Effect of spray volume on the moisture of stored corn and wheat grains

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Abstract

Insecticide spraying is the main method of preventive pest control in stored products. The goal of this work was to evaluate the effect of spray volume on the moisture of stored grains of corn and wheat. Two kg of each type of grain were placed into plastic bags and sprayed with theoretical doses of zero, 1, 3, 5, 8, and 10 liters of water per ton of grain. Grain moisture content was evaluated 24 hours after the spray operation by the oven method. The increase in grain moisture was quadratic and showed the same trend in both corn and wheat. Grain moisture after spraying 10 L t\(^{-1}\) showed little increase (0.8 \%) as compared to the initial moisture content. Thus, the application of any spray volume as used in this study makes no difference for a possible better uniformity in the distribution of insecticide throughout the sprayed material.

Key words: Stored products, chemical control, application technology, desorption, hygroscopic equilibrium.

Introduction

Moisture content is the most important factor for grain preservation during storage. Grain stored with high moisture contents is subject to great losses caused by the attack of insects and fungi.

Spraying the grain with residual insecticides is the most important method of preventive pest control used in storage facilities; in order to prevent the grain from regaining moisture, storage companies use low mix volumes, in the order of 1 to 2 L t\(^{-1}\); however, studies can be found in the international literature on the effectiveness and residues of insecticides under laboratory conditions, in which a variety of spray volumes are used, ranging from 0.7 L t\(^{-1}\) (Arthur et al., 1991) to 10 L t\(^{-1}\) (Daglish et al., 1996).

Under laboratory conditions, it is very difficult to treat grain with low mix volumes, and disuniformity in the distribution of the insecticide may occur; on the other hand, high mix volumes favor distribution of the insecticide, but can increase grain moisture content up to levels that may compromise its effectiveness.

The maximum protection period provided by...
insecticides depends mainly on characteristics of the grain, and moisture content is one of the most important factors in insecticide degradation (Fleurat-Lessard, 2002).

Grain metabolic activity increases rapidly at moisture contents higher than 14% (Rowlands, 1967). Rowlands (1967), observed that the enzymatic activity catalyzing oxidation-reduction and hydrolysis reactions in wheat grain increased markedly when the moisture content in the grain was higher than 15%.

Several authors have demonstrated a loss of effectiveness in organophosphorus insecticides in corn and wheat grains at moisture contents higher than 14% (Watters, 1959; Strong and Sbur, 1960, 1964; Rowlands, 1966; Samson et al., 1987).

Samson et al. (1988) and Afridi et al. (2001) demonstrated that organophosphorus insecticides are less stable than pyrethroids in corn and wheat grains with moisture contents higher than 13%. The objective of this work was to evaluate the effect of spray volume on the moisture content of corn and wheat grains under laboratory conditions.

Material and methods

The experiment was conducted at the Insecticide Toxicology Laboratory of Departamento de Entomologia, Fitopatologia e Zoológia Agrícola of Escola Superior de Agricultura “Luiz de Queiroz” (ESALQ/USP). The moisture content determinations for the grain were performed at the Seeds Laboratory of Departamento de Produção Vegetal at ESALQ/USP, in Piracicaba, SP, Brazil.

A triple-stack yellow semiflint HT 98A corn hybrid and wheat cultivar BRS 208 were used, both developed by Empresa Brasileira de Pesquisa Agropecuária (Embrapa - Brazilian Agricultural Research Corporation).

Spraying was achieved by placing 2 kg grain into plastic bags; each bag received one of six water volume treatments: zero, 1, 3, 5, 8, or 10 mL kg⁻¹, corresponding to theoretical applications of zero, 1, 3, 5, 8, and 10 L t⁻¹. Applications were performed using a sprayer attached to an air compressor at a constant pressure of 150 kPa. During spray, the plastic bags were agitated by hand, so as to allow distribution of the liquid to be as homogeneous as possible. After spraying, the grains were kept inside open plastic bags and stored in the laboratory under uncontrolled conditions for a period of 24 hours, after which the water content in the grain was evaluated by means of the oven method at 105 °C ± 3 °C for 24 hours, according to Regras para Análise de Sementes – RAS (Seed Analysis Procedures) (Brasil, 1992). The temperature and relative humidity in the laboratory ranged from 20.3 to 27 °C and from 36 to 55 %, respectively.

Data analysis was performed by analysis of variance, using a mathematical model for a completely randomized design in a factorial arrangement, and the F test was used to measure the significance of factors (grain species, spray volume, and grain species × spray volume) in the model (Stell and Torrie, 1970; Pimentel-Gomes, 1987). Polynomial regression analysis was used to produce a detailed spray volume factor analysis.

Results

The analysis of variance for corn and wheat grain moisture is presented in Table 1. There was a significant effect \((P < 0.0001)\) of grain species and spray volume, but no effect of the species × volume interaction was observed. This result indicates that the spray volume effect on grain moisture is not species-dependent, i.e., the increase in grain moisture owing to sprayed water volume follows the same trend in both corn and wheat. Significant effects were also observed in the linear \((P < 0.0001)\) and quadratic \((P = 0.0033)\) regressions. For this reason, we chose to use the quadratic spray volume effect on grain moisture, since it is the effect with the highest significant regression degree (second-order polynomial).

Figure 1 shows the curves fitted for corn and wheat grain moisture. It can be observed that both
curves are parallel and show a quadratic increase
\((0.0223x + 0.0061x^2)\) as a function of water
volume applied. Therefore, equivalent increases
in corn and wheat grain moisture contents are
observed as sprayed water volume increases.

**Table 1.** Analysis of variance for corn and wheat grain moisture.

<table>
<thead>
<tr>
<th>Cause of Variation</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Species</td>
<td>1</td>
<td>6.5878</td>
<td>6.5878</td>
<td>551.53</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Spray Volume</td>
<td>5</td>
<td>3.4722</td>
<td>0.6944</td>
<td>58.14</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Linear Regression</td>
<td>1</td>
<td>3.2208</td>
<td>3.2208</td>
<td>269.65</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Quadratic Regression</td>
<td>1</td>
<td>0.1271</td>
<td>0.1271</td>
<td>10.64</td>
<td>0.0033</td>
</tr>
<tr>
<td>Regression Deviation</td>
<td>3</td>
<td>0.1242</td>
<td>0.0414</td>
<td>3.47</td>
<td>0.0319</td>
</tr>
<tr>
<td>Species×Volume</td>
<td>5</td>
<td>0.0156</td>
<td>0.0031</td>
<td>0.26</td>
<td>0.9302</td>
</tr>
<tr>
<td>Residue</td>
<td>24</td>
<td>0.2867</td>
<td>0.0119</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>10.3622</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1 DF = Degrees of freedom;  
2 SS = Sum of squares;  
3 QM = Mean square.

**Figure 1.** Means and fitted curves for spray volume effect on corn and wheat grain moisture.

**Discussion**

Both grain species are characterized by having high carbohydrate contents, which present similar matrix potentials (Ngoddy and Bakker-Arkema, 1976); this characteristic explains the similar behavior of these grains.

The initial moisture contents of corn and wheat grains were 11.5 and 10.7 %, respectively. This difference was due to the fact that each grain species came from a different storage facility, and during storage the grains reached equilibrium moisture contents corresponding to the particular temperature and relative humidity verified in
each storage facility.

The grain moisture contents after spraying 10 L t⁻¹ were, on average, 12.3 and 11.5 % for corn and wheat, respectively, thus demonstrating a 0.8 % increase in relation to their initial values. It is likely that the grain moisture contents reached higher values right after spraying. However, because of the characteristics of the laboratory environment in which the grains remained, such as moderate temperature and, particularly, low relative humidity, moisture loss may have occurred, favored by the desorption process in the grain. According to Puzzi (2000), when exposed to the atmosphere, a small volume of grain reaches hygroscopic equilibrium with the air relative humidity within a relatively short period.

Pixton and Warburton (1968) studied the time required for wheat grain to reach hygroscopic equilibrium when arranged in 1-cm-thick layers, and observed that 90 % of total moisture reached equilibrium after the second day in the desorption process, and after the fifth day in the adsorption process. Air humidity is of great importance for grain moisture content. Thus, when water vapor pressure in the air is lower than the water vapor pressure on the surface of the product, the grain will yield the water required to reach equilibrium. In this respect, Bittencourt et al. (2000) observed a gradual moisture content decrease in corn seeds after they were sprayed with insecticides, and verified that the desorption process was influenced by low relative humidity during storage.

The results in the present study suggest that the water supplied by insecticide sprays is adsorbed on the structure of the grain, making up part of “free water”, and is easily removed by environmental factors. On the other hand, it is likely that the hygroscopic equilibrium in the sprayed grain has almost been reached, since, according to Macray, cited by Puzzi (2000), there are two grain moisture contents when it is in equilibrium at the same relative humidity; in the desorption process, hygroscopic equilibrium is reached at higher moisture contents than in the adsorption process.

In general terms, the sprayed grains showed relatively low moisture contents which, at first, did not compromise insecticide effectiveness in controlling pests.

It was therefore concluded that the spray volumes studied here slightly increased the moisture contents of corn and wheat grains under laboratory conditions. Therefore, any of the spray volumes in this study can be used, with the main objective of obtaining greater uniformity in the distribution of the mix throughout the mass of grains.

Acknowledgements

The authors thank Carlos Longatti for logistic support, Helena Chamma, for support with grain moisture determinations, and Arlei Coldebella, for the statistical analysis.

References


