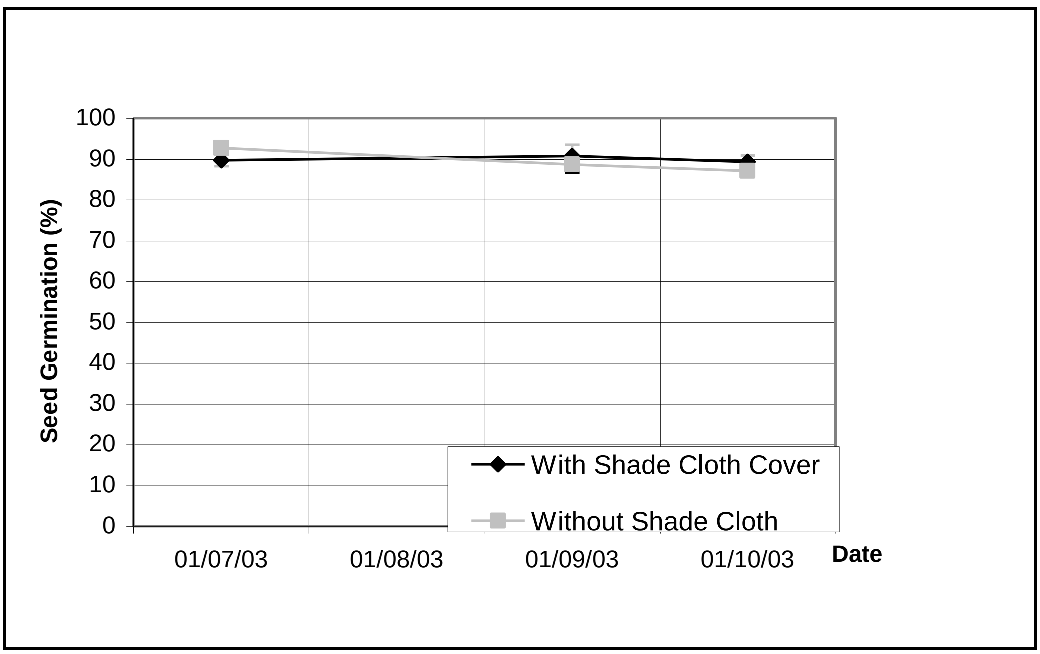

Figure 3. Seed germination of the variety A-3770 RG (initial moisture content of 15.5%). Middle sector.

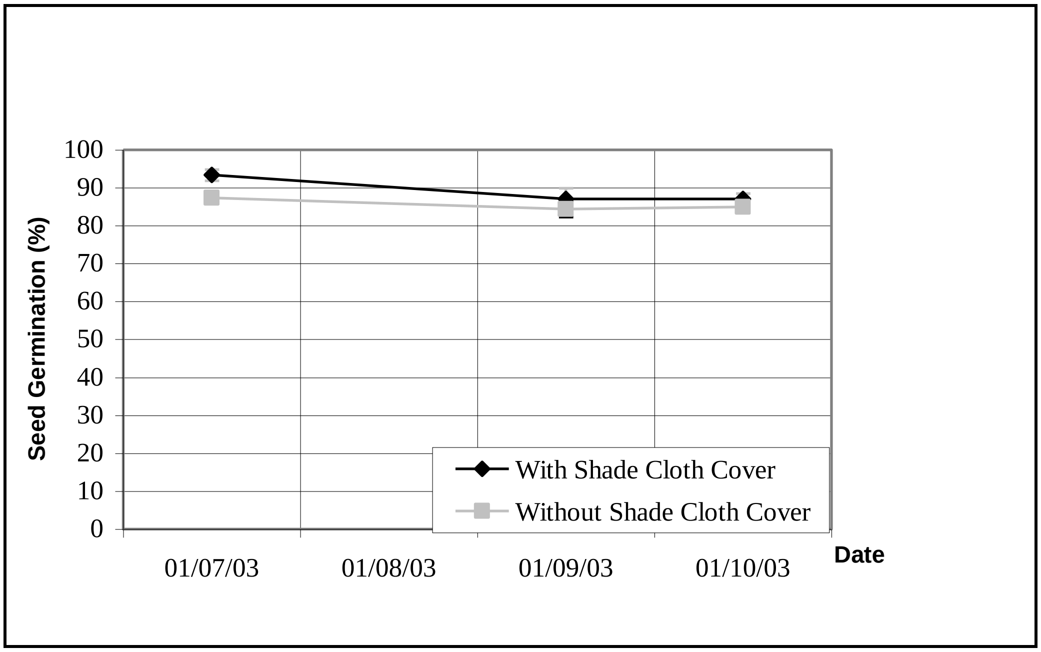

Figure 4. Seed germination of the variety A-3770 RG (initial moisture content of 15.5%). Bottom sector.

SG for the variety A-4910 in the part without SCC was 74% for the Top sector and 77% for the Middle and Bottom sectors; these values are below the minimum of 80% required for commercial use of soybean seeds. In the part with SCC, only seeds from the Top sector (up to 0.1 m from the plastic surface) did not exceed the minimum SG value required, reaching a SG of 74% in October (fig. 5), whereas the Middle sector had a SG of 83% and the Bottom sector, 88% (fig. 5). In this case, seeds were maintained in the storage bags until December, when the Top sector had a SG of 70% in the part with SCC and of 22% in the part without SCC. In the Middle and Bottom sectors with SCC, SG was 83% and 90%, respectively, and in the part without SCC, SG was 60% and 74% for the Middle and Bottom sectors of the bag, respectively (fig. 6 and 7).

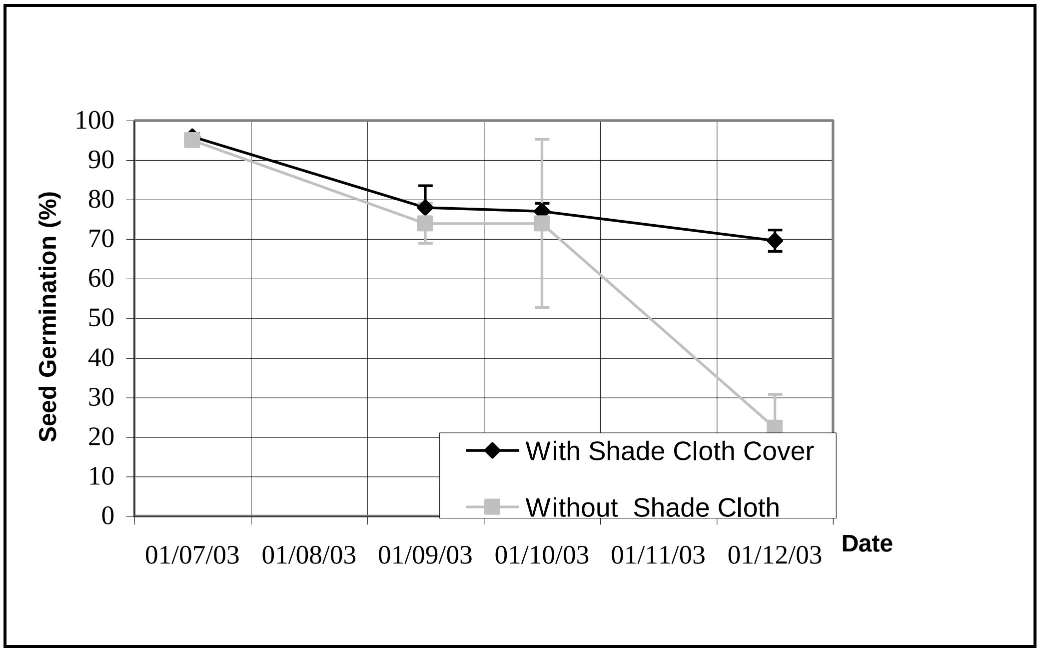

Figure 5. Seed germination of the variety A-4910 (initial moisture content of 15.7%). Top sector.

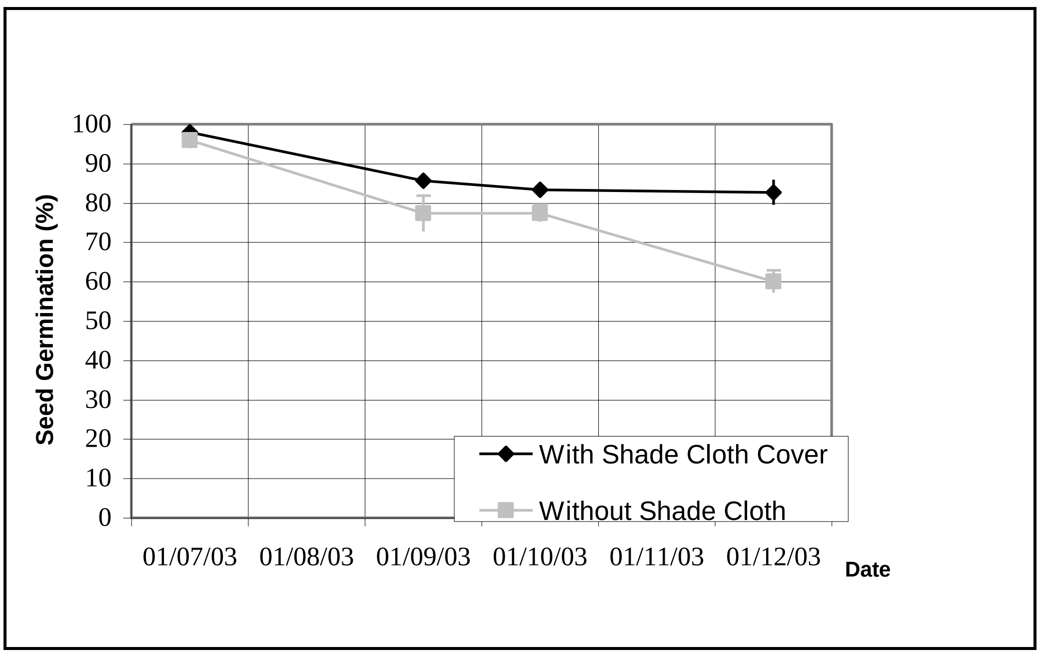

Figure 6. Seed germination of variety A-4910 (initial moisture content of 15.7%). Middle sector.

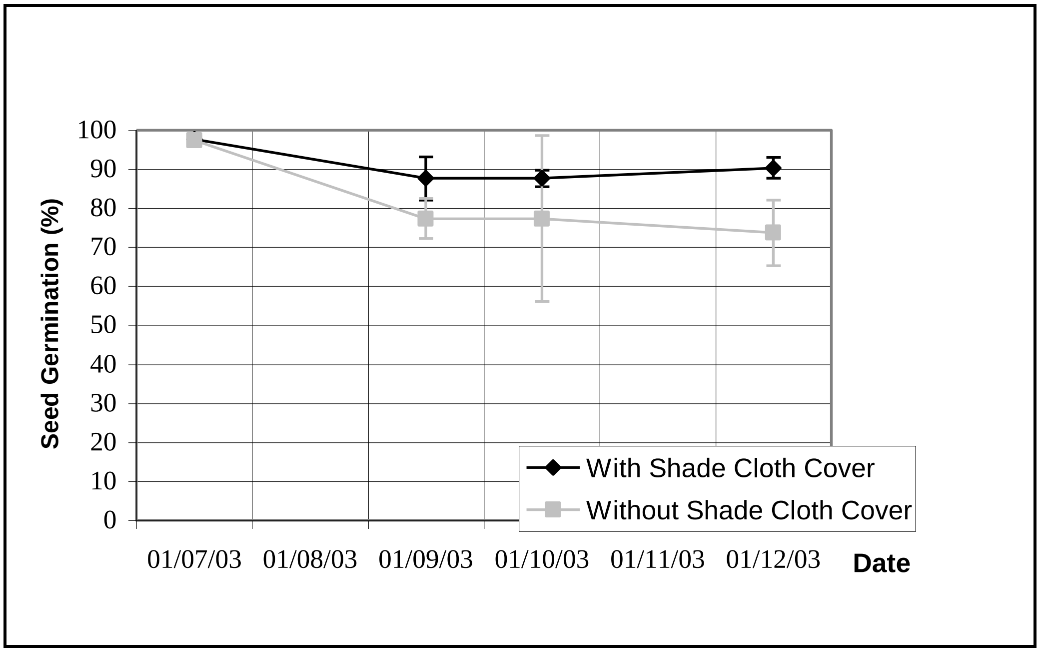

Figure 7. Seed germination of the variety A-4910 (initial moisture content of 15.7%). Bottom sector.

SG values of the variety A-3770 RG stored with average seed m.c. of 10.8% were above 92% in the three sectors with SCC all throughout the assay. In the Top sector without SCC, SG was 87%, and both in the Middle and Bottom sectors, SG was 91% (fig. 8, 9, 10).

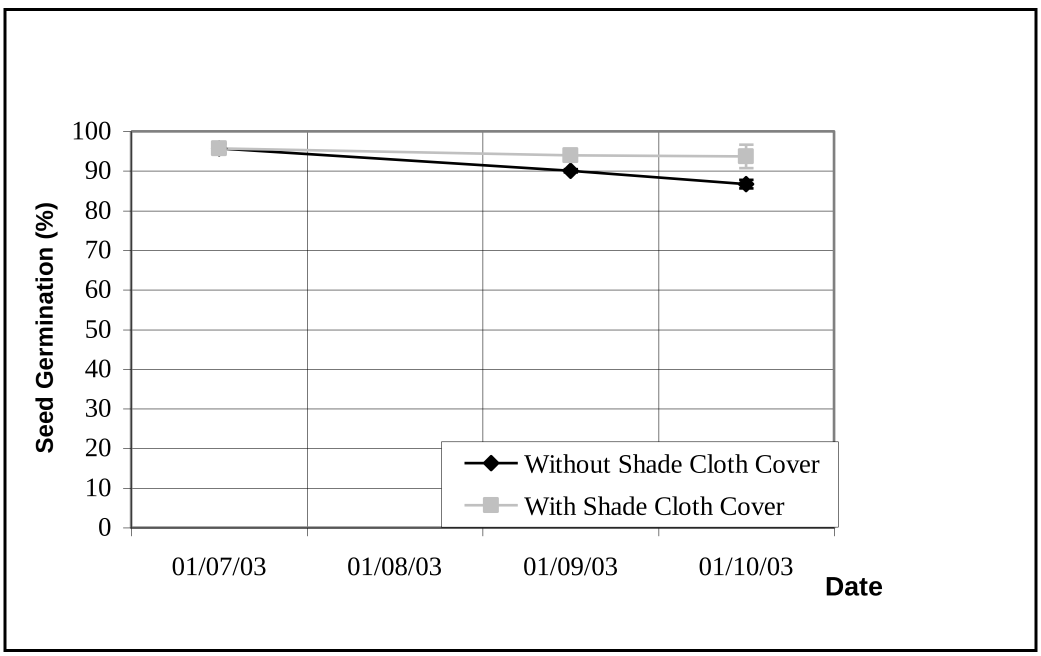

Figure 8. Seed germination of the variety A-3770 RG (initial moisture content of 10.8%). Top sector.

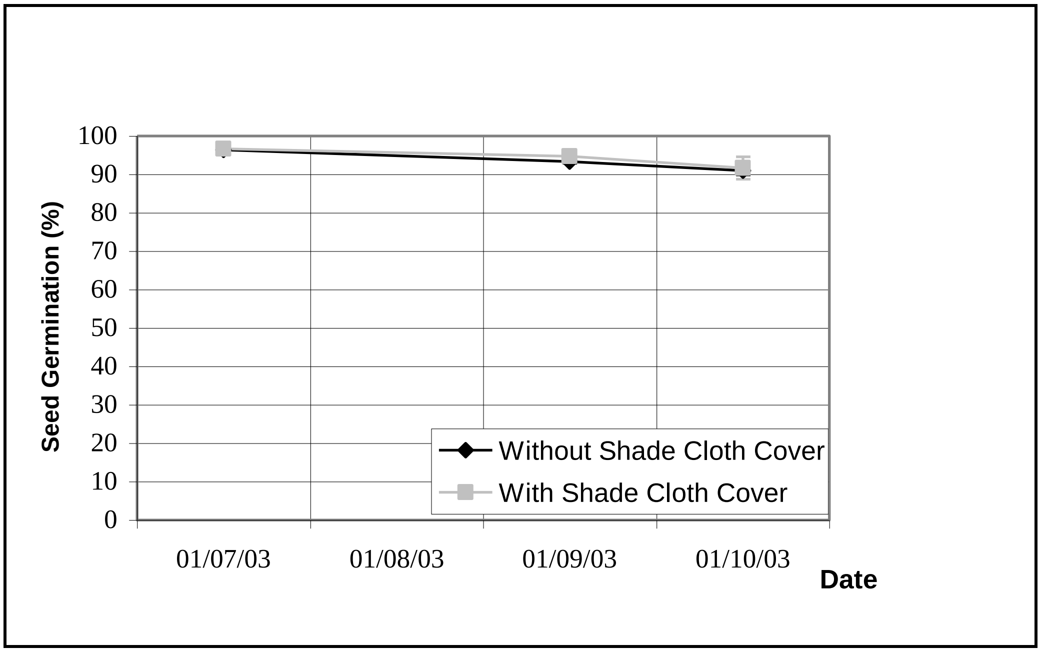

Figure 9. Seed germination of the variety A-3770 RG (initial moisture content of 10.8%). Middle sector.

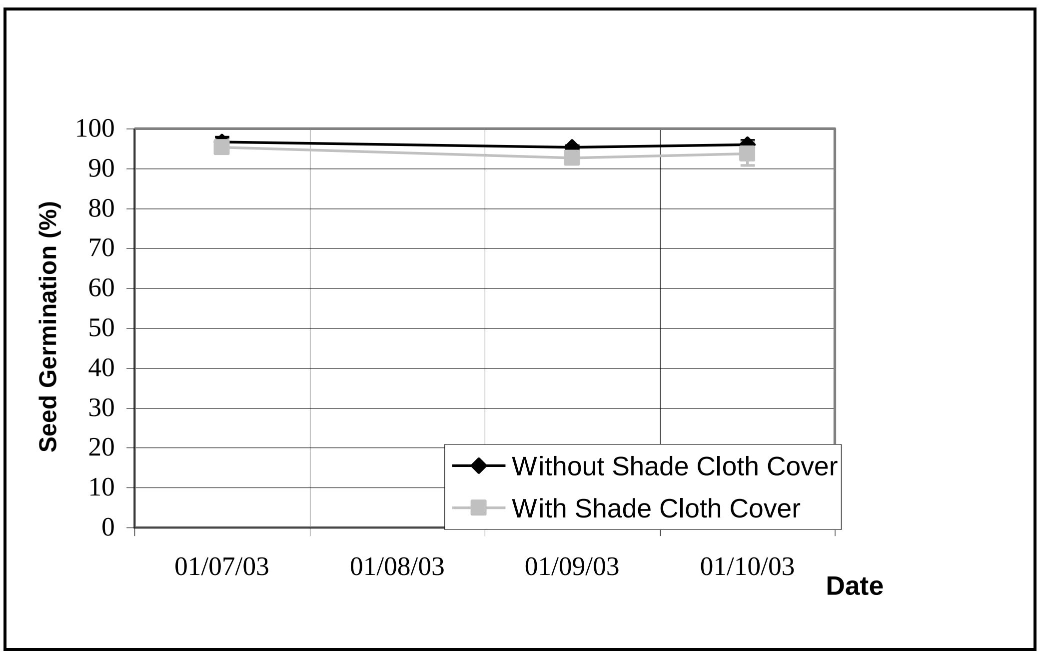

Figure 10. Seed germination of the variety A-3770 RG (initial moisture content of 10.8%). Bottom sector.

4.2 Temperature of the Intergranular air

Data of grain temperature of the intergranular air recorded at different points of the grain mass from the plastic surface transversally up to 1.2 m deep showed that temperature was always higher in the part without SCC than in the part with SCC for both varieties (A-3770 RG and A-

4910) (fig. 11 and 12). This difference was of 4.5 ºC for the variety A-4910 and of 2 ºC for the variety A3770 RG, and the maximum values were recorded near the plastic surface. This is because grains have very low thermal conductivity, i.e., they have insulating capacity, which means that in the short period evaluated ambient temperature values were not high enough or high temperature values did not last long enough so as to affect grain temperature, as recorded by Casini and Santa Juliana (2006). Indeed, these authors found that shade cloth cover caused a 5.38 ºC difference in December, whereas in the July-September period no differences between parts with and without SCC were detected.

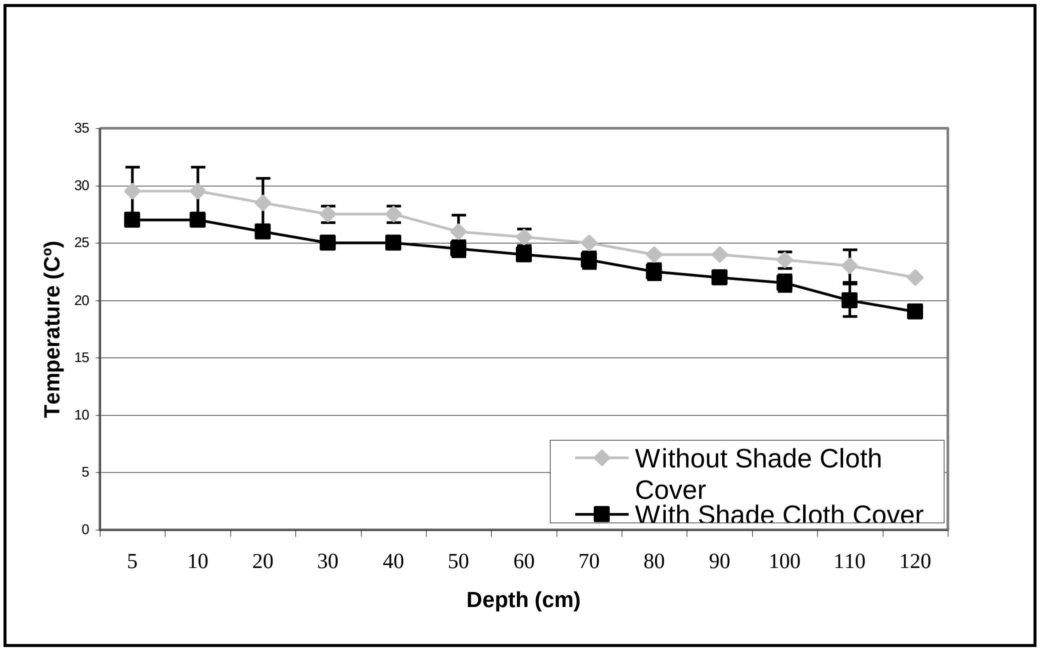

Figure 11. Grain temperature recorded at different depths within the grain mass (variety A-3770 RG).

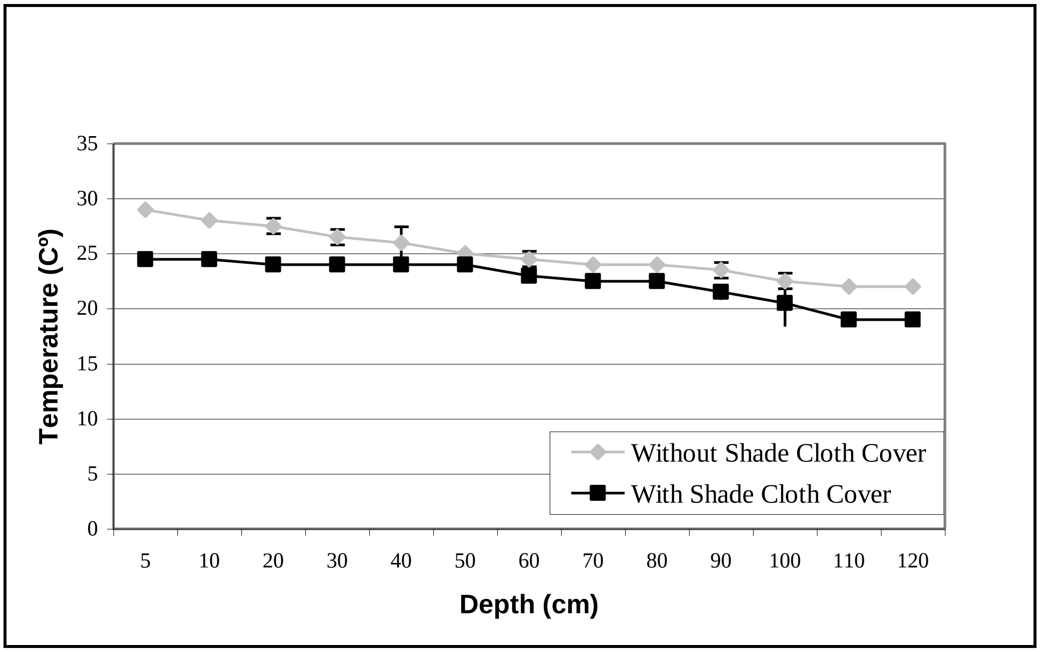

Figure 12. Grain temperature recorded at different depths within the grain mass (variety A-4910 RG).

The information obtained about temperature is in agreement with other works (Luque and Casini, 2003; Casini and Santa Juliana, 2004), which also reported that grain temperature inside hermetically closed plastic bags followed the average ambient temperature pattern. This effect was also reported by other authors (Bartosik et al., 2002; Pozzolo et al., 2005; Pozzolo et al., 2006; Cardoso et al., 2008a; Hidalgo et al., 2008).

When soybean was stored in late autumn or early winter, initial grain temperature had minimum values, increasing with increased ambient temperature in spring, and reaching maximum values in summer. The bag proved useful for grain heat transfer into the air and soil two months after storage. The reason for this might be that the volume/area relationship is significantly lower for a plastic bag (0.7 m^3/m^2 for a 200 t bag) than for a traditional storage system (metal bin) of similar capacity (1.27 m^3/m^2 for a silo of 7 m in diameter, 9 m in height, 200 t capacity) (Bartosik et al., 2004).

4.3 Relative Humidity of Intergranular Air and Seed Moisture Content

Seed m.c. was determined at the moment of bagging the different soybean varieties. At the end of the assay samples were taken from the two parts (with and without SCC) and the three sectors (Top, Middle, and Bottom). The data for the variety A-3770 RG, stored with an average initial seed m.c. of 10.8%, did not show variations.

Independently of the presence or absence of shade cloth cover and of the sector, no variations in seed m.c. were recorded during the assay period (fig. 13).

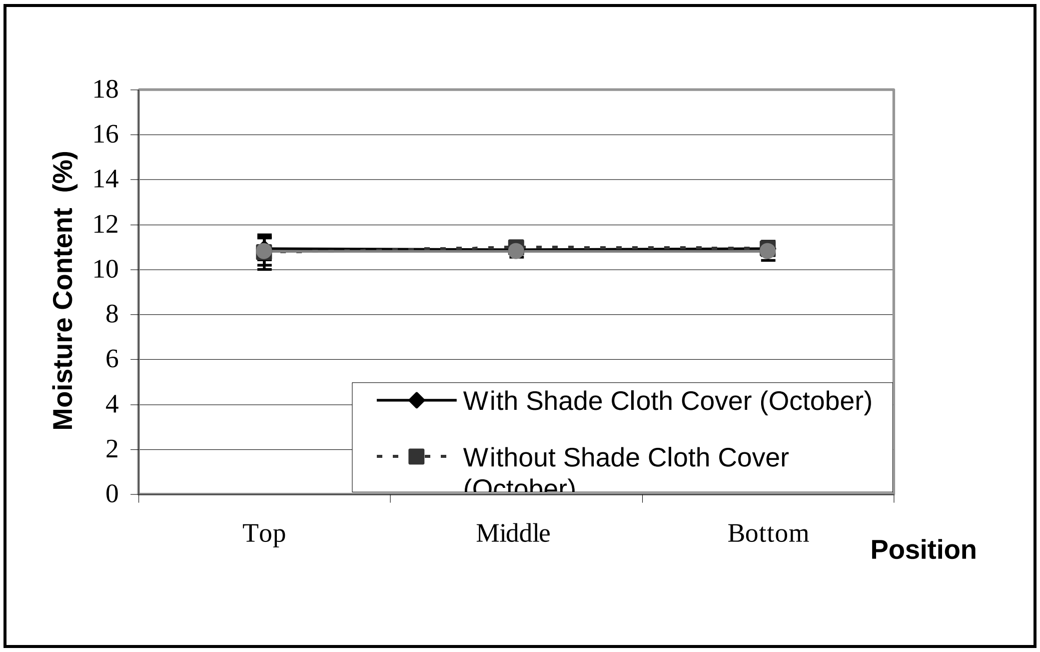

Figure 13. Evolution of grains moisture content (variety A-3770 RG).

In the same variety, A-3770 RG, but stored with an average seed m.c. of 15.5% (fig. 14), an increase in m.c. of the order of approximately one point was observed in the Top sector of the part without SCC, the average value in that sector being 16.4% at the end of the assay. This increased moisture effect might have been due to repeated water condensation and/or adsorption cycles in the upper seed layer, caused by daily oscillations in temperature, especially in spring. With temperature decrease during the night, RH reached values of up to 100%; thus, condensation on the seed surface and the plastic cover occurred, increasing seed m.c. of the upper layer over time. This condition of high seed moisture (and high RH%) in the Top layer may generate suitable conditions for the development of yeast and other anaerobic microorganisms that affect grain quality and characteristics.

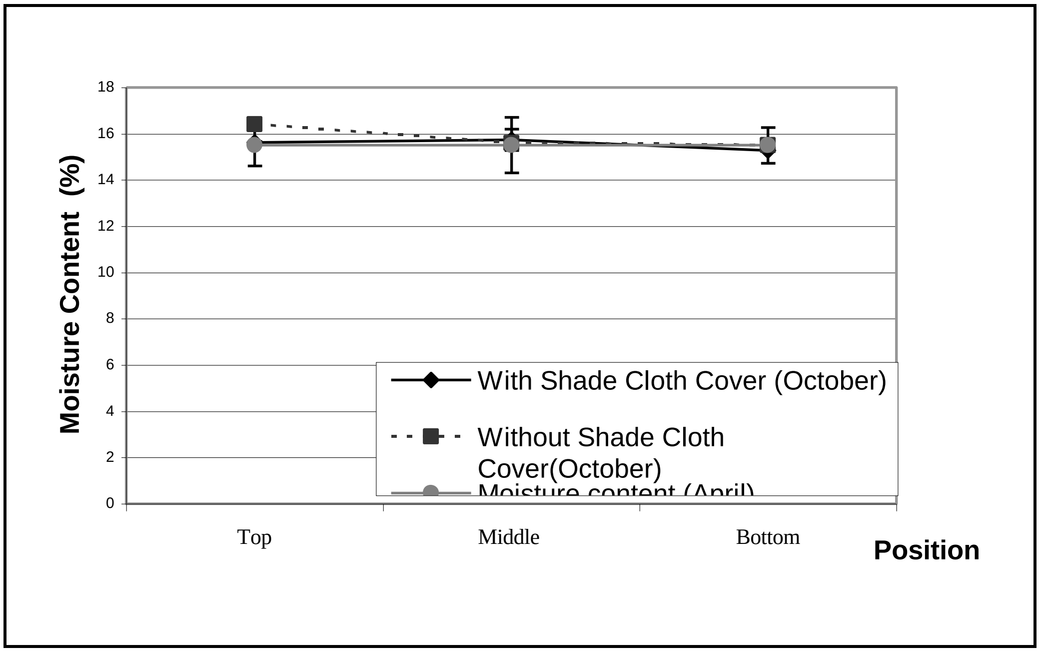

Figure 14. Evolution of grain moisture content (variety A-3770 RG).

These results agree with data of temperature (fig. 11 and 12) and RH (fig. 15 and 17) which showed an increase in RH in the Bottom sector of the part without SCC, reaching values of 100% in the top 10 cm within the seed mass. However, in the sector with SCC, RH of the intergranular space was of 82% and 77% at depths of 5 and 10 cm, respectively. In addition, in the remaining part of the profile observed, RH in both parts presented similar values, exceeding the 67% safe limit established for the development of the different fungus species that occur in the grains (Lacey et al., 1980). However, the part with SCC exhibited a better RH performance under storage conditions of high seed m.c., showing values along the profile sensitively lower than in the part without SCC.

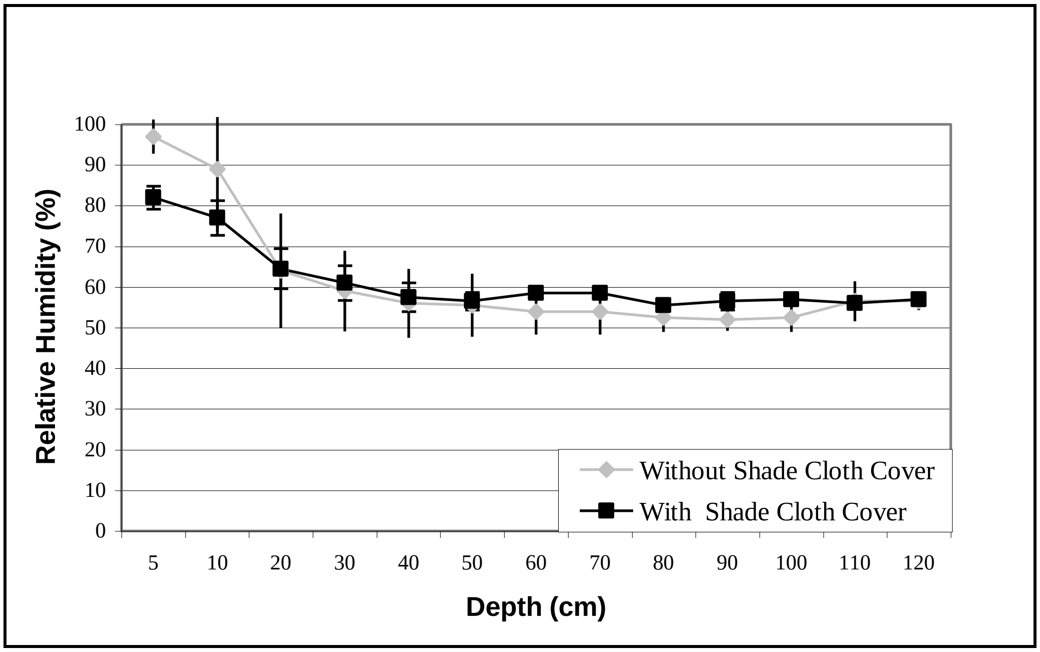

Figure 15. Relative humidity of the bulk atmosphere (variety A-3770 RG).

The same behaviour was observed for the variety A-4910 (fig. 16), with an initial average seed m.c. of 15.7%. At the end of the assay period, moisture of the seeds taken from the Top sector of the part without SCC exhibited an average value for the three sectors of 15.6%, a value similar to that of grain moisture at the start of the assay. However, in the Top sector without SCC the value was 0.7% higher, and in the lower part the average seed m.c. at the end of the assay was 0.9 % lower than the initial moisture value. This stratification is due to moisture migration inside the bag, either by convective air movements (Casini, 2004) or water vapour migration to the surface, ending with condensation of moisture on the grain and the internal bag wall. This effect is strong in areas with great thermal amplitude (La Nación, 2004). Hence, temperature of the grain stored in silobags is modified due to different reasons, and therefore the equilibrium between the grain and the environment is locally altered. These temperature gradients within the grain mass produce moisture migration from the hottest areas to the coldest ones; such redistribution may generate hot spots suitable for grain spoilage (Gastón et al., 2007). Hot air is in equilibrium with grain moisture. When convective movements move hot air upwards, either of two situations may occur: if hot air is saturated or almost saturated, when moving to colder areas its humidity retention capacity decreases and it condensates. On the other hand, if temperature decrease is not enough to condensate or the air is far from its saturation point, when the air moves to colder areas its RH increases, producing an unbalance between air humidity content and seed m.c., which leads to a passage of humidity from air to seeds over time. It should be taken into account that depending on the type of seed stored the intensity of the humidity stratification phenomena occurring inside the bag varies.

Soybean seeds are more hygroscopic than corn seeds and therefore the condensation process not only influences moisture of those seeds that are in contact with the bag wall but also produces a stratification of mean humidity over time (Rodríguez et al., 2001). Such stratification is not important enough to mitigate homogenization of moisture at the grain level that occurs inside the bag (Cardoso et al., 2008b).

The stratification observed in the part without SCC was not observed in the part with SCC.

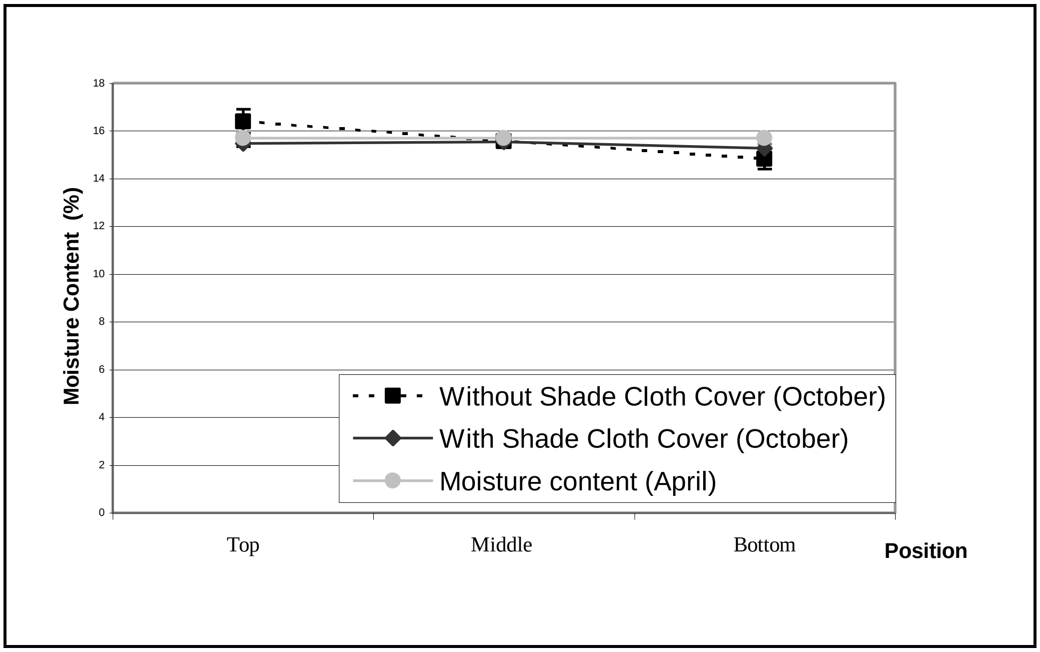

Figure 16. Evolution of grain moisture content (variety A-4910).

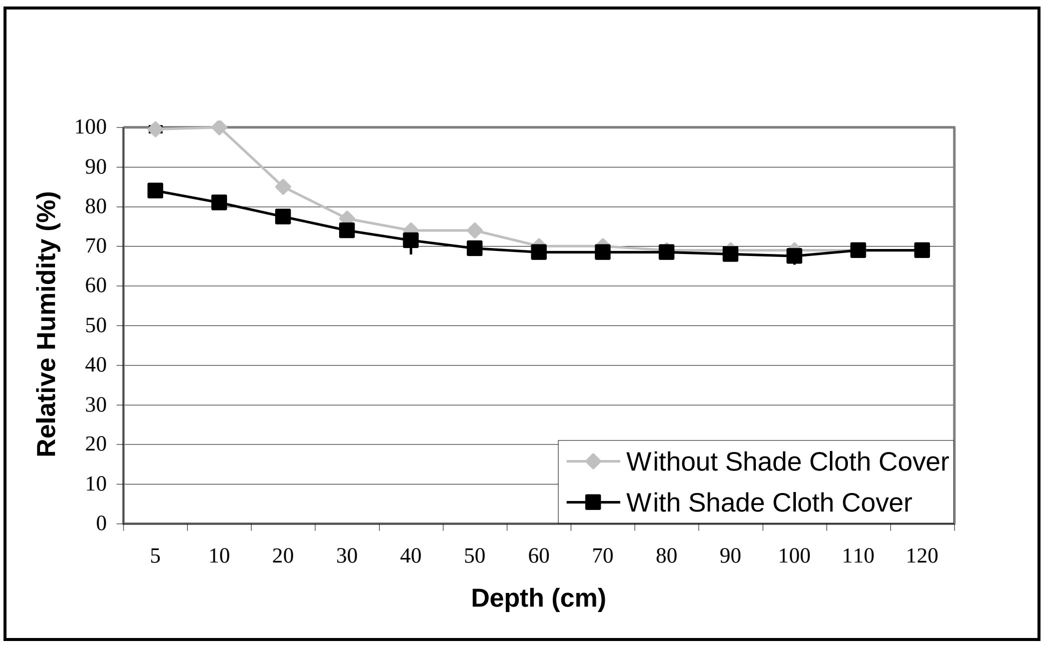

Figure 17. Relative humidity of the bulk atmosphere (variety A-4910).

5. CONCLUSIONS

The results of this work show that shade cloth cover was effective to preserve SG when seeds stored had high moisture content. Moisture stratification was not observed in the part with shade cloth cover; cover was very effective to reduce seed deterioration. Seeds with high m.c. and stored without SCC showed a strong decrease in SG. Differences in the bag profile (sectors) were also observed. This is because of seed moisture stratification due to high relative humidity of the intergranular air in the Top sector of the bag. A difference in behaviour between varieties was also observed.

With seed m.c. of 10.8%, the use of shade cloth cover did not show differences that may justify its use.

Seed moisture was the main cause of the decrease in SG of the different varieties. SG decrease was more noticeable in seeds with highest m.c., not only considering the variety, but also in the different sectors of the bag. In the Top sector, where moisture stratification was greatest and temperature increased, SG deterioration was most important.

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