SOME FACTORS INFLUENCING THE EFFECTIVENESS OF GRAIN PROTECTANTS

W. MINETT
Division of Agricultural Chemistry
Department of Agriculture, Victoria
Melbourne, AUSTRALIA

INTRODUCTION: Grain protectants are compounds applied to stored grain with the intention of conferring lasting protection against insect attack. Because of the many restrictions that must be applied to a chemical used on raw grain, the number of insecticides available for this purpose is strictly limited. It is vital, therefore, to make the utmost use of the available materials, and to do this the various factors influencing their performance need to be analysed.

FACTORS INFLUENCING EFFECTIVENESS: Persistence of residues at insecticidal levels is an important feature of grain protectants and this property is governed by many factors. Important among these are grain moisture content and storage temperature. The literature relating these factors to insecticide degradation has been discussed by Rowlands[1] whose reviews[1,2] of the metabolism of insecticides on grain will be referred to extensively in this section of the paper. Strong and Sbur[3] using bioassays considered 14% a critical moisture level in regard to insecticidal malathion residues. Using data from chemical assays, Minett and Belcher[4] demonstrated a critical moisture content for malathion breakdown on wheat of about 11.5-12.0%, above which the loss of malathion increased more rapidly with increasing moisture content.

Higher storage temperatures generally result in more rapid degradation of grain protectants, particularly organophosphorus compounds, largely by stimulation of enzyme activity[1]. Typically, a 10°C increase in temperature will result in a 1 1/2 to 2 fold increase in reaction rate. The influence of aeration on temperature should also be mentioned here since it is a technique designed to reduce the temperature of stored grain.

Formulation and the method of application of grain protectants can also affect their persistence significantly. Work done at the Pest Infestation Control Laboratory, in England[7] and also in Australia[8] has indicated that uneven application of pesticides can result in longer lasting residues, but pilot scale experiments at Slough[9] may not have confirmed their earlier reports. These experiments will be discussed more fully later on. Rowlands[2] observed that formulation does not generally influence the performance of grain protectants, since this has little effect on the translocation and long term degradation of the pesticide. However, an anti-penetrant such as sodium carboxy methyl cellulose added to an emulsion spray can slow the rate of uptake of pesticides, so delaying enzymic breakdown. Desmarchelier[5] has found that loss of dichlorvos can be readily controlled if applied unevenly to grain in edible oils.

The presence of existing fumigant and insecticide residues on grain can affect the persistence of grain protectants[2]. Of particular interest in Australia at present is the application of dichlorvos to grain previously treated with malathion. This has been shown by Rowlands[10] to delay the degradation of both insecticides.

The condition of grain together with the chemical nature of the insecticide applied, has a bearing on the effectiveness of grain protectants. Desmarchelier[5] reports that pirimiphos methyl and presumably other insecticides rapidly become ineffective when high levels of broken grain and dust are present. The chemistry of an insecticide largely determines the region of the grain in which it concentrates and hence its effectiveness against different insect spp. Green[6] pointed out that a grain protectant which resides mainly in the germ would be highly effective against *Oryzaephilus surinamensis*. Alternatively, a chemical which appeared mainly in the endosperm would be valuable against *Sitophilus* spp.

To complete this brief survey two factors will be mentioned which, while not related to the persistence of grain protectants, nevertheless have a bearing on their effectiveness. Firstly, synergists are valuable adjuncts in the field of grain protection [2], a classic example being the use of piperonyl butoxide as a synergist for pyrethrins. And perhaps the most important factor of all influencing the use of grain protectants is the development of resistance to insecticides among grain insects, since this problem may well, ultimately, cause their obsolescence.

EXPERIMENTS WITH NON-UNIFORM INSECTICIDE DISTRIBUTION: Dr. Williams of the Victorian Plant Research Institute and the author have conducted experiments in which wheat was treated non-uniformly with malathion and dichlorvos. Laboratory results[8] showed that as few as 1 or 2% of grains in a bulk need to be treated with malathion to maintain control of storage pests. There is also a marked tendency for the rate of breakdown of insecticide to be inversely proportional to its concentration on the treated grains.

The first field trial conducted to test these findings failed to achieve its purpose, because treated and untreated grains were mixed immediately after application of malathion emulsion. This allowed extensive transfer of insecticide, even though only 1% of the wheat intake was sprayed. This result certainly demonstrated that elaborate measures often employed to achieve even coverage are unnecessary provided the required total quantity of grains ensures that the insecticide distribution obtained is similar to that resulting from conventional treatment.

Work by Kane and others[9] at Slough has underlined the problems of achieving a significant degree of unevenness of malathion distribution in stored grain. They reported that redistribution of insecticide occurred even in stationary grain, but this was greatly increased with grain movement. Following laboratory studies, Bramhall and Rowlands[11] suggested that because of rapid redistribution of malathion amongst the individual grains in a bulk, the same pattern of malathion distribution will finally result whether the insecticide is applied uniformly or non-uniformly.

In our second field trial, a quantity of grain was treated 2 weeks before harvest with malathion at 750-800 ppm. During intake this was admixed at the rate of 1% with newly harvested wheat. Analysis of groups of 25 grains taken from the bulk showed that increased non-uniformity of insecticide distribution was obtained when compared with conventional treatment. This was accompanied by greater persistence of residues in the experimental treatment and, consequently, a longer period of protection against insect infestation.

We consider that there are advantages to be gained from non-uniform treatment of bulk stored grain, but formidable problems remain to be solved in making the technique work in practise. For example, pretreatment of grain at very high levels of insecticide requires a supply of grain before harvest, as well as extra storage space at silos and presents the inevitable hazard of keeping stocks of highly treated grain at storage premises.

However, the principle is applicable to other grain protectants and in the case of dichlorvos, could be of special value, as application of the insecticide to a small portion of a bulk could reduce volatilisation losses. We have conducted pilot scale studies in which 3.8 ppm dichlorvos applied unevenly to wheat was as effective in bioassays as 5.4 ppm applied uniformly. Preliminary work has also been done with insecticide impregnated carriers and we are considering combining these with aeration in wheat bulks as an extension of the idea of non-uniform distribution. This approach is attractive in that direct application of insecticides to grain is avoided and residue problems minimised.

Finally, the exciting work of Desmarchelier in Canberra should be mentioned, who has been experimenting with various methods of introducing dichlorvos vapour into bulk stored grain. He has introduced dichlorvos vapour into bulk wheat by application of emulsion to the grain surface followed by downward flow aeration. The treatment proved highly effective against *Ephestia cautella*, *Ephestia kuhniella* and *Plodia interpunctella*, dichlorvos resistant *Sitophilus oryzae* and dichlorvos resistant *Rhyzopertha dominica*. *Cryptolestes* spp., however, appeared to survive the treatment.

To summarise, there appear to be various ways of achieving some form of non-uniform treatment. The distribution of highly dosed grain has been tried successfully, although further development is needed. We are currently experimenting with a concentrated jet of malathion applied continuously to the grain stream, but Green's[6] suggestion of applying concentrated insecticide in short bursts may prove more effective than this.

The idea of incorporating insecticide impregnated carriers in a bulk seems worthy of further evaluation, and we hope to begin trials with dichlorvos strips in 500 bushel bins in the near future. Desmarchelier's layering technique in conjunction with aeration also appears to be highly promising.

It is hoped that it is clear from this brief report that many possibilities of non-uniform application of grain protectants remain to be explored and that useful contributions to the field of grain storage should result.

REFERENCES:

[1] Rowlands, D. G., The metabolism of contact insecticides in stored grains, Residue Reviews 17 (1967) 105.

[2] Rowlands, D. G., The metabolism of contact insecticides in stored grains. II. 1966-1969, Residue Reviews 34 (1971) 91.

[3] Stròng, R. G., Sbur, D. E., Influence of grain moisture and storage temperature on the effectiveness of malathion as a grain protectant, J. econ. Ent. 53 3 (1960) 341.

[4] Minett, W., Belcher, R. S., O'Brien, E. J., A critical moisture level for malathion breakdown in stored wheat, J. stored Prod. Res. 4 (1968) 179.

[5] Desmarchelier, J. M., Alternative Insecticides to Malathion, Aust. Wheat Board Pest cont. Conf. 1973.

[6] Green, A. A., The use of insecticides, Chemy. Ind. (1969) 1452.

[7] Tyler, P. S., Horler, D. R., Rowlands, D. G., Robbins, B., The distribution of insecticides among grains, Pest Infest. Res. 1968 (1969) 33.

[8] Minett, W., Williams, P., Influence of malathion distribution on the protection of wheat grain against insect infestation, J. stored Prod. Res. 7 (1971) 233.

[9] Kane, M. J., Clark, J. S., Green, A. A., Horler, D. F. The distribution of insecticide among grains, Pest Infest. Res. 1970 (1973) 112.

[10] Rowland, D. G., The metabolic fate of dichlorvos on stored wheat grains, J. stored Prod. Res. 6 (1970) 19.

[11] Bramhall, J. S., Rowlands, D. G. The uptake and translocation of malathion by the stored wheat grain, J. stored Prod. Res. (In press).