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Mechanical and physical control in apple orchards as preventative fungal disease management

Holb, I.J.

University of Debrecen, Faculty of Agriculture, Institute of Horticulture, 138. Böszörményi str., Debrecen, H-4032, Hungary (holb@agr.unideb.hu)

Summary: In this minreview, mechanical and physical control against apple fungal diseases among non-chemical control approaches were summarized. This overview listed five groups of mechanical and physical control methods: pruning, removal of inoculum sources, shredding of leaf litter, burying of inoculum sources and flaming of leaf litter. These methods were shown to reduce succesfully infection potential of inoculum sources in orchards and these non-chemical control measures are one of the most essential approaches for preventative fungal disease management. However, most of these methods are not widely spread in the apple-growing practice due to relatively low control efficacy, medium to high labour costs and/or time limits during the season.

Keywords: *Malus x domestica* Bork., mechanical and physical control, apple fungal diseases, pruning, removal and shredding of leaf litter, burying and flaming of leaf litter

Introduction

In apple production, the key fungal disease are apple scab (*Venturia ineaqualis*), apple powdery mildew (*Podosphaera leucotricha*), European canker (*Nectria* [*Neonectria*] *galligena*), brown rot (*Monilinia* spp.) and the disease complex of flyspeck and sooty blotch in preharvest disease management of apple (Holb, 2009). Among control methods one of the most environmentally freindly control approach is the mechanical and physical control against apple fungal diseases among non-chemical control approaches. The most known methods in mechanical and physical control methods are pruning, removal of inoculum sources, shredding of leaf litter, burying of inoculum sources and flaming of leaf litter (Table 1). These methods are known to reduce/eliminate inoculum sources of fungal diseases in apple orchards. The aim of this minireview was to summarize mechanical and physical control methods against the above mentioned six fungal diseases in preharvest disease management.

Pruning

Pruning of trees can reduce several diseases of apple by the removal of diseased plant parts. Dormant pruning reduces overwintered conidial inoculum of apple scab (Holb et al., 2004; 2005). The authors showed if autumn scab incidence on leaves was above 40%, the upper two-third of

Table 1. Some reviewed aspects of mechanical and physical control approaches used against scab, powdery mildew, European canker, brown rot, flyspeck and sooty blotch in preharvest disease management of apple

Mechanical and physical control approaches	Fungal disease				
	Apple scab	Apple powdery mildew	European canker	Brown rot	Flyspeck and sooty blotch
Pruning	woody-shoot, bud, shoot, leaf, fruit	woody-shoot, shoot, bud	infested twig, leaf scars, shoot	mummified fruit, infested fruit	infested fruit
Removal of alternate host	wild apple, hawthorn, mountain ash, firethorn, locquat	–	–	rosaceous hosts	blackberry
Removal of crop debris	fallen leaf; against primary inoculum	–	–	dropped fruit; clustered fruit against asexual inoculum	clustered fruit; against asexual inoculum
Shredding of leaf litter	against primary noculum	–	–	–	–
Burying of inoculum; flaming of leaf litter	against primary inoculum	–	–	–	–

terminals may need to be pruned before bud break in order to eliminate overwintered conidia associated with buds (Holb et al., 2005).

Dormant season pruning also reduce primary inoculum of apple powdery mildew. Removal of shoots during winter pruning is a well-knonw control practice (e.g. Csorba, 1962; Hickey and Yoder, 1990; Holb, 2005). Seasonal disease development of powdery mildew can also be reduced by removal of infected shoot not only in dormant bud stage but during the season on unfolded young shoots (e.g. Csorba, 1962; Hickey and Yoder, 1990).

Dormant pruning is one of the major management options against European canker. Removal of infested twigs reduces the spread of the disease but pruning cuts can be important sites for a new infection (Kennel, 1963; Swinburne, 1971). High inoculum dose and young pruning wounds resulted in higher risk of infection (Xu and Butt, 1996). Therefore, all cuts needs to be protected with for instance fungicide treatment, wound-treatment with an effective canker paint (Cooke, 1999).

Pruning of mummified fruits is also an effective control practice to reduce inoculum sources of brown rot (Wormald, 1954; Leeuwen et al., 2002). During the season, all infected fruit should also be removed for effective brown rot management (Holb and Scherm, 2007).

Removal of inoculum sources

Removal of inocuéum sources are mostly done by removal of infected crop debris such as infected leaves, dropped fruit and clustered fruit.

For instance, *V. inaequalis* overwinters on leaf debris and many studes demonstrated that fallen leaf removal reduced the primary inoculum source of apple scab in the following spring (e.g. Louw, 1948; Holb, 2006, 2007; Gomez et al., 2007). These studies demonstrated that leaf removal can reduce ascospore production by 56 to 79% and leaf scab incidence in spring by 18-57%. Fallen leaf removal can be performed in combination with other orchard management activities (Holb, 2007).

Removal of dropped fruit is also an effective control method against *Monilinia fructigena* (Holb and Scherm, 2007). Authors demonstrated that the early summer fruit drop serves as a bridge between inoculum of overwintered fruit mummies in the spring and the first infected fruit in the tree in midsummer. Therefore, removal of these dropped fruits reduces disease incidence on fruit in the tree in organic orchards.

Removal of clustered fruit reduces sooty blotch and flyspeck, because clustered fruit provide a more favourable microclimate for disease development than single fruit (Sutton, 1990b). Clustered patterns of fruit also increase brown rot of apple fruit due to fruit to fruit contact and/or insect damage among the members of the cluster (Leeuwen et al., 2000; Xu et al., 2001, Holb and Scherm, 2008).

Removal of infected branches and stems during the season also reduces inoculum sources of *N. galligena* (Scheer, 1980).

Shredding of leaf litter

Leaf shredding can reduce primary scab infection from 45 to 85% and therefore a common sanitation practice in most orchards (Sutton et al., 2000; Vincent et al., 2004; Holb, 2007, Holb and Kunz, 2016). Leaf shredding or fallen leaf removal should be combined with other non-chemical control methods such biological control and disease resistant cultivars in order to increase efficacy (Holb and Kunz, 2016).

Burying of inoculum sources

Burying can be a used succesfully if leaf removal/ shredding can be difficult to perform. Ploughing and disc cultivation are suggested for this purpose (Louw, 1948; Holb, 2007), however, efficacy of disc cultivation is only 50-58%. Therefore, Holb (2007) indicated that efficacy of disc cultivation needs to increase by combining it with other non-chemical control options.

Flaming of leaf litter

Flaming is mainly used against weeds in orchards though it has reducing efficacy on overwintering inoculum sources of *V. inaequalis* in fallen leaf litter (MacHardy, 1996; Anderson, 2007). Flaming is not burning the aim is causing cells rupture of the pathogens. Leaf litter on the orchard floor should be heated at a minimum of 70 °C; otherwise, it does not have enough cell rupture effect on *V. inaequalis* ascocarps. Flaming is costly which is two to four times higher than other sanitation or chemical control methods.

Conclusions

Mechanical and physical control methods are one of the most basic approaches for reducing inoculum sources in apple orchards, but most of these methods are not widely spread in the apple growing practice due to their relatively low efficacy, meidum to high labour costs and/or time limits during the season. Integration of mechanical and physical control methods with other non-chemical control methods can effectively increase disease reduction efficacy and their use in commercial orchards.

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