Needle disease strategy Research Programme

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Technical Note

Timing of copper application for control of red needle cast pot trial

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Summary: A chemical control option is needed for *Phytophthora* needle diseases of pine. Copper-based fungicides have been shown to be effective at reducing symptom severity in controlled experiments. However, the optimum timing of application is unknown. A timing of copper application trial was initiated at two sites in the central North Island with potted radiata pine in December 2017. Sets of plants were treated in different months (December-June) and the development of disease symptoms monitored. Phytotoxic reactions appeared on sprayed plants in April, after a cold snap. Subsequent disease scoring was challenging as it was difficult to distinguish the symptoms of infection from these phytotoxic lesions and, as a result, scored needle damage was similar or greater on sprayed plants than on unsprayed plants. *Phytophthora pluvialis* was first detected in February, but was not detected again until July. *Phytophthora kernoviae* was first detected in July. From July to September both species of *Phytophthora* were mainly detected on unsprayed trees. It is unclear if this was due to the presence of copper or a lack of healthy needles (susceptible to infection) on sprayed plants.

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Introduction

A cost-effective, chemical control strategy is needed to provide a short-term management option for control of phytophthora needle diseases of pine caused by *Phytophthora pluvialis* (red needle cast; RNC) and *P. kernoviae* (phytophthora needle blight; PNB). Results from artificial inoculation experiments have indicated that copper applied as cuprous oxide, including as per the industry standard used for the management of dothistroma needle blight, is effective in reducing the severity of symptoms of RNC (Rolando et al. in press).

However, the optimum time to apply copper in the field to prevent infection has not yet been investigated. To do this requires a fundamental understanding of the epidemiology of *P. pluvialis* and *P. kernoviae.* Work undertaken thus far (Williams et al. 2016; Hood et al. 2017a, b) indicates that disease expression, release of inoculum, and infection all peak during the cooler part of the year, between June and November. Observations suggest that both species have a polycyclic life cycle that leads to an epidemic scenario in years when outbreaks of red needle cast are most severe. They thus suggest that to control the disease a fungicide treatment should be applied in autumn (or possibly earlier), to destroy inoculum at the beginning of the infection period, and possibly again several months later to maintain a low increase rate. However, at this point we have no data on the interaction between application of a fungicide, presence of natural inoculum and infection.

A field trial was established with potted plants in two mature stands of radiata pine with a history of phytophthora needle diseases in order to determine the optimum time to apply copper to needles to prevent infection from occurring. Plants were sprayed with copper in different months and the development of symptoms monitored.

Method

Plants were exposed to natural inoculum from December 2017 until September 2018 at two sites, Pigeon Road, Kinleith Forest and No. 4 Road, Kaingaroa Forest. Plants were placed under the canopy at the edge of mature stands of radiata pine known to be infected. Copper treatments were applied once to a set of twenty plants every month from December to June at each site. A set of plants was also sprayed every 2-3 months and two sets remained unsprayed for the entirety of the experiment. Copper was applied manually at 1.5 - 2% cuprous oxide (AG Copp 75, American Chemet Corporation) suspension sprayed to run-off (1.72 kg ha^{-1} active ingredient in 100 L water, ~23 g Cu_2O L^{-1}). Plants were set out in five blocks at each site, with four plants of each treatment randomly located in each block. Plants were assessed monthly for disease symptoms (needle damage severity was scored on a 0-3 scale: 0, 0%; 1, 1-10%; 2, 11-50%; 3, >50% needles affected). Needles were sampled every month for detection of *P. pluvialis* and *P. kernoviae* by qPCR (O'Neill et al. 2018). Samples were taken from a subset of approximately 100 plants each month between January and June, but sampled from all plants from July to September.

Results and Discussion

Olive-coloured lesions were observed on several plants from April to May onwards at both sites (Fig. 1A-B). Superficially these symptoms resembled those of infection by species of *Phytophthora*. However, unlike *Phytophthora* infection, where symptoms first appear on older needles (Fig. 1C), symptoms were observed on needles of all ages. Samples of these needles were negative for both *P. pluvialis* and *P. kernoviae*. Inspection of needle damage data at this point showed that severity of these symptoms was greatest on treated plants, especially those sprayed in March or later. The appearance of these symptoms on sprayed plants indicated that they were likely the result of phytotoxicity. Similar phytotoxic reactions have been reported on nursery radiata pine plants treated with copper: "small pale discolorations and dish-like indentations appear on the radiata needles after the first frost" (Jancarik 1969). Phytotoxic reactions first appeared after the first cold snap of the year on 12 April, when temperatures dropped below 2°C at Kinleith and 1°C at Kaingaroa. Severity of phytotoxic reactions was greater at Kaingaroa (Fig. 2), the colder of the two sites.

The presence of phytotoxic reactions on sprayed plants made the scoring of phytophthora needle diseases very difficult. In July, a decision was made to remove all plants treated in March or later, as most of their needles were dead (Fig. 1B). Needle damage severity was scored on the remaining plants until the end of September (Fig. 2). However, it remained difficult to distinguish and score phytophthora needle diseases. Figure 2 shows that needle damage in September was similar or greater on the sprayed plants than on the unsprayed plants, though resulting from phytotoxicity rather than infection by *Phytophthora*.

Radiata pine is a pioneer species and does not cope well in shade. As the potted plants were positioned under the canopy of mature stands they may have been physiologically stressed, and this may have contributed to the severity of the phytotoxic reactions observed. To our knowledge, the phytotoxic effect of copper sprays applied during the cooler parts of the year is unknown on plantation trees.

Figure 1 A-B, copper phytotoxicity on potted radiata pine plants at Kaingaroa in June; **A**, olive lesions on a plant recently sprayed with copper; **B**, needle death on a sprayed plant (left) compared to a healthy unsprayed plant (right). **C**, *Phytophthora pluvialis* infection towards the base of an untreated radiata pine plant at Kaingaroa in August.

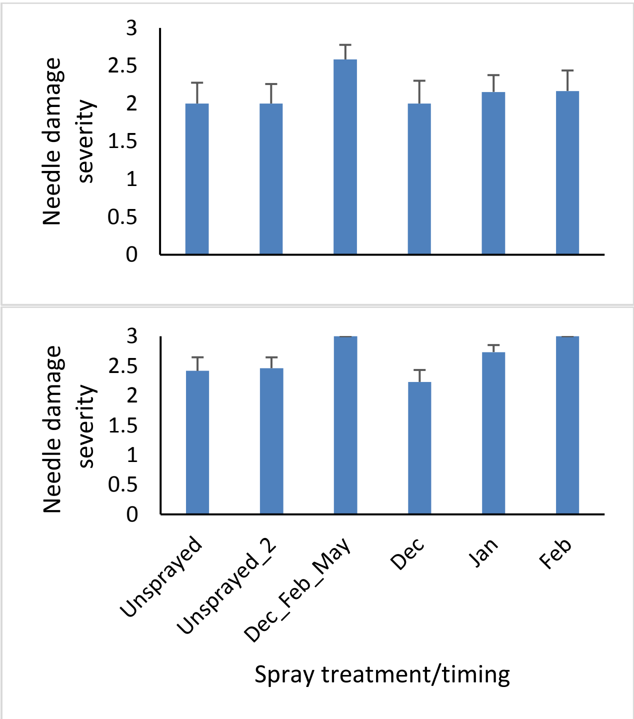

Figure 2 Needle damage severity on potted radiata pine plants at Kinleith (top) and Kaingaroa (bottom) in September.

Phytophthora pluvialis was detected on a needle sample collected from an untreated radiata pine plant at the end of February at Kinleith. Classic early symptoms of RNC, in the form of olive coloured lesions at the base of needles and black resin bands, were observed on the sample. After this, there were no more positive detections until July (Fig. 3). *Phytophthora kernoviae* was first detected in July. The proportion of samples positive for either pathogen was greatest in September.

Needle surface copper concentrations as low as 13 – 26 mg kg^{-1} needle tissue have been shown to prevent infection in artificial inoculation studies (Rolando et al. in press). Needle surface copper concentrations on the plants in this trial were analysed in July. At this time, mean copper concentrations on treated plants were well above this level (e.g. 78 ± 24 mg kg^{-1} for plants treated in December).

Generally, detections of *P. pluvialis* and *P. kernoviae* were greater on unsprayed trees than on treated trees (Fig. 3). However, we cannot say whether this was due to the presence of copper or due to a lack of undamaged needles for infection. Species of *Phytophthora* are primary pathogens and poor competitors against secondary micro-organisms, and thus require healthy plant tissue for infection and disease development.

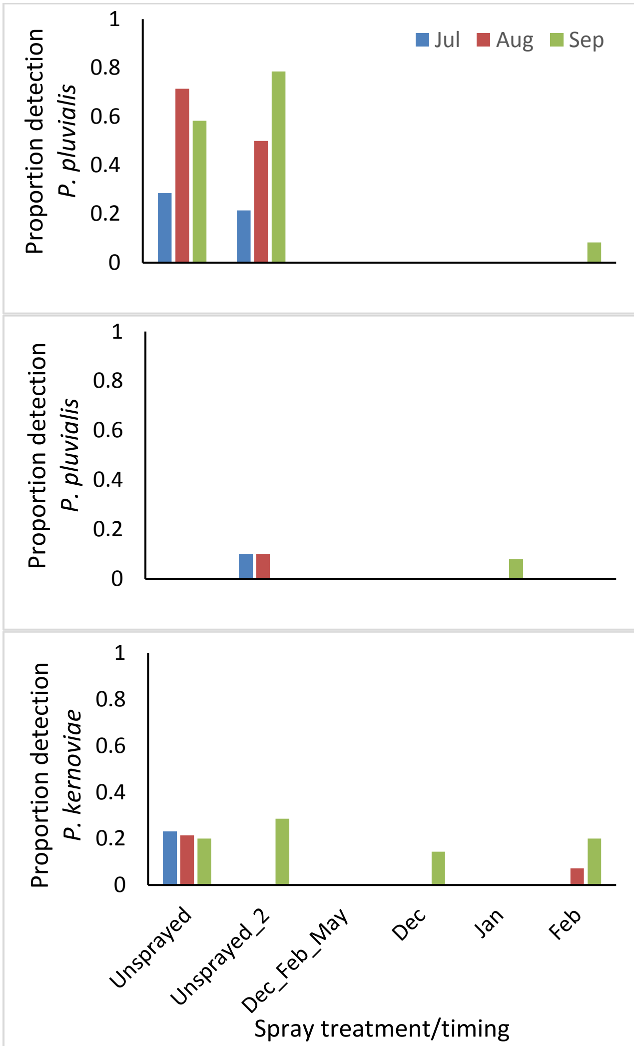

Figure 3 Detection by qPCR of species of *Phytophthora* in needle samples collected from potted radiata pine plants in July, August and September. Top, *P. pluvialis* at Kaingaroa; middle, *P. pluvialis* at Kinleith; bottom, *P. kernoviae* at Kinleith. *P. kernoviae* was not detected at Kaingaroa.

Conclusion

- Phytotoxic reactions were:
  - Seen on potted radiata pine plants that were sprayed with copper.
  - Observed after the first cold snap of the year in April.
  - Greatest on plants sprayed in March or later.
- There was greater detection of *Phytophthora pluvialis* and *P. kernoviae* on unsprayed plants than sprayed plants. However, it is unclear whether this was an effect of copper or the lack of suitable needle material for infection.
- Further studies are needed to identify the optimal period for copper application for the control of phytophthora needle diseases.
- Results are currently being gathered from a complimentary timing of infection trial where plants are exchanged fortnightly, rather than sprayed with copper.

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