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Bulk soybean grain mass temperature in warehouses with isolated vents and vent-exhaust combined systems

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ABSTRACT: *This study aimed to compare the temperatures in the mass of bulk soybeans (**Glycine max**) in warehouses with isolated vents and vent-combined exhaustion. A completely randomized design was used, with two treatments and ten repetitions. Treatments consisted of warehouse with curved vents and warehouse with curved + static exhaust vents. Each repetition contained the average of all readings in three days in all cables of the warehouse part under study, totaling 10 repetitions per month. The variable analyzed was the temperature in the grain mass in the lower, middle and upper parts of the warehouse from January to May 2012. The environment temperature and humidity were also registered. Static hoods, along with curved vents on the roof of the warehouse showed a tendency to reduce the temperature of the soybean mass with decrease in environmental temperature and increase in relative environmental humidity.*
Key words: *static exhaust, **Glycine max**, post-harvest and curved vents.*

Temperatura da massa de grãos de soja a granel em armazéns com respiros isolados e em conjunto com exaustores

RESUMO: *Este trabalho teve por objetivo comparar as temperaturas na massa de grãos de soja (**Glycine max**) a granel, em armazéns verticais metálicos munidos de respiros isolados e em conjunto com exaustores. Foi utilizado o delineamento experimental inteiramente casualizado, sendo dois tratamentos com dez repetições. Os tratamentos consistiram em armazém com respiros curvos e armazém com respiros curvos + exaustores estáticos. Cada repetição continha a média das leituras de três dias em todos os cabos do setor do armazém em estudo, totalizando as 10 repetições por mês. A variável analisada foi a temperatura na massa de grãos nos terços inferior, médio e superior do armazém, do mês de janeiro ao mês de maio de 2012. Também se registrou a temperatura e umidade relativa ambiente. Conclui-se que os exaustores estáticos, agregados aos respiros curvos no teto do armazém, apresentam tendência de redução da temperatura na massa de grãos de soja com decréscimo da temperatura e aumento da umidade relativa do ar ambiente.*
Palavras-chave: *exaustores estáticos, **Glycine max**, pós-colheita e respiros curvos.*

Great part of the soybean (***Glycine max***) produced in Brazil is stored in bulk. Grain storage aims product conservation. The objective is to reduce losses, protecting it and preserving the grain biological, chemical and physical properties (ZUCHI et al., 2013).

Varying temperatures of the grain mass cause air convection currents. Movement of humidity in the ecosystem creates points of high relative humidity and high grain humidity content and, consequently, points with environmental conditions which favor the development of insects and fungi (MISHRA, 2012).

Vents and/or exhaustion systems are istalled on the warehouse roofs aiming to equalize the silo in ternal pressure during the loading/unloaing processes, since providing the aeration air exit makes easier to re move gases originated from the stored grain ecosystem and dislocating the hot air acculated in the warehouse upper part through the convection currents. There fore, the possibility of water vapor concentrated in the warehouse ceiling, the oxidtion of metallic structures, the grain germination, the proliferation of plagues and safety risks are reduced (JIAN & JAYAS, 2012).

The difference between curved vents and exhaust vents is that the latter have autonomous ehaust power. According to the Storage Unit Certi fication National System, every storage unit, whose construction or expansion was started after the publi cation of the norm 12/2009 of 12/05/2009 must have an air exhaustion system, either natural or mechani cal. For the existing units, a time of five years of that

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same date was allowed for the installation or adapta tion of such equipment (MAPA, 2010).

The grain storage capacity in Brazil was studied by PATINO et al. (2013), methods of insect management in stored products were verified by PHILLIPS & THRONE (2010), and NASCIMENTO et al. (2012) analyzed the consequences of different aeration strategies in stored grains.

However, the authors of this study have not reported in the literature any scientific paper comparing curved vents and exhaust vents installed on the grain warehouse roofs. Therefore, this study aimed to compare the temperatures of bulk soybean grain mass, in metallic vertical storage units with isolated curved vents or with a vent- static exhaust combination.

The study was developed in a storage unit belonging to the company Cargill Agrícola® S/A, located in the city of Ponta Grossa – PR. A completely randomized experimental design was employed, comprising two treatments and ten repetitions. Treatments consisted of a warehouse with curved vents and a warehouse with curved vents + static exhaust vents.

Two vertical metallic storage units were used, measuring 30 meters high and 26 meters diameter. Each unit had a capacity of approximately 12 thousand tons. One of the units was provided with 64 curved vents on the roof, and the other had 64 curved vents and 16 static exhaust vents Cycloar®, all evenly distributed in the upper part of the storage unit (Figure 1).

Each warehouse presented nine thermometry cables. Each cable presented temperature sensors at 1,5 meter interval, placed in vertical position in the grain mass. Therefore, the storage unit was in accordance with the norm n. 12/2009, with at least one reading point at each 100m^3 static capacity, and the points were placed in a similar way (MAPA, 2010). All the thermometry system was monitored by the software Fockink®.

The variable under analysis was the soybean grain mass temperature at different depths in the warehouses with isolated curved vents and vent-static exhaust combined systems. The data was computed according to the thermometry report, considering the period between January and May 2012, with the register of average temperatures in the lower, middle and upper parts of the warehouse. Also, temperature and external air relative humidity throughout the period were recorded.

Each repetition presented the average of a three-day reading in all cables of the part of the warehouse under study, totaling 10 replications a month. The homoscedasticity of variances was verified through the Hartley test. Variance analysis through the F test was applied, along with the comparison of averages through the Tukey test, with over 95% confidence level of probability.

Hartley test revealed the variance homoscedasticity, and there was no need for transforming the averages to apply the F and Tukey

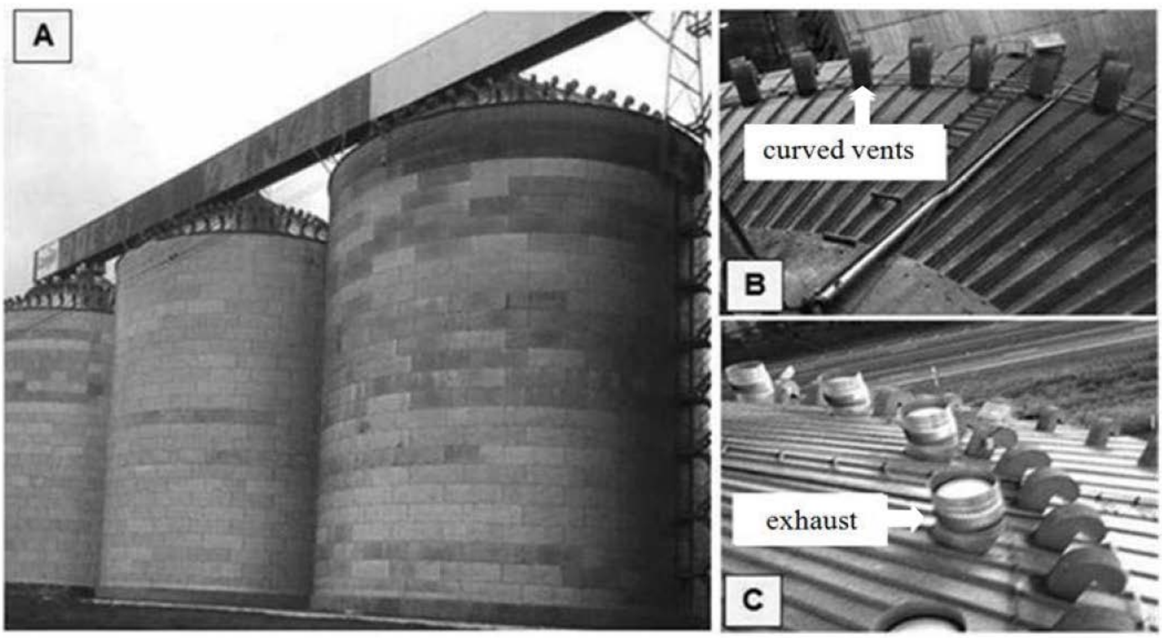

Figure 1 - Vertical metallic warehouses (A) 30m high and 26m diameter, full of bulk soybean, with curved vents on the roof (B) and with vent + exhaust system (C), Ponta Grossa – PR.

tests. Throughout January, February and March the temperatures did not present statistical difference in the three parts of the storage units. This result might be associated to the lower relative humidity and higher air temperature when compared to the remaining months of evaluation (Table 1).

The variance analysis showed significant difference, with a confidence level of 95% probability in April, when the average temperature in the warehouses with curved vents and vents + static exhaust systems were compared. Temperatures in the warehouses did not differ statistically regarding the grain mass and the different depths under study.

In April, the warehouse with bulk soybean and vent-static exhaust system presented average temperature in the lower, middle and upper parts below the warehouse with curved vents only.

In May, the tendency observed in April remained in the lower and middle parts, when comparing both warehouses. However, when comparing the grain mass temperature at different depths, the variance analysis revealed temperature reduction in the upper part of the warehouse with curved vents only. The vent-static exhaust combined the system kept under homogeneous temperature in the points under study.

With reduction in temperature, there was a reduction in the possibility of convection currents in the warehouse. The benefits mentioned by JIAN & JAYAS (2012) and MISHRA (2012) could be: reduction in the possibility of condensation of the water vapor present in the warehouse ceiling, oxidation of the warehouse metallic structure, grain germination, proliferation of plagues and safety risks.

In April and May, period in which the difference between treatments was observed in certain parts of the storage unit, the lowest temperatures and highest air relative humidity percentages were recorded, when compared to the other months. These factors associated to the static exhaust system added to the warehouse roof might have cooperated with the grain mass temperature reduction. Therefore, the importance of installing exhaust systems in the storage units, following MAPA (2010) recommendation through Norm n. 12/2009 was confirmed.

Static exhaust systems along with curved vents on the warehouse roof were seen to present a tendency to reduce the soybean grain mass temperature when there was reduction in temperature and increase in the air relative humidity.

Table 1 - Bulk soybean grain mass average temperatures, in different parts of vertical metallic warehouses with curved vent and exhaust systems, from January to May 2012, Ponta Grossa – PR.

Treatments	Lower part temperature (ºC)	Middle part temperature (ºC)	Upper part temperature (ºC)	Air temperature (ºC)	Air relative humidity (%)
---January---					
vent	23.7 a[1]A[2]	24.6 aA	24.3 aA		
vent + exhaust	22.8 aA	23.5 aA	23.3 aA	21.3	77.8
CV (%)	6.2	7.5	7.8		
---February---					
vent	26.2 aA	27.9 aA	28.2 aA		
vent + exhaust	25.3 aA	26.3 aA	26.7 aA	23.6	71.5
CV (%)	10.0	6.7	9.1		
---March---					
vent	24.8 aA	25.8 aA	25.0 aA		
vent + exhaust	23.7 aA	24.5 aA	24.1 aA	20.5	72.4
CV (%)	10.5	13.3	12.4		
---Abril---					
vent	27.9 aA	30.2 aA	29.2 aA		
vent + exhaust	22.7 bA	24.9 bA	25.2 bA	19.0	83.2
CV (%)	10.1	16.8	12.0		
---May---					
vent	21.6 aA	22.4 aA	19.6 aB		
vent + exhaust	19.4 bA	18.6 bA	18.7 aA	17.2	81.7
CV (%)	9.7	12.8	12.7		

1. Averages followed by the same small letter in the column did not differ in the F test (P > 0,05).
2. Averages followed by the same capital letter in the line did not differ in the Tukey test (P >0,05).

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