HOW WILL PLANT DISEASES IMPACT ON PASTURE PRODUCTION UNDER CLIMATE CHANGE: A CASE STUDY OF STYLOSANTHES ANTHRACNOSE

Sukumar Chakraborty
CSIRO Division of Tropical Crops and Pastures, 306 Carmody Road, St. Lucia, Australia 4067

ABSTRACT
Impact of climate change on plant diseases is poorly understood due to the paucity of studies in this area. A process-based approach to quantify the impact on pathogen/disease cycle is potentially the most useful in defining impact of factors like elevated CO_2 on plant diseases. This study establishes the influence of twice-ambient CO_2 on components of the anthracnose disease cycle caused by *Colletotrichum gloeosporioides* in the tropical pasture legume Stylosanthes scabra. Compared to ambient CO_2, at 700 ppm, time between inoculation and symptom appearance (incubation period) and percentage leaf area diseased were significantly reduced in the two cultivars Fitzroy and Seca; time to appearance of sporulating lesions (latent period) remained unaffected; while spore production per unit diseased tissue increased significantly. Further research is needed to determine if increased spore production and a more favourable microclimate under elevated CO_2 may lead to rapid development of more damaging pathotypes.

KEYWORDS
Stylosanthes, anthracnose, elevated CO_2, incubation period, latent period

INTRODUCTION
Many of the expected changes in global climatic factors may have relatively small direct impact on plant diseases as these are within the range of current variation. Elevated CO_2 levels will be a major change to which plants and pathogens are not currently exposed. Increased productivity has been predicted for most food, fibre, forest and pasture plants under twice-ambient CO_2 where plants were not generally suffering from disease, weed competition or insect herbivory (Wittwer, 1995). These predictions are likely to be modified when potential impacts of pests, diseases and weeds are considered.

Climate change may alter the physiology, morphology and geographical distribution of hosts and pathogens and influence the economic impact of diseases on production systems. These changes are likely to influence the major stages in the pathogen/disease cycle including host-pathogen co-evolution. A process-based approach is potentially the most useful to define impacts of plant diseases on sustainable pasture production under elevated CO_2. The paucity of knowledge for most managed and natural ecosystems and pastures in particular, means that targeted research on model systems is needed to examine different approaches in dealing with the impact. This paper examines the influence of elevated CO_2 on components of the anthracnose disease cycle caused by *Colletotrichum gloeosporioides* in the tropical pasture legume *Stylosanthes scabra*.

METHODS
Plants of S. *scabra* cultivars Seca, resistant, and Fitzroy, susceptible, were grown in small plastic pots at 30/25°C day/night with 14h photoperiod at 500υmol/m^2/s at the CSIRO controlled environment facility in Brisbane. All plants were grown in 350ppm CO_2 for 3 weeks when half of them were transferred to a room with 700ppm CO_2 while all other conditions were maintained as before. At six weeks of age, 60 plants of each cultivar at each CO_2 concentration were inoculated with 10^6 conidia/ml of C. *gloeosporioides* isolate sr24 pathogenic on both cultivars. Plants were incubated inside perspex tents for 48h and examined daily for the appearance of first signs of disease and sporulation using a 10x hand lens.

Each plant was assessed for disease severity 10 days after inoculation using a 10-point scale where 0, no disease and 9, plant death. The youngest leaf at inoculation from 10-12 plants/cultivar for each CO_2 concentration was shaken in 5ml distilled water for 2h and the resultant suspension was counted using a haemocytometer. Diseased leaf area was measured using image analysis and spore production per unit lesion area was calculated.

RESULTS AND DISCUSSION
Incubation period, measured as the time in days between inoculation and symptom appearance was significantly longer at 700 ppm than at 350 ppm CO_2 in both cultivars (Table 1). Despite this, there was no significant difference in latent period (time between inoculation and sporulation of lesions) between the two CO_2 concentrations for either cultivar. In an earlier study on this disease, Lupton et al. (1995) demonstrated that extended incubation period resulted from a reduction in germination of *C. gloeosporioides* conidia at 700 ppm. As with barley powdery mildew *(Erysiphe graminis)*, this suggests that germination and penetration may be reduced by 700 ppm CO_2 but growth rate of established colonies is faster at 700 ppm than at 350 ppm (Hibberd et al., 1994).

Exposing Seca and Fitzroy to 700ppm for three weeks significantly reduced the percentage of leaf area diseased (Table 1). The level of reduction in severity at the elevated CO_2 was higher in Fitzroy than in Seca. This and the significant ($P<0.01$) cultivar x CO_2 interaction suggested that the two cultivars have different resistance mechanisms. Spore production per unit lesion area increased significantly at elevated CO_2 without an increase in severity. This indicates altered host physiology at elevated CO_2 and is consistent with evidence of increased carbohydrate content at elevated CO_2 affecting cereal rust (Manning and Tiedemann, 1995) and mildew (Hibberd et al., 1994).

Reduced severity at elevated CO_2 implies a potential reduction in economic damage from anthracnose. However, increased precipitation and temperature under climate change along with larger canopies in elevated CO_2 may create more favourable microclimate to enhance disease development. An increased number of inoculum units may survive between seasons. Whether pathogen population size would increase under polycyclic epidemic conditions leading to rapid development of more damaging pathotypes from enhanced fecundity is not known. Likely consequence on production, feed quality and pasture stability may be more serious for perennial pastures such as *Stylosanthes* than for annual pastures. Results from such apparently simple experiments are useful due to practical difficulties of running field trials under elevated CO_2. More research is needed on the effect of CO_2, O_3, UV-B and other factors associated with climate change for a comprehensive assessment of their impact on pasture diseases.

REFERENCES
Hibberd, J.M., Whibread, R., and Farrar, J.F. 1994. Elevated atmospheric CO2 concentrations and powdery mildew of barley. Proc. BSPP Climate change conference, September 1994, Newport, UK.

Lupton, J. A., Chakraborty, S., Dale, M., and Sutherst, R. W. 1995. Assessment of the enhanced greenhouse effect on plant diseases - a case study of *Stylosanthes* anthracnose. 10th Biennial Australasian Plant Pathology Conference, Lincoln University, New Zealand, 28-30 August. p. 108.

Manning, W.J., and Tiedemann, A.V. 1995. Climate change: potential effects of increased atmospheric Carbon Dioxide (CO2), Ozone (O3), and Ultraviolet-B (UVB) radiation on plant diseases. *Environmental Pollution* **88**: 219-245.

Wittwer, S.H. 1995. Food, climate and carbon dioxide, the global environment and world food production. CRC Press, Boca Raton, p. 236.

Table 1
Mean incubation period, latent period, disease severity and spore production with standard error in parenthesis for Colletotrichum gloeosporioides causing anthracnose of Stylosanthes scabra Fitzroy and Seca at ambient (350 ppm) and twice-ambient (700 ppm) atmospheric CO2 levels

Cultivar	CO2 level (ppm)	Incubation period (days)	Latent period (days)	Disease severity (0-9 scale)	Spore production (no/sqmm of lesion)
Fitzroy	350	3.3 (0.06)	5.2 (0.1)	7.1 (0.2)	253 (57)
Fitzroy	700	3.7 (0.06)	5.1 (0.1)	5.3 (0.2)	681 (186)
Seca	350	3.2 (0.05)	4.8 (0.1)	3.3 (0.1)	416 (99)
Seca	700	3.8 (0.05)	5.0 (0.1)	2.8 (0.1)	598 (101)
Analysis of Variance					
Cultivar	P<0.56	P<0.01	P<0.01	P<0.74	
CO2 level	P<0.01	P<0.72	P<0.01	P<0.01	
Cultivar X CO2 level		P<0.10	P<0.21	P<0.01	P<0.31