Identifying the cause of cereal yield decline in lucerne companion cropping systems; and the role of agronomy for mitigating cereal productivity losses

Robert H. Harris

School of Agriculture, Food and Wine
University of Adelaide
South Australia

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Student Declaration

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ABSTRACT

Integrating perennial plants like lucerne into farming systems has been widely recommended to mimic pre-agricultural native vegetation, to improve year round transpiration and reduce the off-site impacts of agriculture on the surrounding environment. Despite perennial plants providing greater hydrological benefits compared to traditional annual plant based farming systems; integration of lucerne into farming systems remains a challenge. One approach that may enhance the integration is companion cropping, where annual crops are sown directly into an existing lucerne stand. However, past research has shown that this practice can be harmful to the productivity of annual crops, due to competition with lucerne for environmental resources. Yet beyond quantifying the effect on annual crop production, little is understood about what causes the loss of yield. Understanding the underlying mechanisms dictating the performance of annual crops growing with lucerne could help design agronomic strategies that mitigate competition, and improve annual crop productivity; in turn potentially improving industry acceptance and adoption of both lucerne and companion cropping.

In this study, two field experiments showed that competition was apparent early in the growing season prior to cereal stem elongation; when cereal biomass in the presence of lucerne was significantly lower than that of cereal grown in monoculture. Although there were no differences in cereal establishment, companion cereals produced significantly ($P<0.05$) less tillers, spikes, cereal biomass, and consequently grain yield compared with cereals grown in monoculture. Both field experiments showed that fertiliser N could potentially increase companion cereal productivity, and that in-crop lucerne suppression could improve cereal grain quality by reducing lucerne pod contamination. Apart from quantifying the temporal effects of competition between the companion cereal and lucerne and assessing the role of agronomic strategies for mitigating competition, field experiments did not give much insight into what was causing the loss of companion cereal productivity.

Simulation modelling using APSIM (Agricultural Production Systems Simulator) explored competition between the companion cereal and lucerne, and each component's response to resource supply and agronomic intervention over longer periods. APSIM was found to satisfactorily simulate both simultaneous and stand alone wheat and lucerne growth, after comparison with field observed data. Although APSIM tended to deplete soil mineral N more rapidly under lucerne than field observations indicated, necessitating soil mineral N to be constrained within previously measured values in long-term simulations.

Simulations showed that companion cereals were frequently sown into drier soil profiles, due to soil water extraction by lucerne over the preceding summer/autumn period, compared with monoculture cereals sown after the summer/autumn fallow. Competition for soil water appeared the major contributing factor to companion cereal performance, and simulated data predicted that companion cereals had to rely solely on in-crop rainfall. Therefore companion cropping in low rainfall environments where growing season rainfall (April to October) is less than 350 mm, or in environments where crops rely heavily on stored soil water at sowing for subsequent production, would be unsuitable for reliable grain production from companion cropping.

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