To plant or not to plant: Managing the risk of fumigant phytotoxicity

Dr Dylan McFarlane and Dr Scott Mattner, VSICA Research

- The Victorian Strawberry Industry Development Committee are currently funding research by VSICA Research to develop tests for measuring fumigants in soil so that growers know when it is safe to plant their crops
- Researchers are testing two different technologies (photoionisation detectors and colorimetric tubes) that instantaneously detect fumigants in soil
- The use of these technologies in field surveys has already prevented growers from planting into soil containing fumigant residues at 15 sites
- The project has established a field trial in the industry that is evaluating the tolerance of different strawberry varieties to the presence of fumigant residues in soil
- Preliminary results showed strong correlations between the concentration of fumigants in soil and growth inhibition in lettuce as an indicator plant
- If results continue to show success it is anticipated the technologies will be developed as a product or service to growers in Victoria

Fumigant phytotoxicity of strawberry

Soil fumigation is an effective practice used by many strawberry growers to control pathogens and weeds, and increase fruit yields. For example, a recent survey showed that more than 80% of strawberry growers in Victoria fumigate soil to control the fungus *Macrophomina phaseolina* that causes the disease charcoal rot.

One of the challenges with soil fumigation is that planting runners too early into treated soil can kill or reduce the vigour and yield of strawberry plants (this is called fumigant phytotoxicity). Compounding this, fumigant labels usually indicate variable plant-back periods (the time between fumigation and planting) for strawberry, ranging from 7 days to longer than 35 days. This is because there are so many factors that influence how long fumigant residues remain in soil, including fumigant formulation, application rate, soil temperature and moisture, organic matter, clay content and others.

Also, it is not known if some strawberry varieties are more tolerant of fumigant residues at planting than others. These factors can make the decision of when to plant after fumigation and punching holes into plastic mulch very difficult for growers.

Recently, nearly all strawberry growers in Victoria that fumigate soils transitioned from the use of traditional plastic mulch made from low density polyethylene (LDPE) to totally impermeable films (TIFs). LDPE mulches are very leaky to fumigants, while TIFs are impermeable and seal them in the soil for long periods. The adoption of TIF dramatically increased the control of soil-borne diseases, like charcoal rot (Figure 1), and minimised the emissions of gaseous fumigants to the atmosphere. However, the longer residual times of fumigants under TIF may have contributed to incidences of phytotoxicity in strawberry in Victoria because growers are unsure of how long to increase their plant-back times (Figure 2).

Figure 1. The adoption of TIF mulch with fumigants (L) drastically increased control of the soil-borne disease charcoal rot compared with standard LDPE mulch (R) in the strawberry industry in Victoria. Photo credit: VSICA

Growers need a reliable method to immediately predict when they can plant to avoid fumigant phytotoxicity (after the minimum plant-back recommendation on the product label). Traditional tests using lettuce germination as an indicator of the risk phytotoxicity take at least 3 days to complete and results are often open to interpretation (e.g., lettuce may germinate but the tips of roots blacken and grow poorly indicating the presence of fumigants).

In response to these issues, the Victorian Strawberry Industry Development Committee (VSIDC) funded a project by VSICA Research to evaluate the robustness of in-field methods that immediately quantify concentrations of fumigants in soil to better assess the risk of phytotoxicity before planting.

The project will also evaluate the relative tolerance of different strawberry varieties to fumigant residues in soil in field trials.

Survey of Victorian strawberry farms

The project used handheld photoionisation detectors and colorimetric tubes (Gastec®) (Figure 3) to quantify the concentration of fumigant residues of 1,3-dichloropropene and chloropicrin in soil prior to planting at 30 strawberry farms across Victoria.

The sites were chosen to cover different growing regions, soil types, moisture and organic matter contents, and temperatures for strawberry production across Victoria. The photoionisation and colorimetric methods provide instantaneous results in the field and therefore could assist growers in making more informed decisions about when to plant their strawberry crop after fumigation. Assessments commenced after the minimum plant-back period on the product label.

Figure 2. Fumigant phytotoxicity from planting strawberry too early into soils after fumigation (L). Symptoms of phytotoxicity in strawberry can include plant death, stunted growth, reddening of the leaf margins, dead runner roots, and new roots emerging from the top of the crown (R). Photo credit: VSICA

Overall, we found the colorimetric tubes more reliable for detecting fumigant residues at greater depths in soil than the photoionisation detector. This is mostly because the pump on the photoionisation detector stalled when taking samples at greater depths.

Without the fumigant detection tests, growers at 55% of the sites we tested would have planted into soils containing concentrations of fumigants with the potential to cause phytotoxicity in plants. Most of the growers at these sites decided to delay planting a further week based on the test and this resulted in no plant deaths.

At one of the sites, the grower decided to plant into soils where fumigant residues were detected and determined to be a moderate risk of phytotoxicity. A few months after planting the grower noticed signs of phytotoxicity (wilting and black roots followed by plant death) on >20% of their plants at the site.

Statistical analysis of data from the sites showed that the time between fumigation and scheduled planting was not well correlated (r = 0.02) with the concentration of fumigant in soil. The combined factors of time after punching holes in plastic mulch and soil temperature provided a better indication of the concentration of fumigants in soil at planting (r = 0.52), but was still not reliable enough for growers to predict when it was safe to plant. This means that plant-back time alone is not sufficient for growers to predict if fumigants are still in soil or when it is safe to plant crops after fumigation.

In contrast, soil testing with colorimetric tubes was completed and results communicated to growers within 30 minutes. Most growers commented that this helped them with their decisions on when to plant, and provided them with greater certainty in planning labour and when to collect their runners.

Phytotoxicity thresholds and strawberry varieties

A field trial was established this autumn on a commercial strawberry farm at Silvan, Victoria to determine the effect of planting at various intervals after fumigation on the survival, time to fruiting, and early fruit yields of strawberry. We measured fumigant concentrations at each planting time using colorimetric tubes and conducted a standard lettuce test. Planting began at the minimum plant-back-time on the fumigant label, and continued at regular intervals until no fumigant residues were detected in the soil. We included different strawberry varieties (*Cabrillo*, *Albion*, *Monterey*) and planting material (bare-rooted runners and plug plants) in the trial.

Preliminary results showed that the growth of lettuce in germination tests was highly correlated with the concentration of the fumigant 1,3-dichloropropene in the soil. The relationship predicted that there was no suppression of lettuce growth when concentrations of 1,3-dichloropropene were at 1 µg/ml (Figure 4). However, it is important to determine if a similar relationship occurs for strawberry plants as the trial continues through the season. The data is vitally important to further develop risk profiles and concentration thresholds of fumigants in soil that predict phytotoxicity in strawberry more accurately.

Figure 3. Dr Dylan McFarlane drawing gases through colorimetric detector tubes (Gastec®) to determine the concentration of fumigants in soil. Photo credit: VSICA

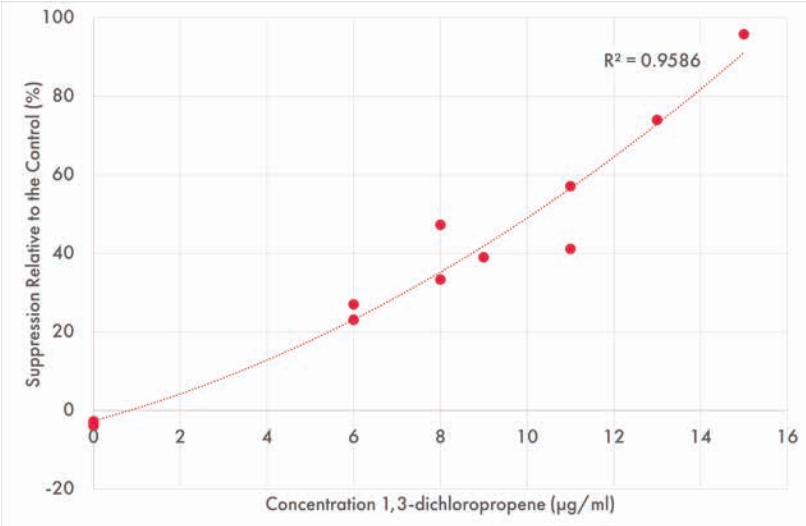

Figure 4. Relationship between the concentration of the fumigant 1,3-dichloropropene in soil at a depth of 10 cm in the field, and its growth suppression of a lettuce indicator plant in the laboratory.

How will this project help strawberry growers?

Experiments are continuing on the use of different methods for testing concentrations of fumigants in soil before planting. We aim to establish another field trial on plant-back times in summer using different varieties (e.g., short-day) and cold-stored planting material. If the methods continue to be successful, it is anticipated that the technologies will be developed as a product or a service to Victorian growers.

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