MANAGEMENT OF VAM FUNGI

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INTRODUCTION

In common with about 80% of all plants, cotton forms VAM (vesicular-arbuscular mycorrhizas). VAM are associations of soil-borne fungi with the roots of plants. Presence of the fungi in the roots increases the uptake of mineral nutrients that diffuse slowly through soil, such as phosphate, zinc, copper, potassium and ammonium. The fungus spreads beyond the nutrient depletion zone surrounding the root and accesses the pool of nutrients in the soil. VAM fungi also influence the resistance of plants to drought stress and pathogens. VAM are mutually beneficial because the plant supplies the fungus with organic food.

Cotton roots are normally mycorrhizal. At six weeks of age, up to 70% of the roots are colonised by VAM fungi. Where VAM are absent or sparce, the seedlings are stunted (Figure 1). Though the seedlings may reach normal size by the end of the season, the delay in growth may reduce the production of cotton. Reasons for reductions in the population of VAM fungi in soil are complex and we do not yet fully understand how or why populations vary.

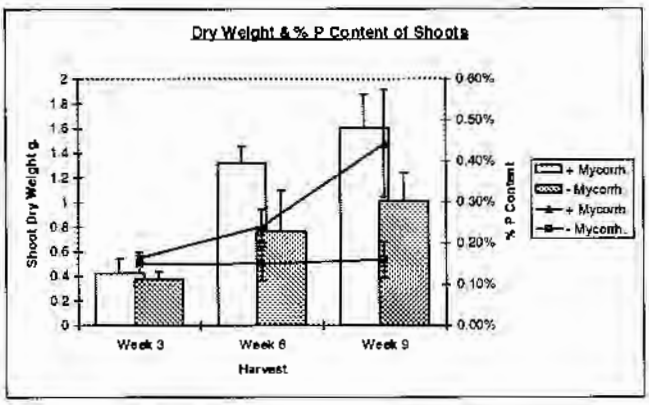

Figure 1: Affects of mycorrhizal infection on growth of cotton and P content of shoots. The histograms indicate plant growth, mycorrhizal (pale) grow faster than non-mycorrhizal (dark) seedlings. The lines indicate P uptake being correlated with plant growth.

Factors which are known to reduce the density of VAM fungi in soil include intensive cultivation, long fallows, overuse of phosphatic fertiliser, use of various pesticides, high densities of various insects that eat fungi, compaction of soil and waterlogging of soil. Several of these factors are common in cotton growing and may be part of the reason for reductions in cotton production. The research of these issues in Australia has only just begun. A group comprising Dr Steve Allen at Narrabri, Associate Professor John Brown at University of New England and Dr Peter McGee at The University of Sydney have commenced a program broadly aiming to examine the role of VAM fungi in the sustainable production of cotton.

The aim of the research at the University of Sydney is to develop a model which predicts the level of fungi in soil prior to planting so that remedial action may be taken if needed.

THE RESEARCH

Can we use information we have now to develop the model? In brief, the answer is no, and this is because the information has been developed from different systems of production, different climates, different soils and for different purposes. We can, however, use the information as the basis of our research.

Disturbance

That soil disturbance shatters the network of fungal hyphae is well documented. Cultivation of soil will reduce the total density of fungus in the soil, leading to a reduction in the uptake of phosphate because of a reduction in the amount of VAM in roots. In Canada, production of corn is reduced by cultivation, the most extreme reduction being observed when soil was reduced to peds of 5mm (Miller & McGonigle, 1991) because of a reduction in the rate of uptake of phosphate. The goal of our research must be to determine how much disturbance reduces the density of VAM fungi in soil.

Long Fallow

The VAM fungi rely on a plant to provide energy. Absence of a suitable host leads to starvation of the fungi. This becomes very important where long fallows are used, either deliberately to store water or accidentally where the rainfall is insufficient for planting. Decline in the production of crops associated with loss of VAM fungi associated with long fallow have been documented by Thompson

(1987). The goal of our research must be to determine how much the fungus is affected by fallow.

Phosphatic Fertiliser

Addition of phosphatic fertiliser to soil has a complex interaction with VAM fungi. The plant grows faster because of the increased availability of phosphate. Phosphate reduces the density of VAM in roots, thus decreasing the contribution made to plant P uptake by the fungus. Reduced VAM in roots also reduces the uptake of Zinc unless Zn fertiliser is applied. Also, addition of P to soil may reduce the total population of VAM fungi in soil, though this needs to be examined rigorously. We need to know how much fertiliser reduces the density of fungus in soil and what effects it has on the uptake of other nutrients.

Crop Rotations

The crops used in rotations with cotton change with the perceived demands of the market. Crops differ in their relationship with VAM fungi. Some like cotton, sunflower and linseed are heavily reliant on VAM for their growth and development. Others like Canola and all brassica-like plants do not become mycorrhizal at all. Wheat and oats are in between. The presence of nonmycorrhizal plants is very similar to fallow as far as the mycorrhizal fungi are concerned. While we will not be examining the effect of rotations in our studies, it is the subject of study by Associate Professor John Brown.

Wet/Dry Cycles

VAM fungi germinate in response to moisture and temperature. Several field studies have demonstrated that the fungi have an optimal temperature range at which they germinate and grow. The fungi require adequate moisture before they germinate, and if germination is in the absence of plant roots, the fungal unit will lose viability through germination and senescence. We will examine the loss of fungal density in soil through wet/dry cycles.

Use of Pesticides

Understandably, fungicides often influence the growth and development of non-target fungi. Seed dresssings are needed to reduce damping-off. We do not know how much they reduce VAM infection in the critical early stages of seedling growth.

RESULTS

The methods used to determine the density of VAM fungi in soil are slow and laborious. Essentially, they measure the rate at which seedlings become mycorrhizal. The time to initiate infection, the rate at which the roots become mycorrhizal and the maximum level of infection are calculated. This process measures mycorrhizal infectivity of soil.

We have collected undisturbed soil cores from Dalby, Narrabri and Warren from cotton fields immediately prior to harvest. In these soils, the density of VAM fungi is high (see Figures 2 and 3). The initial experiment aimed to determine if the infectivity is reduced by disturbance. Soil was passed through a 5mm sieve and packed back in the tubes. We have examined infectivity at collection and will continue over the next 18 months to determine whether long fallow reduces infectivity. At collection, infectivity of the disturbed and undisturbed soils was similar (see Figure 3). We assume that disturbance reduces the hyphal network but that sufficient other fungal units exist at harvest of the crop that the loss is not detectable or significant. We will determine if the same situation exists following wet/dry cycles.

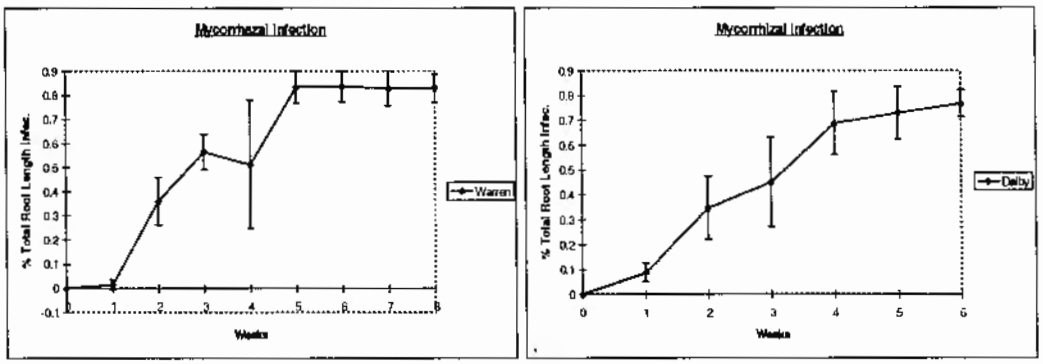

Figure 2: Mycorrhizal infectivity of soils from Warren and Dalby.

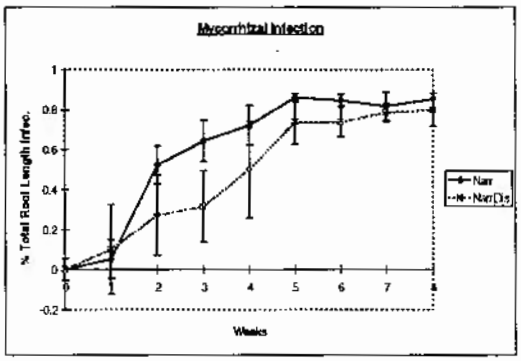

Figure 3: Mycorrhizal infectivity of soil from Narrabri with and without disturbance.

We have also examined five varieties of cotton to determine whether they all depend on VAM for growth. Siokra L23, Siokra 1-4, Sicala VI, CS 50 and Deltapine 90 all responded to mycorrhizal infection in sterile soil. We are now using CS 50 because it showed an average response to VAM and is widely used in the cotton growing areas. In this experiment, it became evident that our experimental system contained inadequate phosphate and nitrate and we are addressing these issues now. We need the experimental system to examine the influence of pesticides on infectivity of soil. In preliminary experiments, it became evident that some fungicides and nematicides may affect plant growth as well as fungal infection. These effects need to be separated.

In preliminary experiments, it also became evident that individual species of VAM fungi from cotton growing areas differ quite markedly in their effect on plant growth, at least in the early stages. While we have not pursued this issue, it needs to be considered when we look at field data and laboratory studies that use a single fungus.

References.

Miller MH & McGonigle TP (1991) Soil disturbance and the effectiveness of arbuscular mycorrhizas in an agricultural ecosystem. In MYCORRHIZAS IN ECOSYSTEMS, Ed: DJ Read, DH Lewis, AH Fitter & IJ Alexander. CAB, Oxford.

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