Food safety risks posed by pesticide residues in changing cropping systems

Mike Bell[1], Vineeta Syna[2], Lukas van Zwieten[3], Gary Harch[1] and Neil Halpin[4]

[1] Qld Dept Primary Industries and Fisheries, PO Box 23 Kingaroy 4610 Qld. Email mike.bell@dpi.qld.gov.au
[2] formerly Peanut Company of Australia, Haly St. Kingaroy 4610 Qld.
[3] NSW Dept Primary Industries, Wollongbar Agricultural Instit., Wollongbar 2477, NSW. Email lukas.van.zwieten@dpi.nsw.gov.au
[4] Qld Dept Primary Industries and Fisheries, Bundaberg Research Station, Kalkie 4670 Qld. Email neil.halpin@dpi.qld.gov.au

Abstract

Residues of persistent agrichemicals are a constraint to crop rotation options in emerging coastal sugarcane cropping systems. Glasshouse studies using soil from fields in the coastal Burnett area in Qld showed that residues of both Dieldrin and BHC/Lindane represented significant food safety risks to crops of peanut and, to a lesser extent, soybean. Direct uptake through the pod wall was important in peanuts, and root uptake and subsequent translocation was also important in both species. Accumulation of residues of both chemicals in plant tops of the grain legumes and of maize showed that hay made from either crop represented a risk to food safety standards in livestock products. Risks from residues of DDT were minimal, due to an apparent inability of this chemical to cross plant membranes. A surrogate method for estimating residue bioavailability may provide a means of rapid pre-planting assessment of potential food safety risks.

Key Words

Organochlorin residues, food safety, peanuts, soybeans, sugarcane

Introduction

Sugarcane cropping systems in coastal Queensland are changing in response to a need to implement more profitable and environmentally-sustainable management practices. Part of that change involves the planting of mainly grain legume break crops in a short fallow period between sugarcane cycles (Garside and Bell 2001). These crops fulfil the dual roles of breaking the sugarcane monoculture and providing cash returns, with the most successful species being the summer grain legumes soybean (*Glycine max*) and peanut (*Arachis hypogaea*). Food safety has always been an issue for the directly-consumed peanut crop, but use of soybeans in edible markets has resulted in increasing attention being paid to this crop as well.

Historically, both the sugarcane and tobacco industries used persistent organochlorin and organophosphate pesticides as part of accepted management practice. Although not used for many years, the persistence of chemical residues or their metabolites in soils that are now diversifying into new crop species represents a potential food safety risk (Morris and Sampson 2006). This paper reports results of experiments examining the risks to food safety posed by residues of organochlorin pesticides found in soils in the coastal Burnett region of SE Qld.

Methods

The most prevalent agrichemical residues found in compulsory pre-sowing soil tests conducted by the Peanut Company of Australia were residues of the persistent organochlorin insecticides DDT, Dieldrin or BHC/Lindane, or their toxic breakdown products. Soil from commercial fields previously shown to contain significant residue concentrations was collected, sieved, re-analysed using standard quantification procedures and then used in a series of glasshouse pot trials.

Randomised complete block experiments with 4 replicates were established to determine the food safety risks from growing peanuts in soils with a range in residue concentrations, established by diluting high-residue test soils with soil from nearby fields with no detectable residues. An experiment with separated root zone and pod zone treatments was established to determine the mode of uptake (direct absorption through the pod wall versus root uptake and subsequent translocation). A third experiment was undertaken to determine the relative potential for accumulation of Dieldrin and BHC/Lindane by peanut, soybean and maize. A surrogate method of detecting bio-available residues, in which semi-permeable membranes filled with triolein were incubated with test soils for up to 35 days, was also evaluated.

Results and Discussion

Peanut kernel concentrations of both BHC/Lindane and Dieldrin were linearly related to the residue concentration in the soil (Fig. 1), but there was no evidence of DDT accumulation at any soil concentration. Kernels accumulated Dieldrin at concentrations *ca*. 70% of those found in the bulk soil, while kernel BHC concentrations were 40% greater than those in the bulk soil. Both BHC and Dieldrin were found to enter kernels via direct pod uptake (i.e. in soils with no residues in the root zone), or via root uptake and subsequent translocation into developing kernels (Fig. 2). Results show that far from being overprotective, the peanut industry strategy of excluding fields in which soil residue concentrations are $\geq$ the maximum permissible kernel residue concentration, combined with rigorous kernel testing programs, are warranted.

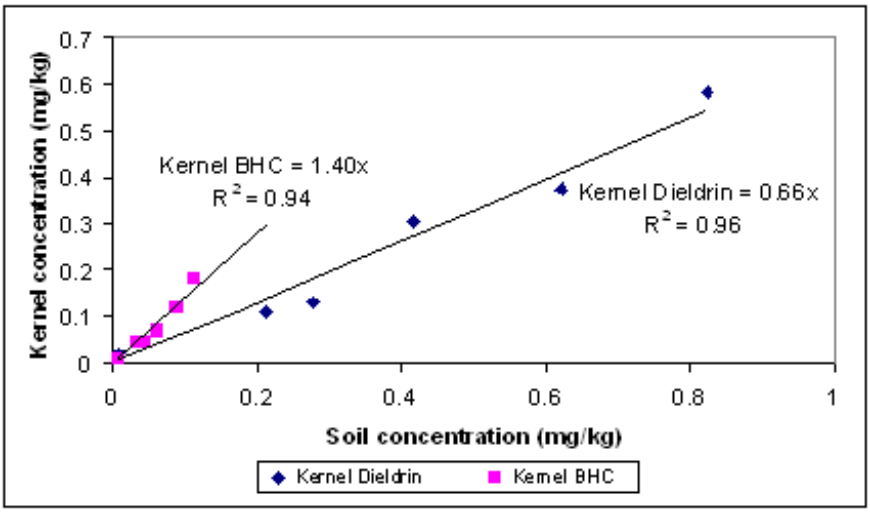

Fig. 1 Relationship between soil and kernel concentrations of Dieldrin and BHC in peanut.

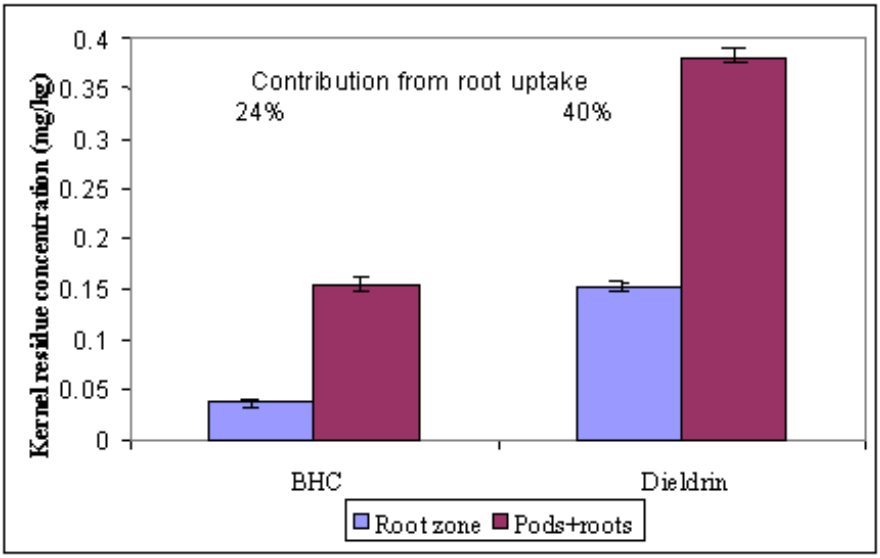

Fig. 2 Effect of position of Dieldrin and BHC residues (pod or root zone) on kernel concentration.

The pot trials comparing plant and kernel/seed residue concentrations in peanut, maize and soybean were grown in soils with residues of BHC (Fig. 3) and Dieldrin (Fig. 4). All species accumulated both BHC and Dieldrin in plant tops, although peanuts accumulated higher concentrations than maize or soybean. Seed/kernel concentrations of both residues were also much higher in peanut than the other species. Concentrations of Dieldrin in soybean seed (0.02 mg/kg) were low, while concentrations of BHC in soybean were below the LOR (limit of reporting). Concentrations of both residues were <LOR in maize seed.

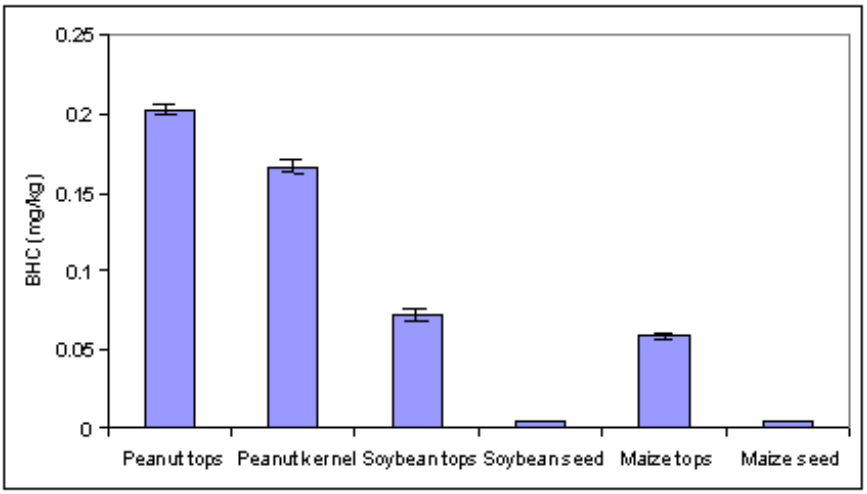

Fig. 3 Comparison of BHC accumulation in tops and seeds/kernel of maize, peanut and soybean.

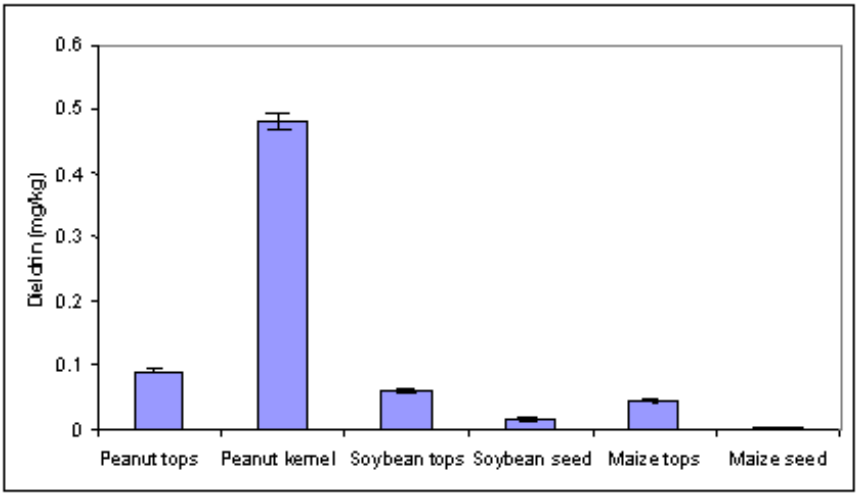

Fig. 4 Comparison of Dieldrin accumulation in tops and seeds/kernel of maize, peanut and soybean.

The semi-permeable membranes rapidly accumulated organochlorin compounds from soil, with BHC and Dieldrin concentrations reaching a plateau after about 12 days in all soil types. Membranes proved to be very sensitive indicator of the presence of residues, with final concentrations up to 7 times those found in soil.

Conclusion

Aged residues of Dieldrin and BHC in some soils used for sugarcane and tobacco cropping represent significant food safety risks for peanuts grown for human consumption. In addition, peanuts, maize and soybeans grown for forage/hay production on those same soils may represent contaminant risks for meat of livestock fed with these materials. Soil tests to determine residue limits will be an important guide to species selection for break crops in emerging sugar farming systems.

References

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