CHAPTER 7

GENERAL DISCUSSION

Agriculture began, probably 8 000 to 10 000 years ago, somewhere between the Nile in Egypt and the valley of the Indus River in western India (Salmon & Hanson, 1964). Since then, mankind has been challenged with crop diseases (Baker & Cook, 1974). However, only around the middle of the nineteenth century, control of diseases began to receive special attention (Salmon & Hanson, 1964; Agrios, 1988). Today, control of plant diseases is most successful and economical when all available pertinent information regarding the crop, its pathogens and the environmental conditions are part of an integrated control program. This may comprise quarantine, evasion of the pathogen, improving the growing conditions of plants, various cultural and sanitation methods, the use of fungicides, biological control agents and the use of resistant varieties (Agrios, 1988). Integrated control programs are well known for crops such as citrus and mangoes (Agrios, 1988; De Jager, 1999) and cashew (*Anacardium occidentale* L.) is no longer an exception (Waller *et al*., 1992; Martin *et al*., 1998).

The present study was aimed at elucidating aspects of host tolerance mechanisms to the powdery mildew pathogen (*Oidium anacardii* Noack) infection, disease epidemiology and pathogen reaction to potential antagonists and chemical fungicides with a general view of integrated disease management.

Cashew was introduced into east Africa in the XVIth century (Milheiro & Evaristo, 1994) but economically important phytopathological aspects were only recorded from the 1970's onwards (Ohler, 1979; Intini, 1987; Milheiro & Evaristo, 1994). Amongst the various diseases reported, powdery mildew was the most important in Tanzania and Mozambique (Nathaniels, 1996). A wide range of options for integrated cashew management (ICM) has since been evaluated with limited success (Waller *et al*., 1992; Martin, *et al*., 1998; Shomari, 1998; Topper *et al*., 2000). This study illustrated the mechanism of infection of *O. anacardii* on both susceptible and tolerant cashew varieties. Host type reaction differences based on cytoplasmic aggregate densities were noted. The enormous increase in cytoplasm below the infection site seemed to result mainly from synthesis (McKeen & Rimmer, 1973) or rapid traumatotactic migration of cytoplasm (Bushnell & Zeyen, 1976). Similar results have been associated with expression of partial resistance in other host-pathogen systems such as *Puccinia graminis* Pers. on wheat, *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. on beans and *Phytophthora infestans* (Mont.) de Bary on potato (Bushnell & Zeyen, 1976; Aist & Bushnell, 1991). The applicability of the finding in terms of general identification of varietal cashew tolerance to powdery mildew was not explored further.

The present study confirmed that *O. anacardii* possesses a short conidiophore, with one basal cell (Castellani & Casulii, 1981) and that it produces ellipsoidal, thin walled, unicellular and hyaline conidia (Shomari, 1996). It also revealed that the conidial outer wall pattern is honey-comb ornamented with predominantly smooth septa. Such characteristics fit in well for members of *Oidium* subgenus *Pseudoidium* (Y.S. Paul & J.N. Kapoor) comb. Et. Stat. Nov. (Holomorph *Erysiphe* Sect. *Erysiphe* U. Braun) of the new classification proposed by Cook *et al*. (1997). However, it should be noted that the perfect stage of *O. anacardii* is still unknown (Intini, 1987; Shomari & Kennedy, 1998).

When the atmospheric relative humidity, at temperatures of 26-28°C, is around 90-100% for at least six hours, *O. anacardii* is capable of infecting the host (Intini, 1987). However, for a powdery mildew epidemic to occur, weather conditions favourable for conidia release are necessary and susceptible tissue must be available (Schoeman *et al*., 1995). We found susceptible cashew inflorescences blooming from May to November. This coincides with previous observations by Milheiro and Evaristo (1994). However, the appearance of cashew powdery mildew epidemics was only determined by conditions of average minimum and maximum temperatures between 20 and 30°C, air relative humidity of at least 40% and an estimated dew point around 30, under the tree canopy. Temperatures below 15 and above 35°C are known to restrict conidial germination (Shomari & Kennedy, 1999) and thus may have played a major role for disease onset or decline respectively. However, the magnitude of changes of any of the above weather parameters during the course of the disease epidemic could not be directly related to fluctuations in disease severity.

Shomari (2000, *personal communication)* derived a predictive model using data from *in vivo* work which described the effect of temperature and relative humidity conditions on germination of *O. anacardii* conidia. However, the model could not succeed in the field due to variations in conducive conditions for conidial germination between the interior and exterior of the tree canopy (Shomari & Kennedy, 1999). Localities have different powdery mildew development patterns and nut production ratios (Nathaniels & Kennedy, 1996; Topper *et al.*, 2000). A model formulated to monitor the disease progress as a function of climatic influences would enable a more precise timing of fungicide applications and thus avoid unnecessary sprays (Peak *et al.*, 1986). Therefore, the effect these and/or other weather parameters have on other processes such as sporulation rate and penetration processes needs to be explored.

The microbial antagonism that is seen in biological control of plant pathogens is broadly based on the categories of competition (for nutrient and space), parasitism (which may be production of volatile or nonvolatile antibiotics) and hyperparasitism (Singh & Faull, 1988). The 72 isolates from mildew infected cashew leaves and florets had no significant inhibition effect on conidial germination and mycelium development of *O. anacardii*. The pathogen-antagonist niche-overlap pre-condition for a viable biocontrol interaction (De Jager, 1999) was fulfilled at sampling as well as at screening. However, none of the natural epiphytes were antagonistic *in vivo* while the commercial products were. *Bacillus subtilis* and *B. licheniformis* were previously shown to be antagonistic against a range of plant pathogens on avocado (*Persea americana* Mill.) (Korsten *et al.*, 1995; Korsten *et al.*, 1997) and mango (*Mangifera indica* L.) (Pruvost, 1991). Mangoes, avocado and cashew all belong to the family Anacardiaceae. Stack *et al.* (1988) stated that some organisms may be effective only in the presence of other related microorganisms or additives. This is why some formulated products contain nutrients that enable bio-agents to survive during the initial establishment stages (Fokkema, 1976; Hirano & Upper, 1986). Furthermore, Klincare *et al.* (1971) studied the composition and activity of the epiphytic microflora of some Russian agricultural plants and concluded that under conditions of pure culture, only a few were in antagonistic interrelationship with each other. In this research, antagonist combinations were not investigated and should be considered in future studies.

The comparative study of fungicides illustrated that the use of triazoles for powdery mildew control on cashew in Mozambique can be integrated with other fungicides such as Trical or Flint. However, it was also demonstrated that under the current economic environment within Mozambique, none of the fungicides resulted in increased economic benefits compared to non-treated plots. A major understanding of integrated cashew management strategies (Waller *et al.*, 1992; Masawe, *et al.*, 1997; Boma *et al.*, 1998; Sijaona & Mansfield 2001;

Sijaona *et al*., 2001) is therefore recommended in order to minimise the number of applications and maximise biological efficiency of the chemicals. Policy considerations on the price at farmer's level, based on the quality of nuts rather than simply quantity, need to be revised.

The present research brings together aspects of germplasm identification for tolerance to powdery mildew which, if properly integrated with the knowledge on disease epidemiology plus chemical and biological control, would enhance cashew nut production in Mozambique. From this study, future work should focus on determining economic integrated treatment programs that will reduce the costs involved in cashew nut production today.

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