CHAPTER 1

GENERAL INTRODUCTION

The history of hydroponics dates back to the seventeenth century, with commercial use commencing in the early 1940's (Zinnen, 1988; Stanghellini & Rasmussen, 1994). Hydroponic systems are currently employed worldwide to grow high cash value crops such as vegetable, flower, foliage and bedding plants. According to Paulitz (1997), the proportion of vegetables produced in hydroponic systems has been increasing in Europe and Canada, particularly for tomato (*Lycopersicon esculentum* Mill.), cucumber (*Cucumis sativus* L.), lettuce (*Lactuca sativa* L.), peppers (*Capsicum* spp.) and spinach (*Spinacea oleracea* L.). Minor crops include watercress (*Nasturtium officinale* L.), various herbs and spices. In South Africa hydroponically grown crops mainly include tomato, cucumber, pepper, lettuce, brinjal (*Solanum melongena* L.) and strawberry (*Fragaria* sp.), covering approximately 800 hectares (P. Langenhoven - personal communication). Plants are grown using nutrient solutions with or without solid substrates for root support. Hydroponic systems without substrates include the nutrient film technique, deep flow technique, trough culture, and ebb-and-flow systems. Plants can also be cultured in sand, rockwool, or in bags containing peat or sawdust. The nutrient solution can either be recirculated (closed system) or drained after one use (open system) (Jenkins & Averre, 1983; Bates & Stanghellini, 1984; Stanghellini & Rasmussen, 1994).

Although initial capital investment is high, hydroponic systems have several advantages over conventional cultivation in soil. Firstly, inert media, mechanically supporting the plants, provide more consistent rooting conditions for the crop (Zinnen, 1988). Secondly, nutrient regimes and watering are tailored to fit the physiological age of the crop and prevailing environmental conditions. Plant nutrition and the physical environment can be tightly controlled by the grower, resulting in higher yields, better quality and control of crop scheduling. All the elements in the nutrient solution are readily available to the plant, so competition for nutrients can be reduced and greater plant densities can be used (Paulitz, 1997). The third advantage is the avoidance, theoretically at least, of certain root diseases (Bates & Stanghellini, 1984; Zinnen, 1988; Goldberg & Stanghellini, 1990b).

Cultivation in hydroponic systems results in a decrease in the diversity of root-infecting microorganisms compared to conventional culture in soil, but certain types of diseases have become more prominent and damaging in these systems (Stanghellini & Rasmussen, 1994; Paulitz, 1997). Infectious agents, once introduced into the system, are favoured as a result of the abundance of a genetically uniform host, a physical environment with a more constant temperature and moisture regime and a mechanism for the rapid and uniform dispersal of root-infecting agents throughout the cultural system (Favrin *et al.*, 1988; Zinnen, 1988; Stanghellini & Rasmussen, 1994). Hydroponic systems lack the microbial diversity and biological 'buffering' found in natural soils (Paulitz, 1997). Without competition from other microbes the pathogen may quickly become established in the substrate and cause severe disease.

The most important fungal pathogens in hydroponic systems are zoosporic species, being favoured by an aquatic environment (Price & Fox, 1986; Goldberg et al., 1992; Stanghellini & Rasmussen, 1994; Sanchez *et al.*, 2000). *Pythium* is one of the most common and destructive pathogens of crops in recirculating hydroponic systems (Goldberg & Stanghellini, 1990a; Cherif *et al.*, 1994; Stanghellini *et al.*, 1996, 2000). According to Hendrix & Campbell (1973), *Pythium* spp. have a poor competitive ability in soil relative to other root-colonising organisms but often act as primary colonisers of plant tissue. However, in hydroponic production systems, low populations of other microbes and the effective dissemination of zoospores through the nutrient solution increase the potential for disease development (Rankin & Paulitz, 1994).

Root and crown rot and yield reductions caused by *Pythium* spp. have been reported on various hydroponically grown vegetable crops (Stanghellini *et al.*, 1984) particularly cucumber, lettuce, spinach, peppers and tomato (Moulin *et al.*, 1994; Buysens *et al.*, 1995). In South Africa *Pythium* and *Phytophthora* are responsible for most of the root diseases in hydroponically grown crops and are particularly a problem in recirculating systems (A. H. Thompson - personal communication). *Pythium* is present in nearly all hydroponic systems and often infects plants through sites of damage, such as root injury caused during transplanting, or by mineral toxicities, nutrient stagnation or excessive temperatures (Morgan, 1999).

Whilst *Pythium aphanidermatum* (Edson) Fitzp. is probably the most widely reported (Jenkins & Averre, 1983; Rankin & Paulitz, 1994; McCullagh *et al.*, 1996; Wulff *et al.*, 1998) various *Pythium* species are capable of causing disease. Damage caused by *Pythium* ranges from very severe (100 % loss) to light to moderate root or stem damage. In contrast to soil culture where older plants are not as susceptible to damage by *Pythium* spp., damage can be severe in older hydroponically grown plants, with extensive root rot and subsequent plant death (Jenkins & Averre, 1983). According to Stanghellini & Kronland (1986), Moulin *et al.* (1994) and Cherif *et al.* (1997), yield losses can also occur in the absence of any obvious root necrosis and *Pythium* is consistently isolated even from apparently healthy root systems. Factors influencing infection include inoculum density, soil moisture, soil temperature, pH, cation composition, light intensity, and presence and numbers of other microorganisms. Which factor is more important in a given instance often depends on the *Pythium* sp. involved (Hendrix & Campbell, 1973).

The reservoir water used in a hydroponic system as well as the root residues which remain in the hydroponic substrate after a crop has been harvested, could be possible sources of continuous infestation (Menzies & Belanger, 1996; Sanchez *et al.*, 2000). Gardiner *et al.* (1990) noted that during outbreaks of *Pythium* root rot, populations of fungus gnats (*Bradysia impatiens* Johannsen) were very high. It has therefore been suggested that fungus gnat as well as shore flies (*Scatella stagnalis* Fallen) could be potential vectors of *Pythium* (Goldberg & Stanghellini, 1990a; Rankin. & Paulitz, 1994; Stanghellini & Rasmussen, 1994).

To implement effective control procedures it is necessary to ascertain the source(s) responsible for introduction of the pathogen (Goldberg & Stanghellini, 1990b; Stanghellini & Rasmussen, 1994) and to identify the *Pythium* species responsible for yield reductions (Moulin *et al.*, 1994). In this study *Pythium* species. infecting the most important crops in selected hydroponic systems in South Africa were identified, their pathogenicity assessed and the disinfestation of gravel substrate investigated.

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