NOTA TÉCNICA

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

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Moisture content is the most important factor for grain preservation during storage. Grain stored with high moisture content is subjected 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 **1-2** l.t'''; 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''' (**ARTHUR** *et* «**Z..1991**) to **10** l.t''' (**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 levéis that may comprpmise its effectiveness. The máximo protection period provided by insecticides depends mainly on characteristics of the grain, and moisture content is one of the most important f actors in insecticide degradation (**FLEURAT-LESSARD 2002**). Grain metabolic activity increases rapidly at moisture contents **>14 %** (**ROWLANDS 1967**); Kretovich, cited by **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 **>15** %. Several authors have demonstrated a loss of effectiveness in organophosphorus insecticides in corn and wheat grains at moisture contents **>14 %** (**WATTERS 1959, STRONG & SBUR 1960,1964, ROWLANDS, 1966, SAMSONÉÍ** *al.* **1987**). **SAMSONÉÍ** *al.* **(1988)** and **AERIDI** *et al.* **(2001)** demonstrated that organophosphorous insecticides are less stable

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than pyrethroids in corn and wheat grains with moisture contents >13 %. The objective of this work was to evalúate the effect of spray volume' on the moisture content of corn and wheat grains under laboratory conditions.

The experiment was conducted at the Insecticide Toxicology Laboratory of the Departamento de Entomologia, Fitopatología e Zoología Agrícola, Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ/USP), Piracicaba, Sao Paulo, Brazil. The moisture content determinations for the grain were performed at the Seeds Laboratory, Departamento de Producao Vegetal, ESALQ/USP.

A triple-stack yellow semiflint HT 98A corn hybrid and wheat cultivar BRS 208 were used, both developed by Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA - Brazilian Company for Livestock and Farming Research). Spraying was achieved by placing 2 kg of grain into plástic bags; each bag received one of six water volume treatments: 0,1,3,5, 8, or 10 ml.kg"[1], corresponding to theoretical applications of 0,1, 3, 5, 8, and 10 l.t'''. Applications were performed using a sprayer attached to an air compressor at a constant pressure of 150 kPa. During spray, the plástic 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 plástic bags and stored in the laboratory under uncontrolled conditions for a period of 24 h, after which the water content in the grain was evaluated by means of the oven method at 105 ± 3 °C for 24 h, 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 mafhematical 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 x spray volume) in the model (**STEEL & TORREE** 1970, **PIMENTEL-GOMES** 1987). Polynomial regression analysis was used to produce a detailed spray volume factor analysis.

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 x volume interaction was observed. This result indicares that the spray volume effect on grain moisture is not species-dependent, i.e. the increase in grain moisture owing to sprayed water volume f ollows the same trend in both corn and wheat. Significant effects were also observed

TABLE 1.- Analysis of variance for corn and wheat grain moisture.

Cause of variation	DF[a]	SS[b]	MS[c]	F	Pr > F
Grain species	1	6.5878	6.5878	551.53	<0.0001
Spray volume	5	3.4722	0.6944	58.14	<0.0001
Linear regression	1	3.2208	3.2208	269.65	<0.0001
Quadratic regression	1	0.1271	0.1271	10.64	0.0033
Regression deviation	3	0.1242	0.0414	3.47	0.0319
Species _Volume	5	0.0156	0.0031	0.26	0.9302
Residue	24	0.2867	0.0119		
Total	35	10.3622			

[a] DF = Degrees of freedom.
[b] SS = Sum of squares.
[c] QM = Mean square.

FIGURE 1.- Means and fitted curves for spray volume effect on corn and wheat grain moisture.

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). Fig.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. Both grain species are characterized by having high carbohydrate contents, which present similar matrix potentials (**NGODDY & 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 carne 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 valúes. It is likely that the grain moisture contents reached higher valúes right after spraying. However, because of the characteristics of the laboratory environment in which the grains remained, such as modérate 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.
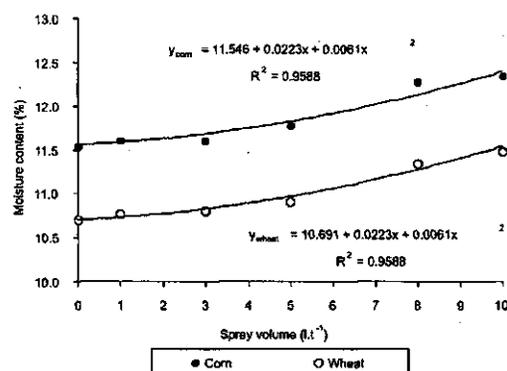
PIXTON & WARBURTON (1968) studied the time required for wheat grain to reach hygroscopic equilibrium when arranged in **1**-cm-thick layers, and observed that **90** % of total moisture reached equilibrium after the second day in the desorption process, and after the fifth day in the adsorption process. Air humidity is of great impórtanos 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, **BITTENCOÜRT** *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.

Literature

Afridi IAK, Parveen Z, Masud SZ. 2001. Stability of organophosphate and pyrerhroid pestiddes on wheat in storage. J. stored prod. res. 37:199-204.

Arthur FH, Throne JE, Simonaitis RA. 1991. Chlorpyrifos-methyl degradation and biological efficacy toward maize weevils (Coleóptera: Curculionidae) on corn stored at four temperatures and tliree moisture contents. J. econ. Ent. 84:1926-1932.

Bittencourt SRM, Fernandes MA, Ribeiro MC, Vieira RD. 2000. Desempenho de sementes de milho tratadas com inseticidas sistémicos. Rev. bras. Sementes 22: 86-93.

Brasil. 1992. Ministerio da Agricultura, do Abastecimento e da Reforma Agraria. Departamento Nacional de Producáo Vegetal. Divisáo de Sementes e Mudas. Regras para análise de sementes. Brasilia. 363 pp.

Daglish GJ, Eelkema M, Harrison LM. 1996. Control of *Sitophilus oryzae* (L.) (Coleóptera: Curculionidae) in paddy rice using chlorpyrifos-methyl or fenitrothion in combination with several other protectants. J. Stor. Prod. Res. 32: 247-253.

Fleurat-Lessard F. 2002. Qualitative reasoning and integrated management of the quality of stored grain: a promising new approach. Ibid. 38:191-218.

Ngoddy PO, Bakker-Arkema FW. 1976. A generalized theory of sorption phenomena in biological materials. Part I. The isotherm equation. Trans. amer. Soc. agrie. Eng. 13: 612-617.

Pimentel-Gomes, R, 1987. Curso de estatística experimental. Sao Paulo, Nobel Press. 466 pp.

Pixton SW, Warburton S. 1968. The time required for conditioning to equilibrium with specific relative humidities. J. Stor. Prod. Res. 4:261-265.

Puzzi D. 2000. Abastecimento e armazenagem de graos. Campiñas, Instituto Campineiro de Ensino Agrícola. 666 pp.

Rowlands DG. 1966. The activation and detoxification of three organic phosphorothionate insecticides applied to stored wheat grains. J. Stor. Prod. Res. 2:105.

———. 1967. The metabolism of contact insecticides in stored grains. Residue Rev. 17:105-177.

Samson PR, Bengston M, Parker RJ, Keating JA. 1987. The effect of grain moisture on the biological activity of fenitrothion residues on maize in storage. Pestic. Sci. 19:135-144.

———, Parker J, Jones AL. 1988. Comparative effect of grain moisture on the biological activity of protectants on stored corn. J. econ. Ent. 81: 949-954.

Steel RGD, Torrie JH. 1960. Principies and procedures of statistics - with special reference to the biological sciences. New York, McGraw-Hill. 481 pp.

Strong RG, Sbur DE. 1960. Influence of grain moisture content and storage temperature on the effectiveness of malathion as a grain protectant. J. econ. Ent. 53: 341-349.

———. 1964. Influence of grain moisture and storage temperature on the effectiveness of five insecticides as grain protectants. Ibid. 57:44-47.

Watters FL. 1959. Effects of grain moisture content on residual toxicity and repellency of malathion. Ibid. 52:131-134.