Effects of Dryacide® on the physical properties of grains, pulses and oilseeds

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Abstract

The effects of the insecticidal inert dust Dryacide® on physical properties relating to the handling and storage behaviour of cereal grains, pulses, and oilseeds have been evaluated in laboratory tests. Seven Dryacide® levels from 0–500 mg/kg were applied to 14 different commodities and the effects on bulk density and flow rate measured. Dryacide® application resulted in decreased bulk density and slower flow rates, both effects being dose dependent. The magnitude of these effects varied and was greatest for maize and least for the oilseeds. Bulk density decrease at maximum dose varied from 2–9%, and flow rate was correspondingly less by 4–39%. The same effects were noted with other inert dusts such as silica aerogel, diatomite and rice husk ash.

The relationships offer promise as a rapid measure of Dryacide® level in treated grains, pulses and oilseeds.

Introduction

Inert dusts have a long history of use for the protection of stored products from attack by storage insect pests. Most of these dusts are based on silica and rely on the ability of silica to absorb and abrade an insect's waxy cuticle, leading to desiccation and death. In traditional small-scale storage, cereals or dry legumes are mixed with these dusts to achieve protection of vital food stocks between harvests. As the commodity is removed from the store the dust can be brushed or washed off and the commodity is obtained in an insect-free condition. The dusts are relatively safe to handle and there is no residue of insecticide left in the grain as there might be if a dilute insecticide dust had been used. Diatomite has often been used as have synthetic fumed silicas and highly siliceous dusts such as manufactured paddy husk ash.

In the past decade there has been widespread use in Australia of the product Dryacide® in which diatomite is coated with synthetic silica. This product is more active than diatomite and less expensive and easier to handle than the synthetic silicas. The product has been evaluated by the Australian grain industry and is now widely used for the treatment of storage sheds and silos to give a residual protective deposit.

When Dryacide® is applied directly to grain, changes in physical properties take place reducing the bulk density, the angle of repose and the flow rate of the grain. These changes alter the handling properties to such an extent that the Industry has had to prohibit the use of Dryacide® on grain delivered to the bulk handling system. It is nevertheless realised that the use of a non-residual, safe to handle, effective pest control method which will not be affected by the development of resistance would have enormous benefits for the storage of grains and legumes, particularly on a small scale. Experiments are therefore in progress to see if the use of Dryacide® can be adapted to bulk handling, principally by interposing methods of dust removal at intermediate stages of the handling system. The changes in physical properties which cause concern can also be used as a means of sensitive and rapid semiquantitative determination of the level of inert dust, a analysis which is otherwise quite difficult to achieve. This paper describes the use of these properties to estimate the quantity of a range of inert dusts on various durable commodities.

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Materials

The four inert dusts tested were: Dryacide®, Diatomite, Cabosil (synthetic silica), and Amosil (rice husk ash).

Fourteen different commodities were used: wheat, barley, maize, oats, ryecorn, sorghum, milled rice, field peas, faba beans, chickpeas (kabuli and desi types), canola, sunflower, and safflower.

Methods

The effect of various levels of Dryacide® on 10 commodities was determined by taking 1 kg of the commodity and testing the bulk density and the flow rate in 3 replicates first on the untreated commodity and then through progressively increasing the level of Dryacide® from 10 mg up to 500 mg/kg. Bulk density was measured with a standard chrondrometer on an approximately 600 g sample. The minimum difference of measurement of 0.5 g gave an adequate sensitivity of about 0.7%. Flow rate was measured in a 22 cm diameter plastic funnel with an outlet of 20 mm for all samples except maize and field peas, for which a 24 mm outlet was used. One kg of commodity was tipped into the funnel with the outlet lightly stoppered. The time from removal of stopper to appearance of a clear view through the funnel was recorded. Each determination was carried out with a minimum of 3 replicates. The sensitivity of the flow test is about 3%.

The angle of repose was measured by allowing 1 kg to flow from a funnel onto a flat sheet of paper and determining the height of the pile.

Results

Results are given in Tables l and 2. It may be seen in Table I that the addition of as little as 10 mg caused a measurable change in bulk density. For practical purposes, however, there was a significant change when 50 mg had been added to most of the cereals. The exceptions were oats and sunflower seeds, both of which have low bulk densities which were not changed by the addition of dust. The number of seeds per gram is given in Table 1. Clearly, the change in bulk density was not related to the size of the seeds.

Table 1 Change in bulk density for a range of commodities treated with Dryacide®.

Dust g/tonne	Maize	Hard wheat	Feed wheat	Barley	Rye corn	Chick-pea	Field-pea	Oats	Sorghum	Canola	Sunflower
0	78.3	80.5	73.2	73.5	70.7	75.7	80.3	51.7	78.2	66.0	40.8
10	76.7	80.2	72.5	72.7	70.8	75.2	79.5	51.5	77.5	65.8	41.0
20	76.3[a]	79.8	72.5	72.3	70.3	74.8	79.3[a]	51.7	77.3[a]	65.5	41.0
50	75.3	78.7[a]	71.5[a]	71.3[a]	69.8[a]	73.7[a]	78.5	51.2	77.3	65.3	40.7
100	73.7	77.7	70.3	70.7	68.5	72.7	78.0	51.5	77	64.8[a]	40.0
200	73.3	75.8	68.5	69.5	67.7	72.2	77.2	50.5	76.2	64.5	40.0
500	71.3	74.3	67.7	68.2	66	71.2	76	49.7[a]	75.3	63.8	40.1
Change%	8.9	7.7	7.5	7.2	6.6	5.9	5.4	3.9	3.7	3.3	2.0
Seeds/g	3.9	29		24	47	5.4	4.6	23	36	332	19

[a]Indicates minimum sensitivity.

The results of measuring changes in flow rate are given in Table 2. In maize and wheat there is a significant change when only 20 mg/kg has been added, but for other commodities a change of properties is seen only with greater quantities of Dryacide®. The biggest changes occur with maize, wheat, oats, chickpeas and field peas, and the least with canola. The change in flow rate does not appear to be dependent on the size of the seeds, although initial flow rate of untreated seeds is lowest for the larger seeds. The effect of Dryacide® on the bulk density of wheat is given in Figure 1, on the angle of repose in Figure 2, and on flowrate in Figure 3. The figures show that, even at a residue as low as 5% of the recommended application rate, there is still a very marked change in the measured property.

A comparison was also made of the change of bulk density caused by four different dusts on the 14 commodities. The results are shown in Table 3. The change in bulk density is greatest in the dusts based on prepared silica, Cabosil and

Table 2. Change in flow rate for a range of commodities treated with Dryacide®

Dust g/tonne	Maize	Hard wheat	Feed wheat	Barley	Rye corn	Chick-pea	Field-pea	Oats	Sorghum	Canola	Sunflower
0	8.3	9	9.7	9.9	10.7	7.6	6.8	15.2	9.7	10.6	17.5
10	8.2	9	9.8	9.7	10.6	7.8	6.8	13.6	10.1	10.4	18.1
20	8.5	9.1	10	9.6	10.3	7.8	6.9	13.6	9.8	10.5	17.7
50	9.2	9.4	10.3	9.8	10.6	8.2	7.1	14.3	9.6	10.3	18.3
100	9.7	9.7	10.5	10.3	10.9	8.7	7.4	14.8	9.7	10.6	19.2
200	10.9	10.2	11	10.9	11.7	9.2	7.7	15.7	10.2	10.7	19.7
500	11.5	10.9	12.1	11.8	12.7	9.5	8.2	17.2	10.8	11.1	20.6
Change%	39	22	24	19	18	25	20	13	11	4	18

Table 3. Change of bulk density following addition of different dusts.

	BD kg/Hl	Cabosil 0.5 [1.0]	Dryacide® 0.5 [1.0]	Diatomite 1.0 [2.0]	Amosil 1.0 [2.0]
Maize	80.3	11.6[11.1]	6.0[7.1]	11.3[12.1]	8.8[11.6]
Wheat	81.2	6.7[7.2]	6.8[8.2]	6.7[6.71	4.7[6.2]
Barley	69.3	5.3[5.5]	3.6[4.6]	3.6[4.6]	2.5[2.3]
Rye	70.7	4.2[4.5]	3.0[3.5]	0.4[0.7]	0.9[1. 1]
Sorghum	79.5	4.0[5,8]	3.0[3.81	2.7[3.0]	1.8[2.1]
Oats	53.3	2.6[3.1]	1.8[2.1]	1.8[1.6]	0.6[1.5]
Rice	82.3		2.6[3.6]		1.8[2.3]
Faba bean	77.7	7.9[8.8]	6.5[6.5]		4.7[5.2]
Desi	76.5	7.1[8.3]	4.0[4.8]	0.7[1.3]	3.0[3.8]
Kabuli	76.0	8.3[8.7]	3.3[4.0]	0.2[0.3]	2.5[2.8]
Field pea	77.0	9.8[10.5]	1.7[1.8]	0.6[0.7]	1,0[4.3]
Canola	66.8	5.3[6.81	1.0[1.3]	1.8[2.0]	0 [1.1]
Safflower	57.5	3.8[4.5]	3.5[4.0]	1.5[1.7]	2.5[3.7]
Sunflower	42.4	>2.2	1.0[2.2]	>2.2	>2.2
			Mean percentage change		
	BD mean	Cabosil	Dryacide®	Diatomite	Amosil
Cereals	74	7.9[8.5]	5.9[7.5]	6.1[6.6]	4.4[7.9]
Legumes	77	10.7[11.8]	5.0[5.6]	0.7[1.0]	3.6[5.2]
Oilseeds	56	6.6[7.7]	3.3[4.7]	2.7[3.01	2.0[3.9]

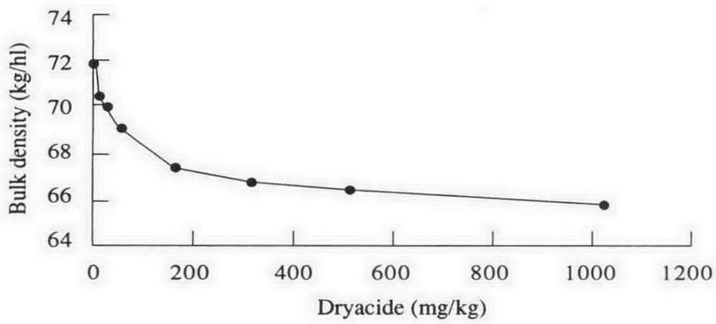

Fig. 1. Effect of Dryacide® on bulk density.

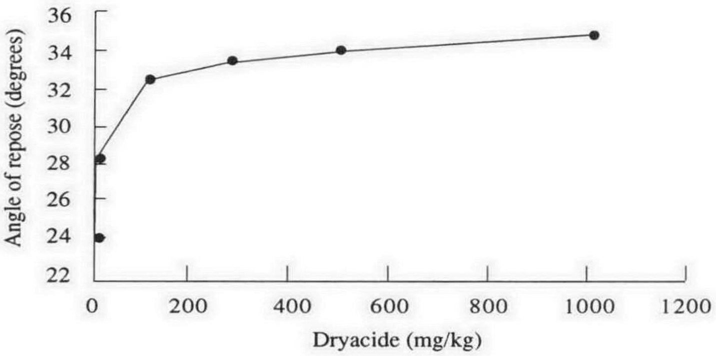

Fig. 2. Dryacide® versus angle of response.

Dryacide®, and less in the other 2 dusts. Changes in bulk density as a percentage of the original bulk density are similar for cereals and legumes, but generally lower for oilseeds.

Discussion

The determination of physical changes resulting from the use of inert dusts has significance in two areas. The effective use of inert dusts requires application rates varying from 1 kg/t of commodity for the synthetic silicas to 3 kg/t for diatomite and other inert dusts. Given their effectiveness and the absence of any toxic residue, the main impediments to the use of dusts are their undesirable effects on the appearance and physical properties of the grain. If these effects could subsequently be ameliorated either by a physical removal process or by diluting treated with untreated grain it may be possible to admix dusts with bulk grain. The tests have shown that even with a 20-fold dilution, the changes in bulk density, angle of repose and flow rate remain a substantial proportion of the changes resulting from complete treatment. This tends to rule out the possibility of diluting out the effects and means that the dusts can be used only where changes in grain physical properties are unimportant, or a means can be found to remove them before critical processing stages.

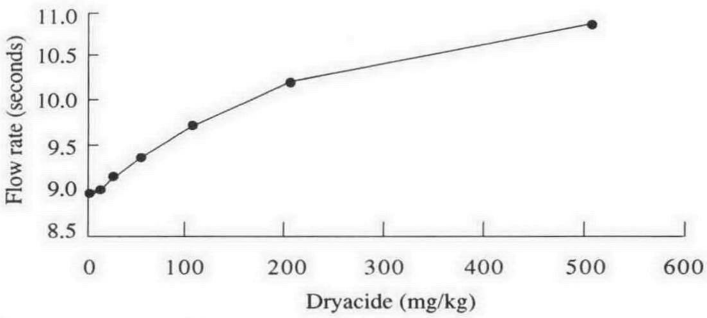

Fig. 3. Effect of Dryacide® on grain flow.

One of the major uses of inert dusts is for the protection of pulses. This stems from the proven effectiveness of this type of treatment against the pests of beans, from the lack of effectiveness of the grain protectant insecticides and the almost complete absence of any product for treatment of beans in storage. Commercial treatment of pulses often involves washing before processing. Tests have shown that this is an effective way of restoring the pulses and removing the inert dust. The effect of dust treatment on the physical properties of field peas and chickpeas is in the mean range of the cereals. The dusts cannot be removed from cereals by sieving, and although it is possible to remove much of the dust in mill-scouring processes there is still a handling problem up to the mill and adjustments to be made in the scouring process itself It is difficult to analyse grain for the presence of silica dusts due to the lack of any specific properties and gravimetric methods are time-consuming and need laboratory facilities and an experienced analyst. The methods described here, on the other hand, can be carried out in a matter of seconds at any point in the handling chain.

There is a considerable variation in both bulk density and flow rate between different grades of wheat, but grades with low bulk densities (70 kg/hectolitre) and flow rates (above 11 seconds) are not typically the grades going to flour mills. The effect of addition of Dryacide® on a large scale is very obvious when grain fails to flow out of railcars or silos, and the storage capacity of silos is greatly reduced. The method is an attempt to quantify those changes. Nevertheless, the method depends on finding reasonably consistent properties within the same bulk of grain and this requires further investigation.