The use of mixed species cropping to manage pests and diseases – theory and practice

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ABSTRACT

Mixed species cropping is often perceived as a viable tool to increase on-farm biodiversity in organic agriculture and is a potentially important component of any sustainable cropping system. Apart from increasing total farm productivity, mixed species cropping can bring many important benefits such as improvement of soil fertility management and suppression of pests and/or diseases. In this sense it can be seen as performing different eco-services in the farm system. This paper discusses mixed cropping in this context while focusing on its potential and actual use as a tool to manage pests and diseases in organic farming systems.

Keywords: mixed cropping; biodiversity; organic pest and disease management

INTRODUCTION

Mixed species cropping is the growing of two or more plant species in the same field in the same year and, at least in part, at the same time. Mixed species cropping permits an intensification of the farm system, which results in increased overall productivity and biodiversity in cropped fields (Vandermeer, 1989). Mixed species cropping has been seen as a promising technique to develop sustainable farming systems because it often has multifunctional roles and can potentially provide a number of eco-services within the farm system. Examples may include the addition and recycling of organic material, water management, protection of soil from erosion and pest or disease suppression. This functional diversity contributes to ecological processes to promote the sustainability of the whole farm system (Altieri, 1999).

MIXED SPECIES CROPPING SYSTEMS

Mixed intercropping systems where two, or often more species, are grown intermingled without distinct rows are very commonly used in the tropics but are not generally used in temperate organic horticulture.

Although productivity can be high they usually require more or less intensive husbandry regimes. Row intercropping, growing two or more crops together in rows, and strip cropping, cropping growing two or more species in strips sufficiently wide to allow separate management regimes but sufficiently close to influence each other, have been more widely investigated in the EU and USA in recent years as they have greater potential for mechanisation.

These latter two types of mixed species cropping have also been used to manipulate the system to deliver other eco-services such as nitrogen (N) supply where for instance a legume is used as an intercrop to fixate N that is used by subsequent food crops. They have also been extensively studied as a pest management tool and, to a lesser extent, as a disease management option. Other benefits can also include improved soil structure, improved weed control, microclimate manipulation (e.g. growing a tall crop to provide a wind barrier), providing habitat for natural enemies and even as a trap crop.

In contrast to mixed species cropping regimes, monoculture is the cropping of a single species in a field. In general, as the cropping system moves from a random mix of plants to a monoculture the biodiversity of the system decreases. Total productivity also tends to decrease.

Organic growers in the UK and northern Europe have not generally adopted mixed species cropping systems. This is because increased intensity of production often implies increased use of manual labour a significant immediate cost for organic growers. At present it is difficult to directly offset this cost against the benefits provided because they have not been quantified, except in a few limited cases. In this paper, although we present the potential role of mixed species cropping in pest and disease management, we argue that it will only be when it's full potential as a provider of a range of eco-services have been fully quantified and recognised that it will be widely adopted by growers in organic production systems.

MIXED SPECIES CROPPING AND PEST ATTACK

Studies on the effect of intercropping on pest attacks are numerous and often contradictory due to the difficulty of teasing out the ecological factors that can affect insect-plant relations. Andow (1991) analysed 209 studies involving 287 pest species. Compared with monocultures, the population of pest insects was lower in 52% of the studies (149 species) and higher in 15% (44 species). Of the 149 pest species with lower populations in intercrops 60% where monophagous and 28% polyphagous. The population of natural enemies of the pests was higher in the intercrop in 53% of the studies and lower in 9%.

The results of such studies therefore imply a complex situation in which the specific agro-ecological situation is important. However, in order to develop mixed species cropping as a tool it is necessary to understand the underlying mechanisms involved. Root (1973) defined two hypotheses; (1) the resource concentration hypothesis and (2) the natural enemies hypothesis. In the former insects are attracted to and concentrated on their food plant resources which are more easily found or more apparent in simple (monoculture) systems whilst in the latter natural enemies are more effective and numerous in diverse systems. It seems that the first hypothesis more closely explains observed pest attack although the exact mechanism of concentration on the resource is not defined by Root (1973). There are currently several competing explanations which are probably best synthesised by Finch and Collier (2000). Their appropriate / inappropriate landings hypothesis posits that insect pests settle on plants only when various host plant factors such as visual stimuli, taste and smell are satisfied. This is more likely in monocultures than polycultures where the chance of encountering a ‘wrong’ stimulus is much increased. The complexity of the overall picture makes it difficult to specifically design intercrops for pest control without practical knowledge of pest and crop biology. Examples of intercropping that effectively prevents pests are the use of clover undersowing to deter cabbage root fly (Finch and Edmonds, 1994) and *Medicago litoralis* to deter carrot root fly (Ramert, 1993; Rämert & Ekbom, 1996).

The use of trap crops, usually in strip cropping systems, shows variation in effectiveness (Hokkanen, 1991). A simulation model (Banks & Ekbom, 1999) indicates that the effectiveness of trap crop is correlated with the relative strengths of the attractiveness of the trap crop to principal crop. Several green manure crops were shown to be good trap crops for *Lygus* spp. in a lettuce agroecosystem (Rämert *et. al* 2001).

MIXED SPECIES CROPPING AND DISEASE ATTACK

Mixed species cropping has been shown to be an effective disease management tool, especially in cereals. For example, Vilich-Meller (1992), showed that mixtures of winter-rye/winter-wheat and spring-barley/oats reduced fungal leaf diseases and Lennartsson (1988) showed that a mixture of wheat and *Medicago lupulina* reduced the incidence of take-all disease of wheat, a soilborne pathogen. The underlying epidemiology has also been extensively modelled (Garrett & Mundt, 1999) from the perspective of varietal mixtures and can simply be explained as the reduced chance of fungal spores encountering a susceptible plant in a mix. The effect tends to improve with increase in the number of genotypes in the mix and the randomness of the mix. Although the epidemiology of airborne epidemics makes them amenable to manipulation by mixed cropping it could also be expected to alter microclimates within the crop and from this point of view could effect disease development positively or negatively.

CONCLUSIONS

Mixed species cropping, particularly row intercropping and strip intercropping, could be an important tool for pest and disease management in organic farming systems. However, it is only likely to be widely adopted by organic growers in the UK once the potential benefits –eco-services- have been fully evaluated and can be shown to outweigh the increased management and labour input that will to be necessary for the more complex cropping system. These benefits are especially likely to include improved techniques for management of soil fertility in addition to pest and disease control. It is probable that more practically orientated long term research based in well established organic farming systems will be necessary to achieve this.

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From: Powell et al. (eds), *UK Organic Research 2002: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth*, pp. 207-210.