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Effect of Soil Temperature on Distribution and Population Dynamics of *Fusarium* Species

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ABSTRACT

Environmental factors mainly temperature are believed to determine the distribution and population dynamics of *Fusarium* species in a natural ecosystem. Species may be restricted in their distribution by adaptation to specific sets of soil environmental conditions. Population dynamics of five *Fusarium* species representative of different climatic conditions were studied at three levels of temperature (13-18 / 19-24 / 25-30°C) and constant water potential (field capacity). Temperature had a significant influence on the population level of all test *Fusarium* species. *Fusarium sambucinum* showed noticeable reduction of population at warm temperatures. The population of *F. solani* and *F. compaction* were higher at high temperatures. The population of cosmopolitan species, *F. equiseli* showed little change at all experimental conditions, *Fusarium acuminalum* did not compete well with other species in this experiment, its population being low at all treatments.

Keywords: ***Fusarium*** , Population , Temperature , Distribution , Isolation.

INTRODUCTION

Fusarium species are common in soil in most climates, colonizing plant root and debris. The results of recent mycogeographical studies have demonstrated that some species of *Fusarium* are cosmopolitan while others are restricted to a particular climatic region (Burgess *et al,* 1993; Saremi *et al,* 1997). It has been concluded that the occurrence and population density of *Fusarium* species in the field are influenced by climatic factors, mainly temperature and rainfall. This concl-usion is based solely on the mycogeographical surveys and not on experimental studies. It has been reported that *F. solani* and *F. equiseti* for example were cosmopolitan in distribution, in contrast *F. sambucinum* was restricted to the cool temperate areas (Marassas *et al.* 1988). *Fusarium compaction* was reported mostly in warm temperate areas. There is also increasing evidence that overall activities of soil-borne fungi are mainly controlled by temperature, water potential and their interactions in soil (Cook & Whipps, 1993; Killham, 1994; Griffin, 1972). The effect of temperature on the activity of individual species of fungi, or on the soil mycoflora as a whole, has been studied by several workers (Smiley & Uddin, 1993. Raj & Kapoor, 1993; Mundel *et at,* 1995). This study was designed to clarify how soil environment, mainly temperature factor affects the distribution dynamics of *Fusarium* species in natural soil, and the consequence for *Fusarium* community structure.

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MATERIALS AND METHODS

Five *Fusarium* species were chosen as representative of species adapted to a different range of climatic regions. *Fusarium solani* and *F. equiseti* were chosen as cosmopolitan species. *Fusarium acuminatum* and *F. sambucinum* were chosen to represent cool climates. Cultures were transferred to carnation leaf agar (CLA) and incubated in standard conditions (25°C day 20°C night with a 12 hr photoperiod containing two 40 w cool white fluorescent tubes and one 36 cm black light lube, Philips TL 36 w / 80 RS F40 BLB) for two weeks to form sporodochia, which were then used as a source of microconidia for inoculation of the chaff-grain medium.

Polyester oven bags containing chaff medium were inoculated with conidial suspension of test cultures. The cultures were incubated at room temperature, shaken regularly to enhance colonization. Cultures were air dried, milled and passed through a sieve (710 mm mesh) individually. Sterile sieved (710 mm mesh) soil was added to the inoculum of each species to decrease the concentration of individual propagules. Different amouns of sterile soil were added since the concentration of colony forming propagules per gram of each species was different *(F. solani* 2x10 , *F. compaction* 2.4x10 , *F. equiseti* 1.5x10 , *F. acuminatum* 7.5x10' and *F. Sambucinum* 6x10). The number of colony forming units per gram mixture of each species was determined on PDA media using soil dilution plate (Sangalang *et al,* 1995).

Eighteen pots were used, each containing a plastic bag to prevent drainage of water. Two kg natural sieved soil was added to each pot to a depth of 10 cm. The remainder of the pots were filled with 2.5 kg. of infested soil, containing the five test fungi to bring she tola! weight to 4.5 air-dry soil pot. Infested soil was prepared by mixing the required amount of inoculum of each species with 2.5 kg soil. The final population of each species in the mixture was 2000 cfu/g including both the added inoculum and indigenous *Fusarium* populations. The mixture was shaken thoroughly and only the top soil (10 cm) in the pot was infested. Rye grass *(Lolium perenne* L.) was used in this experiment. Seeds (0.7 g per pot) were sown in infested top soil and pots were placed in natural light at three fluctuating temperature regimes. (13-18, 19-24 and 25-30°C) in the glasshouse. Pots were watered to field capacity by adding the required amount of water depending upon the previous moisture cantent characteristic of the soil. The pots were then weighted and watered every two days to maitain field capacity.

Cylindrical cores, 10 cm. in length and 1 cm. in diameter, were used to collect soil samples. Three subsampls collected from each pot (one from the center and two from opposite sides) were mixed together to form a composite sample of each pot. Six pots were sampled tor each temperature regime. Samples were taken 1-3-6 and 12 months after sowing the seeds. Samples taken from each pot were air dried/crushed, mixed and sieved (710 mm mesh) prior to soil dilution plating. Soil dilution (1/200) in 0.05% water agar were plated onto 3 PAP plates per soil sample. The cultures were incubated in the culture room for 5-7 days and a single hyphal tip of each colony was transferred onto PDA and CLA plates for obtaining pure colony. Species identification was made possible after 7-10 days of incubation according to system suggested by Burgess *et al* (1994).

RESULTS

Effect of Temperature on Populations of *Fusarium* Species in Soil

The results of this study indicated that temperature had a significant influence (P=0.000) on the population level for all live *Fusarium* species in soil. The population

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of the test fungi changed rapidly during the first three months (Figures 1,2) but then changed only slowly over next nine months and by twelve months was approaching equilibrium. *Fusarium sarnbucinum* showed an obvious response to temperature. The population density of this species increased by 25% at cool (13-18°C) temperatures. There was noticeable reduction of population at moderate (19-25°C) and especially at warm (25-3O°C) temperatures (Figure 1).

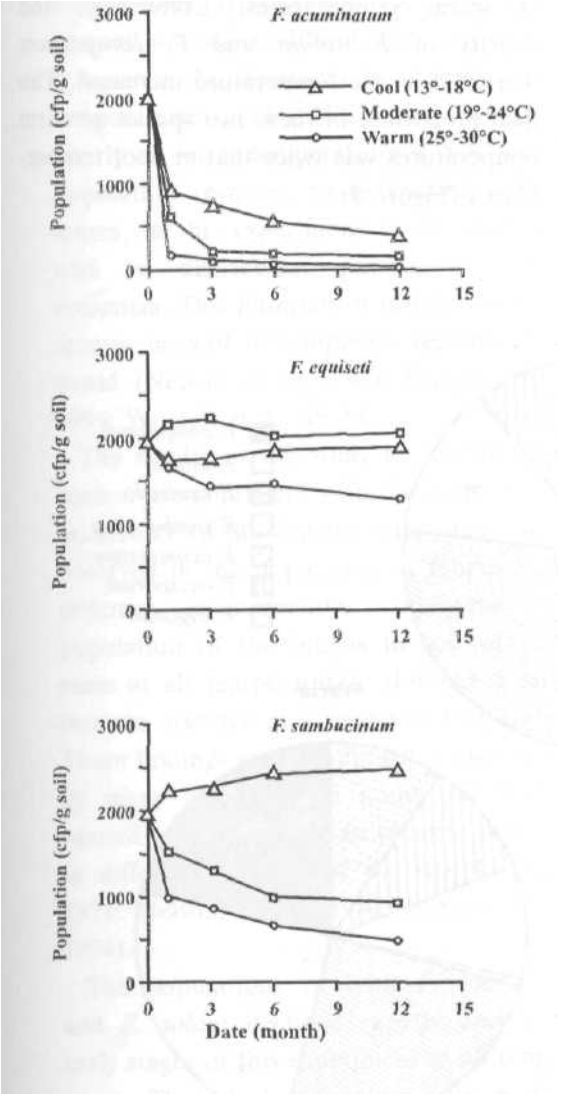

Figure l. Population dynamics of three *Fusarium* species in soil at three levels of temperature (13-18; 19-24;25-30°C) over a one year period.

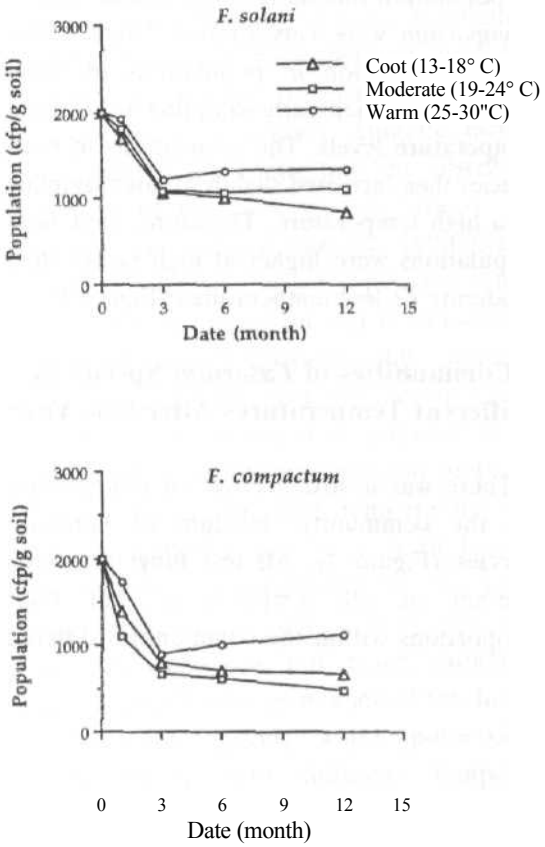

Figure 2. Population dynamics of two *Fusarium* species in soil at three different levels of temperature (13-18 ; 19-24 ; 25-30°C) over a one year period.

The greatest decrease occurred at warm temperatures and the population appeared to be still declining at 12 months. A dramatic reduction occurred in populations of *F. **acuminatum*** in the first few weeks at all temperatures, but at twelve months, the rate of decrease was least at cool (13-18°C) temperatures with 20% of the population remaining, as compared with 7% at 19-24°C and **11.4%** at 25-30°C . In this experiment *F. **acuminatum*** did not compete well, its population being low at all controlled temperatures.

There was little change in population of *F. equiseti* both at cool and moderate temperatures, but the population declined by one quarter at warm temperatures. The highest population density of the fungus occurred at moderate temperature (Figure 1). The patterns

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of population fluctuation of *F. Solani* and *F. Compaction* were very similar. There was a distinct reduction in populations of these two isolates when early sampling at all three temperature levels. The populations of both species then increased slightly at later sampling at a high temperature. Therefore, their final populations were higher at high rather than moderate or low temperatures (Figure 2).

Communities of *Fusarium* Species at Different Temperatures After One Year

There was a strong effect of temperature on the community structure of *Fusarium* species (Figure 3). All test fungi remained present at all temperatures, but their proportions within the communities differed greatly. The chi-squared test confirmed the result that communities of *Fusarium* species were significantly different at different temperatures (Figure 3).

Fusarium equiseti was a major component at all temperature regimes, although its population was highest at moderate temperatures. The populations of *F. sambucinum* and *F. acuminatum* decreased as the temperature increased. *Fusarium sambucinum* was the dominant species at cool temperatures, whereas its propagule density was very low at warm temperatures. Conversely, the density of *F. solani* and *F. compaction* increased as the temperature increased. The final proportion of these two species at warm temperatures was twice that at cool temperatures (Figure 1).

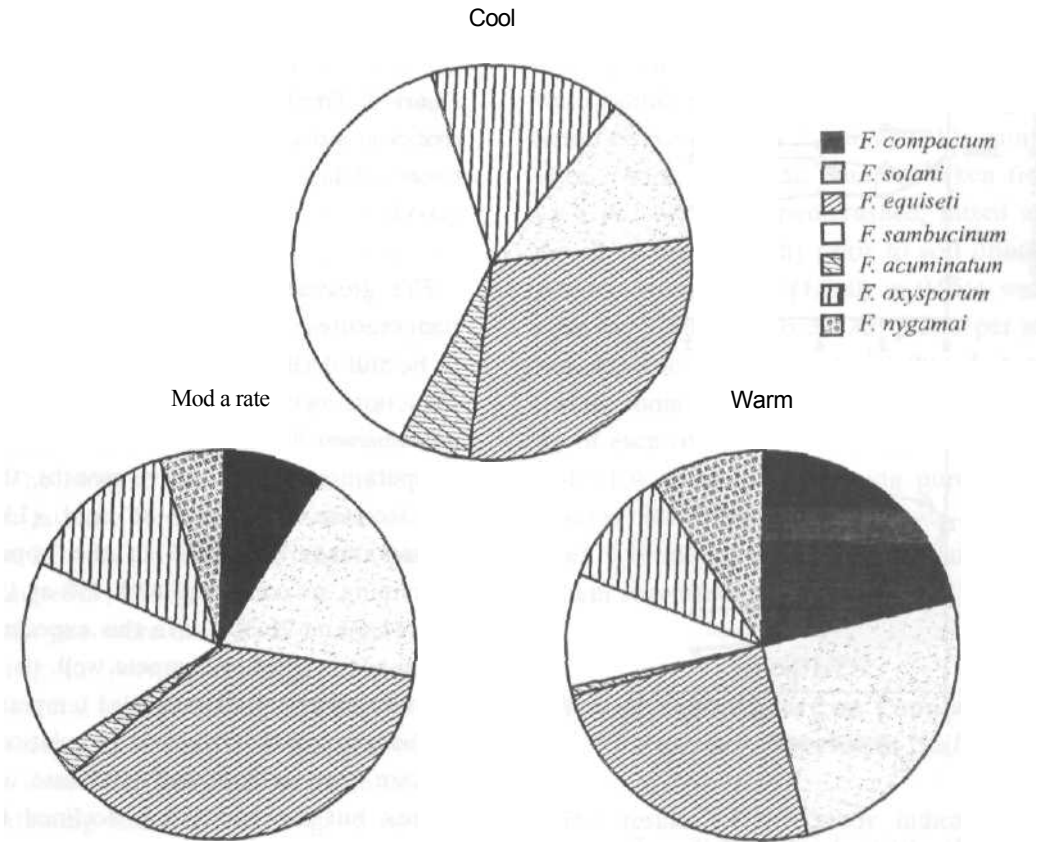

Figure 3. Final population of *Fusarium* species at three levels of temperature.

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The proportion of the indigenous fungi, *F. nygamai* and *F. oxysporum* in the community was also affected by temperature, *F. oxysporum* being present mainly at moderated temperatures.

DISCUSSION

The results in this study indicate that temperature was a major factor affecting population dynamic and community structure of ***Fusarium*** species. The population of *F. sambucinum* hypothesized to be a fungus adapted to cool conditions, increased so thai it became the dominant species in soil at temperatures (13-18°C), and competed poorly at warm temperatures (25-30°C). Its population response to fluctuating temperatures, in this experiment, is in accordance with its distribution pattern in natural ecosystem. This *Fusanum* is mainly a common species in cool to temperate regions of the world (Nelson *et al,* 1983; Burgess *et al,* 1994; Windels *et al,* 1988).

The results of the study in relation to *F. equiseti* are consistent with the cosmopolitan occurrence of this fungus, little changs being observed in the population of fungus under different environmental conditions. The population of the fungus in soil were the same al all temperatures, although a slight increase occurred at a moderate temperature. These findings support the conclusion drawn by many authors who point out that *F. equiseti* is a cosmopolitan species, occurring in different climates of the world (Booth, 1971; Nelson, *et al,* 1981; Burgess, *et al,* 1994).

The populations of both *F. compaction* and *F. solani* declined rapidly during the early stages of this experiment at all temperatures. Their final populations were markedly lower than those of *F. sambucinum* and *F. equiseti* at cool temperatures (Van Wyke *et al,* 1987).

Apart from *F. acuminalum,* ultimate populations of remaining isolates belonging to other species were consistent with their natural occurrence. It can be concluded that temperature as a major climatic factor is responsible for controlling the distribution pattern of *Fusarium* species, however their relative abundance can be influenced by water availability. Indeed population dynamics of *Fusarium* species in soil is influenced by interactions of temperature and water potential. It is possible that high water potential was responsible for high population of *F. solani* at warm temperatures and suppression of *F. acuminatum* at low temperatures in the experiment. The poor activity of *F. acuminatum* may be attributed to its inherent deficiencies as a saprophyte or the experimental conditions not being suitable for development and regeneration of this fungus.

Although various water potentials in combination with different temperature levels were not used in this study, the results indicate the important role of environmental factors mainly temperature and water in the ecology of *Fusarium* species and consequently other soil-borne fungi. In the light of the findings of this investigation, the importance of temperature and water on ecology of *Fusarium* species is confirmed. It may be said that each fungal species is favored by specific levels of temperature and water potential and accordingly each species has a physiological adaptation to a particular environment niche (Liddell, 1992; Liddell & Burgess 1985). It can be said that if a fungal species is going to be introduced to the soil as a biological agent, specific levels of temperature and water potenlial are required for its competitive activities. Indeed, temperature and waver potential and their interactions are main factors in managing fungal population in soil (Subbaro *et al,* 1993).

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