A SYSTEMS APPROACH TO QUARANTINE ENTOMOLOGY: USING ASPARAGUS INFESTATION AS A MODEL

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Quarantine treatments have traditionally been a single process, such as fumigation with methyl bromide. Such treatments to prevent entry of insects were usually to a specified statistical standard, usually probit 9, defined as <32 survivors in 1 million treated insects (Vail *et a*l. 1993). In recent years there has been an upsurge in interest in alternative approaches and how efficacy of control methods can be determined (Baker *et al.* 1990; Vail *et al.* 1993).

The systems approach has provided new insights into quarantine security. The method involves assessing and quantifying the factors that lead to infestation of a particular crop by an insect or insects, and the efficacy of treatments to deal with any infestation once the crop is harvested. The aim is to sum risk factors and treatments to give a risk value that is acceptable to regulatory authorities.

Considerable advances have been made in the U.S.A in applying the approach to apples and cherries (Moffitt 1989), nectarines (Curtis *et al.* 1992) and fruits that are potentially hosts of codling moth (Vail *et al.* 1993) and for produce entering New Zealand potentially infested with tephritid fruit fly (Baker *et al.* 1990; Cowley *et al.* 1991, 1992). Red Ginger disinfestation integrates preharvest and postharvest treatments to control a suite of eight insect taxa (Hata *et al.* 1992). The only situation where a systems approach is used in practice through intergovernmental agreement is for the import of watermelons from Tonga to New Zealand (Cowley *et al.* 1991).

Factors identified as affecting risk of infestation are plant association (sources of infestations), pest phenology (will it be present, what life stages will be present), crop phenology (harvest time in relation to pest phenology), and preharvest management practices. These factors can then be combined with postharvest treatments that are not effective at the probit 9 level to form a series of factors that together guide appropriate quarantine security (Vail *et al.* 1993).

Importers of New Zealand asparagus rely on final fumigation with hydrogen cyanide or methyl bromide to give quarantine security. These treatments can be very damaging to the crop (Beever *et al.* 1983). Use of such fumigants is increasingly unacceptable to consumers and is implicated in ozone depletion (Anderson and Lee-Bapty 1992).

We have attempted to apply systems analysis to the risk of asparagus being infested with insects of quarantine importance and identify factors that can either cause or lessen infestation. If factors that reduce the risk of infestation or indicate a high risk of infestation, when further action will be needed for export to quarantine sensitive markets, can be identified, asparagus growers and exporters will be better able to avoid having their high value crop treated with potentially damaging fumigants. If risk factors indicate a high likelihood of infestation, the asparagus industry can use controlled atmosphere disinfestation (Carpenter unpublished data) or specialised non-damaging fumigants (Carpenter and Stocker 1992).

Asparagus is a good model for study because the plant part that is harvested takes only 2-3 days from emergence from the soil to harvest at 18-23 cm tall. In this short time the asparagus spear will often become infested with thrips and aphids (Watson and Townsend 1981) and red-legged earth mite (*Halotydeus destructor)*. The aim of our project was to determine factors that affected the incidence of these pests on asparagus. We studied flights of aphids and thrips over and on spears on a block of asparagus at the Levin Research Centre with six yellow sticky traps, positioned within the crop, and by dissecting randomly sampled spears. We hand searched for red-legged earth mites in asparagus beds in the Rangitikei District on the West Coast of the North Island, and in Hawkes Bay.

Red-legged earth mite

Red-legged earth mite was only found on a limited range of soil types. In the Rangitikei it only occurred on the Rangitikei Series (recent river alluvium) and on the recent Hokio Sands of the coastal strip. (The soils of the Rangitikei District were described by Cowie *et al.* 1967). Red-legged earth mite has not been found in asparagus planted on Manawatu Sands which are the soil series adjacent to but higher and less often flooded than the Rangitikei series (Cowie *et al.* 1967). When an asparagus block included both Rangitikei and Manawatu Sands, red-legged earth mite was found on the Rangitikei Sands but not on the Manawatu Sands. Just south of the Rangitikei one block of asparagus on Himatangi soils had red-legged earth mite in the past (G. Lewis pers comm.), but it was not found in the winter/spring of 1992/93.

In Hawkes Bay, we have found red-legged earth mite only on Pakipaki and Ngatarawa soils, and on very recent alluvium adjacent to rivers. The Pakipaki soils are based on coarse pumice which limits their ability to hold water and they often have a high peat content that makes them very hard to re-wet once they dry out (Hughes *et al.* 1939). Ngatarawa soils are underlain by gravels so they also dry out quickly (Hughes *et al.* 1939). The recent alluvium adjacent to rivers are equivalent to the Rangitikei Sands and are part of the Twyford Series (Hughes *et al.* 1939).

In areas of appropriate soil type, red-legged earth mite can often be found on legumes and weeds on headlands even if the asparagus bed is weed free.

In both the Rangitikei District and Hawkes Bay the earth mite was not found on asparagus unless there were adjacent weeds. Close inspection of legumes and broad-leaved weeds e.g. ragwort *(Senecio jacobaea)*, creeping buttercup *(Ranunculus repens)* and twin cress *(Coronopus didymus)*, was the fastest way to determine presence or absence.

In Australia, red-legged earth mites has a distribution governed by rainfall (Wallace 1970 a,b) over the 6 months it is active (May-October). It seems that in New Zealand red-legged earth mite is at its ecological tolerance limits in the few areas it occurs with distribution determined by soil type and high summer water deficits (Coulter 1975). In the cool wet summer of 1992/93 we found mites still active in late December and it may be that if the pest does not experience conditions to make it produce diapausing eggs, the population cannot survive.

From these observations it is clear that asparagus growers can reduce the risk of infestation of their product by red-legged earth mite by choosing their soil type carefully. In Hawkes Bay, any asparagus planted on Twyford, Ngatarawa and Pakipaki soils is certain to be at risk from red-legged earth mite infestation. If these soil types are used risk of infestation can be minimised by keeping the crop and headland weed-free. In the Rangitikei District which has cooler summers (Coulter 1975) mite distribution has expanded onto two sites and then retreated again, lending support to the limits of distribution hypothesis.

Thrips and aphids

It has already been shown that the weediness and level of litter present in an asparagus bed affects the level of infestation of thrips and aphids (Watson and Townsend 1981; Townsend and Watson 1984), although the relationship between spear infestation from airborne insects and that due to movement from weeds and litter in the crop is unknown.

Our trapping showed variation in the weekly total of thrips trapped over the asparagus season (from the beginning of October to mid December) from zero to 130 (mean 36.1 ± 46.7). Peak catches occurred over the period 5-19 November 1993. Aphid numbers were high throughout November, dropping quickly in December from a peak of 4351 (mean of 10 weeks data = 1397 ± 1591). We found immature thrips on the sticky traps indicating that they were blown in on the wind. Townsend and Watson (1984) suggested that immature thrips moved from weeds and debris to asparagus spears, whereas our data indicate airborne sources are also involved. We were unable to relate airborne numbers of thrips and aphids to numbers on asparagus spears in any meaningful way, and more work is needed to determine the sources of the airborne populations.

Thus we can conclude that the risk of infestation of asparagus with thrips and aphids is related to weediness of the asparagus block, the amount of litter, weather patterns and potential sources (e.g. willow shelter belts (Carpenter, unpublished data)). Actions to reduce risk would be reduction of crop weediness and litter removal.

Conclusions

We have found that the risk of infestation of asparagus by red-legged earth mite, thrips and aphids is related to a variety of factors.

By choosing appropriate soil types and removing all legumes and weeds from areas where soil type and summer water deficit permit it to live, asparagus growers have a very small risk of having the pest infest their crops. Thus there is no likelihood of quarantine problems. We can be more certain about the actual quantitative risk when we know what else limits the distribution of the pest (as it is not soil type alone).

For thrips and aphids the level of infestation is related to events inside and outside the crop. An individual grower has no control over external factors except perhaps shelter belts, so the risk of infestation is high (but still undefined). To make further progress we need to be able to define the sources and distance travelled by airborne thrips and aphids, how they locate individual spears, and the relationship between trapped numbers, numbers detected in quality assurance and actual levels of spear infestation.

By using a systems approach to studying the insect pests of asparagus we have been able to indicate control points where problems can be addressed. Effective reduction of risk from red-legged earth mite infestation is easily attained. Reduction of risk from aphid and thrips infestation is more difficult and the decision process will determine the type of quality assurance needed and at what level of infestation the crop should be subject to quarantine treatment (e.g. fumigation with dichlorvos (Carpenter and Stocker 1992), redirection to a market which has lower returns to the grower but is not quarantine sensitive (local or export), or redirection to processing.

The systems approach to defining risk allows identification of practical problems from very limited data sets, and enhances the cost-effectiveness of a research programme.

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