POTENTIAL INFLUENCES OF MULTIPURPOSE TREE CHOICE IN THE DEVELOPMENT OF DISEASES OF ASSOCIATED CROPS IN AGROFORESTRY SYSTEMS: WHAT DO WE KNOW TODAY?

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BONDOLE, B. M. L. 1999. Potential influences of multipurpose tree choice in the development of diseases of associated crops in agroforestry systems: What do we know today? This paper is an attempt to put in perspective how a multipurpose tree can influence plant disease dynamics in associated perennials and annual crops. All trends discussed are based on observations made in various parts of the world and are not exclusive to any single species. Any combination of components in agroforestry systems can have beneficial or detrimental influences on plant disease dynamics. The objective of this paper is to bring awareness of potential beneficial or detrimental interactions, mainly how agro-forestry cropping systems can create suitable conditions for what is known as collateral infection on some major components of agroforestry systems. In this respect, the most important aspects to consider when deciding on the appropriate association (tree-crop) is the host-range of any pathogen to either of the components. In some cases, what may pass as only a minor disease to the less important component of the system may be detrimental to the more income generating component. In addition, the potential of multipurpose trees as breeding support for disease vectors, insects or nematodes, should be taken into consideration.

Key words: Agroforestry - plant pathology - multipurpose trees - species choice - collateral infection - vectors - inoculum sources - host range

BONDOLE, B. M. L. 1999. Potensi pengaruh pemilihan pokok pelbagai guna terhadap perkembangan penyakit kepada tanaman bersekutu dalam sistem perhutanan tani: Apa yang kita ketahui mengenainya sekarang? Artikel ini bertujuan untuk mengetahui dalam jangka panjang bagaimana pokok pelbagai guna dapat mempengaruhi dinamik penyakit tumbuh-tumbuhan terhadap hasil tahunan dan pokok saka bersekutu. Semua trend yang dibincangkan adalah berdasarkan cerapan yang dijalankan di pelbagai tempat di dunia dan tidak mengkhususkan kepada spesies tertentu. Mana-mana kombinasi komponen dalam sistem perhutanan tani dapat memberikan pengaruh yang menguntungkan atau merugikan terhadap dinamik penyakit pokok. Objektif artikel ini ialah untuk memberikan pengetahuan mengenai potensi saling tindakan yang menguntungkan atau yang merugikan terutamanya mengenai cara-cara sistem perhutanan tani dapat mewujudkan keadaan yang sesuai, yang dikenali sebagai jangkitan sampingan, terhadap beberapa komponen utama dalam sistem perhutanan tani. Dalam hal ini, aspek paling penting yang perlu dipertimbangkan dalam menentukan sekutu yang sesuai (tanaman pokok) ialah julat perumah mana-mana patogen bagi tiap-tiap komponen. Dalam beberapa kes, apa yang dianggap penyakit minor kepada komponen yang kurang penting dalam sistem tersebut, mungkin boleh menyebabkan kerugian kepada komponen yang dapat menjana lebih banyak pendapatan. Di samping itu, potensi pokok pelbagai guna sebagai sokongan pembaikbiakan kepada vektor penyakit, serangga atau nematod perlu dipertimbangkan.

Introduction

The choice of a multipurpose tree species to be associated with either annual or perennial crops rarely takes into consideration the disease aspects. The choice is mostly dictated by the adaptation of the species to the environment and the services or products it provides. Some species such as *Leucaena* spp., *Acacia* spp. and *Gliricidia* sp. have been vastly adopted due to their nitrogen fixing ability, fodder production potential and their usefulness as fuelwood, pole, post or as pulpwood. Little attention is given to the short- or long-term implication on the development of diseases on associated crops. Boa and Lenné (1994) have compiled a comprehensive list of diseases on 179 multipurpose tree species. This bibliographic compilation shows that many pathogenic fungi, bacteria, viruses and nematodes have been isolated from *Leucaena* spp. On *Leucaena leucocephala*, one of the most frequently adopted species, the authors listed 83 pathogens. Just to mention a few, the range of *Leucaena* spp. pathogens includes *Colletotrichum gloeosporioides*, *C. crassipes*, *Camptomeris leucaenae*, *Fusarium oxysporum*, *F. moniliforme*, *F. solani*, *F. semitectum*, *Ganoderma lucidum*, *Pythium* spp., *Rhizoctonia solani*, *Botryodiplodia theobromae*, *Cephalosporium* sp., *Phoma* sp., *Cladosporium* sp., *Chaetomium* sp., *Penicillium* spp., and *Aspergillus flavus*, one facultative pathogenic bacterium, *Pseudomonas fluorescens*, the root-knot nematodes *Meloidogyne incognita* and *M. javanica*, and the lesion nematode *Pratylenchus zeae* (Boa & Lenné 1994). Apart from *Camptomeris leucaenae*, most of these pathogens are well known as they affect the yield of a broad range of hosts, both annual and perennial crops (Table 1). Although the dynamics of pathogen population and epidemiology are known, the control of these pathogens has been difficult. Measures recommended to control them have been formulated and tested on monospecific forest plantations or annual crops. Yet the introduction of each multipurpose tree in the crop-production systems brings with it its disease problems, and a better understanding of disease dynamics in agroforestry systems is needed.

Plant diseases and characteristics of agroforestry systems

Monospecific tree plantations are managed differently from mixed cropping of non-woody and woody perennials. Environmental factors (relative humidity, soil moisture, soil temperature, species diversity, etc.) in pure forest plantations in most cases are different from those in agroforestry systems. These environmental factors play an important role on diseases and pests. Thus diseases and pathogen populations do not follow the same patterns in pure forest plantations, as in annual monocropping and in mixed cropping common in agroforestry systems.

As a sign of their growing importance, multipurpose trees are cultivated both in pure stands for various products or as a component in more complex agroforestry systems. In either case, they are exposed to various diseases and pests. The intensity of plant diseases and pathogen population dynamics is determined by a number of abiotic and biotic factors. The important abiotic factors are radiation, soil physico-chemical properties, relative humidity, temperature, rainfall and wind. The biotic factors include vegetation, animal species, and soil- and air-borne microorganisms. Abiotic factors can either promote or inhibit the multiplication of pathogenic fungi, bacteria, nematodes or viruses. Microclimatic conditions (temperature, relative humidity and soil moisture) are different in agroforestry systems as compared to monospecific crops of woody perennials or annual crops. Mixed cropping, either of annual crops alone, or of woody perennials and annual crops, tends to reduce above- and below-ground temperature and relative humidity, while in some cases, competition decreases soil moisture. For example, excessive shade tends to promote abnormal apical growth, less vigor in the undergrowth crops and, most probably, promotes foliar and root diseases. It is not yet understood how such changes influence pathogenic populations. No documented data are available on these aspects.

Compared to a sole crop, an increase in cocoa (*Theobroma cacao*) diseases in Papua New Guinea was observed when *L. leucocephala* was used as a shade tree. In contrast, under the same environment, the widespread practice of planting cocoa under coconut palm (*Cocos nucifera*) conferred considerable economic and managerial advantages, and generally cocoa suffered less from pest and diseases than when it was in sole crop (Smith 1985). In this case one can assume that it is the upper component (shade tree) that brings some detrimental influence on the undergrowth component. When comparing different combinations of tuber crops and coconut palm, Menon and Nayar (1979) observed that coconut yields improved in plots intercropped with elephant yam (*Amorphophallus campanulatus*), followed by yam (*Dioscorea alata*) to a lesser extent. In plots with cassava (*Manihot esculenta*) as the intercrop, the intensity of wilt on coconut increased, whereas in the plots in which it was intercropped with yam and elephant yam, the disease intensity declined. Apparently, it is the upper component that suffers from the association and shade does not play any negative role. In this case the two crops share the same pathogen (*F. oxysporum*).

In Rwanda, alley cropping (sesbania-maize) experiments conducted by Yamoah and Burtleigh (1990) revealed that alley width significantly affected common rust (*Puccinia sorghii*) development. The proportion of infected leaves (98%) and number of uredinia (150) per plant of maize (*Zea mays*) in an open field were significantly greater than from maize in 2-, 4-, 6- and 8-m alleys (78 to 83% and 42 to 59 uredinia), and rust development in the middle rows was significantly greater than in the border rows. One may conclude that sesbania alleys might effectively limit the development of *Puccinia sorghii*. Unfortunately, no explanation is given for the positive effect of the sesbania hedge on the incidence of rust. The reduction of rust occurrence may be due to various factors, but definitely the non-susceptibility attribute of *Sesbania* sp. to *Puccinia sorghii* allows it to lower depression on maize yield by playing the role of a physical barrier to air-borne spores.

Table 1. Some susceptible crops to pathogens affecting *L. leucocephala* as collateral host (Boa & Lenné 1994)

Host	Disease/causal agent										
	Colletotrichum gloeosporiodes	*Colletotrichum truncatum*	*Colletotrichum crassipes*	*Colletotrichum graminicola*	*Fusarium oxysporum*	*Fusarium moniliformis*	*Fusarium solani*	*Fusarium semitectum*	*Ganoderma lucidum*	*Meloidogyne incognita*	*Pratylenchus zeae*
Leguminosae											
Phaseolus vulgaris							*	*		*	
Glycine max		*					*	*		*	
Vigna unguiculata	*	*			*		*			*	
Cajanus cajan					*			*		*	*
Solanaceae											
Lycopersicon esculentum											
Solanum tuberosum					*		*			*	
Graminae											
Zea mays					*	*				*	*
Oryza sativa				*	*	*		*		*	*
Sorghum sp.				*	*	*	*	*			*
Malvaceae											
Gossypium hirsutum					*	*	*				
Palmae											
Cocos nucifera	*								*	*	
Phoenix dactylifera					*						
Elaeis guineensis	*				*				*		
Sterculiaceae											
Theobroma cacao	*				*		*		*	*	
Discoreacea											
Dioscorea alata	*										

Host-range implication

Although Menon and Nayar (1979) and Smith (1985) did not name the causal agent, it is known that wilt on cassava, coconut, yam and leucaena is caused by *F. oxysporum*. However, in the coconut-cassava combination, the pathogen seemed to be more depressive on the yield of coconut than on cassava. This case showed that one pathogen may infect many components in an intercrop situation but have varying depressive effects on their yields.

In Nigeria, Emebiri and Obiefuna (1992) observed that the intercropping with cassava reduced the incidence and severity of the sigatoka disease (*Mycosphaerella fijiensis*) on plantain (*Musa* sp.) by 10% , and the interaction of leaf removal and intercropping with cassava reduced the disease incidence and severity by 23 and 25% respectively compared to the sole plantain crop. These are two different situations. Cassava as an intercrop seems to reduce the incidence and severity of sigatoka disease of plantain in Nigeria, but causes a detrimental effect on coconut by increasing wilt incidence in India. In Nigeria, cassava is not host to *M. fijiensis*, the causal agent of sigatoka and therefore does not play the role of a multiplication or collateral host of this pathogen. However, in India, cassava is host to *F. oxysporum* and plays the role of a multiplication host, and hence depresses the yield of coconut without its own yield being affected. While it is certain that cassava increases the inoculum in the soil, it is not equally certain if it also affects the field resistance of coconut to *F. oxysporum*.

The apparent inferiority of *L. leucocephala* to coconut palm as a shade tree for cocoa can be partially attributed to the existence of common diseases between leucaena and cocoa, and also to leucaena's excessive shade or vulnerability to diseases induced by nutrient deficiencies. Smith (1985) reported that the primary infection of leucaena by *F. semitectum* came from collateral hosts within *L. leucocephala* plantations such *Cassia fistula, C. tora, Cymbopogon citratus, Cyperus rotundus, Dendrocalamus strictus, Diospyros melanoxylon, Lantana camara, Murraya koenigii* and *Saccharum munja* . This case shows that some of the most yield depressing pathogens on important food or cash crops, annuals or perennials can primarily originate from collateral weed or woody hosts. Thus, diseases common to multipurpose trees and main annual crops, and also between the multipurpose trees and neighbouring wild plants, can result in very detrimental effects on the main crop. Unfortunately , the role of most multipurpose trees as primary or collateral hosts has so far not been assessed. Another lesson from the work of Smith (1985) is that the introduction of multipurpose trees or shrubs in production systems can be an artificial way of extending the host-range of a pathogen. In addition to the above ten hosts, he identified *Dendrocalamus vulgare* and *Melocanna baccifera* as new hosts for *F. semitectum*.

The economic importance of *Fusarium* spp. is well known. Table 1 shows that *F. oxyporum* species cut across five plant families and can inflict serious economic losses to crops such as cotton (*Gossypium hirsutum*) and palm oil (*Elaeis guineensis*). Optimistic views tend to rely on the pathogenic differences between strains or form species, but such views may be risky when considering facultative pathogens