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Eucalypts in China: Research History, Present Situation and Future Prospect

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Abstract

Silviculture is the major procedures in forest research. Silviculture is traditionally focused on various aspects of tree planting, such as tree selection, site preparation, irrigation and fertilization and so on, and the role of silviculture at that time is to manage forests scientifically for continuous production of goods and services while meeting biological and economic requirements. During the past three decades, an increase in research on silviculture has improved Eucalyptus productivity and on wood properties. But, very little information about this procedure on the review of Eucalyptus grown in China has been published even though this species was introduced many years. This paper reviews the available information regarding research history and progress of silviculture under Chinese ecological conditions and to outline some suggestions to them.

Keywords: Eucalyptus; Silviculture; Research Progress; China

1 INTRODUCTION

Forest trees have a long life span and take a long time to be replaced and the expression of genes in relation to age and competitive environment[1,3,4,19]. So short-rotation plantation management has been becoming a more and more important forest practice inour country [36]. For the last thirty years, the eucalypt plantations have experienced an important development and considerable successful improvements have been achieved by genetic breeding and silviculture. Goncalves et al.[12] gathered together previous studies and analyzed silviculture effects on the productivity and wood quality of eucalypt plantations. Stape et al. [34]. examined the influence of water, nutrients and stand uniformity on wood production of clonal Eucalyptus plantations at eight locations in Brazil. Unfortunately, very little information about breeding and silviculture on the review of Eucalyptus grown in China has been published even though this species was introduced some 130 years ago. This paper aims to summarize the available information regarding breeding and silviculture under Chinese ecological conditions and to outline some suggestions to them.

2 EUCALYPT RESEARCH HISTORY IN CHINA

Eucalypts were first introduced into China by unselected and often incorrect named in about 1890 and originally planted as ornamentals and roadside shade trees [1-5,25,32,]. Large-scale areas of plantations were established by state forest farms for purpose of protecting water and soil conservation and supplying sleepers, timber and fuel wood by 1950s [1,5,25,32]. Government-sponsored planting programs during 1970s and 1980s increased the plantation estate to about 600 000 ha for wood chips and pulps, which main established by state-own forest farms and companies [1,5,32]. The productivity was low (5 to 8 m^3 ha^{-1} $year^{-1}$) and had relatively poor pulping properties because trees from unimproved genetics stock were planted on infertile soils with little or no fertilizer [1,5,25]. It was not until the 1990s that private sector and farmers mainly developed eucalypt plantations [32]. After 20 years of breeding and silviculture, newly established commercial plantations have been substantially improved to more than 20 m^3 ha^{-1} $year^{-1}$ [5,26]. The species successfully introduced and widely planted in the earlier times included E. exserta F. Muell, E. globulus Labill. ssp. Globules, E. citriodora Hook, E. robusta Sm., E. camaldulensis Dehnh., E. tereticornis Sm. and so on.

Over the past years, many projects have been funded both in international and domestic that relate to breeding, silviculture and propagation [1,40]. International cooperation projects (1982–2000) include: "China-Australian

Afforestation Project at Dongmen State Forest Farm" (AIDAB, 1982–1989), "Introduction and Cultivation Experiments for Australian Broad-leaved Trees Species" (FST/1984/057, 1985–1992) and "Development of Germplasm and Production Systems for Cold-tolerant Eucalypts in Cool Regions of Southern China and Australia" (FST/1996/125, 1996–2000). The implementation of these projects had made a great contribution to the systematic introduction of eucalypts. Major domestic scientific and technological projects (1985–2010) consist of: Four "Five-Year" national research project "Breeding and Cultivation Technology of Eucalypt Plantations"; the world bank loan projects of "Scientific Research of Eucalyptus and Promotion of Research Results" and "Research and Extension of Cultivation Technology on Fast-growing and High Yielding Eucalyptus Plantation"; projects of "Construction of Genetic Linkage Maps of E. urophylla and E. tereticornis", "Genome-wide Marker-assisted of Eucalyptus for Polymerization Heterosis", "Efficient Breeding Technology of Molecular and Cell of Eucalyptus", "Introduction of Stress-resistance Breeding Gene Plasmid and Transfer Technology of Eucalyptus " and "Transgenic Breeding and Technology of Eucalypt Clones" supported by National Natural Science Foundation and 863 projects of Ministry of Science and Technology. In addition, the Research Institute of Tropical Forestry (RITF) of the Chinese Academy of Forestry (CAF), the China Eucalypt Research Center (CERC), the Guangxi Academy of Forestry Research and other research institutions undertook many co-operative research projects involving pulpwood of eucalypts with foreign companies since 1997, such as SINO Forest Co., Hong Kong Jiahan Wood Co., Ltd., APP Jinguang Group Asia Pulp Paper Co., Ltd., RGM Golden Eagle International Group Co., Ltd. and Finland StoraEnso Forestry Co., Ltd. [40].

Yang [41] classed three eucalypt research groups in China, namely, former researchers, present researchers and researchers in enterprise. The former researchers include Qi Shuxiong, Bai Jiayu, Yang Minsheng, Wang Huoran and Hou Yuanzhao etc. While the present researchers are composed of Xu Daping, Xiang Dongyun, Xu Jianmin, Xie Yaojian, Chen Shaoxiong, Huang Shaowei and Luo Jianzhong etc. The researchers in enterprise consist of Huang Wending, Wei Runpeng, Wang Shangming, Pan Yongyan, Wang Zhihe and Hong Fuwen.

3 PRESENT SITUATION ON SILVICULTURE

Silviculture is traditionally focused on various aspects of tree planting, such as tree selection, site selection, site preparation, regeneration methods and fertilization and so on, and the role of silviculture at that time is to manage forests scientifically for continuous production of goods and services while meeting biological and economic requirements [10-12]. The productivity of the most forest plantations is less than their physiological potential as defined by the prevailing climate, because the supply or capture of light, water and nutrients is less than optimal [12]. Therefore, the purpose of this part is to identify and ameliorate factors limiting growth, sometimes on a large scale, e.g., by plantation spacing, fertilization, irrigation, thinning and pruning.

3.1 Plantation Spacing

Plantation spacing affects management options and the final product throughout the rotation [29-31]. The goal of such experiment is to identify the spacing required to obtain the desired quantity and quality of wood products within the shortest rotation length possible[12]. Generally speaking, the plantation spacing of eucalypt has not been researched intensively in China. Most studies of responses to initial spacing generally have focused on stem height, diameter and volume growth [15,29,37], and sometimes, some research studied the effect on wood properties [15-16,21-22] and storm resistance [8] because these factors are important in determining volume, economic and end product. Initial spacing of Eucalyptus plantations has been traditionally based on experiments testing a range of densities that generally between 1 m × 3 m and 3 m × 5 m. As a general rule of published research, wider spacing can increase individual stems in diameter and height, whereas total volume per hectare decreased.

However, no known studies have evaluated these growth patterns over time for several species at several spacing on the same site for Eucalyptus in China. It is particularly important to understand how species and spacing may influence the growth [2]. Therefore, more researches need to be studied intensively on different species and clones for different cultivation goals at different sites over time.

3.2 Fertilization

Fertilization is an essential practice in plantation forestry and is implemented to increase growth, shorten rotation times and maximize profits, especially for eucalypts in China. For one thing, the application of fertilizer could increase leaf nitrogen and phosphorus concentrations and photosynthetic rates. For another, the soils available for eucalypt plantations in south China are generally lateritic and lateritic red earths which are acidic in reaction, highly leached, generally heavy in texture and deeply weathered[23-24], with nitrogen, phosphorus, potassium, and copper deficiencies being relatively widespread. Furthermore, phosphorus is often most deficient in soils and is the key nutrient that controls biomass increment of eucalypt plantations [12,40]. After phosphorus, nitrogen is also an important element limiting eucalypt production even where high amounts of nitrogen have been applied due to the erosion, leaching and volatilization [40]. Therefore, dramatically increase growth of eucalypts can be improved by application of fertilizer as basal fertilizer after plantation establishment.

In general, there are relatively few reports on fertilization of eucalypts. Xu et al. [40] have made a lot of studies on nutrient management and effects of phosphorus fertilization in south China. However, others only concentrated on the fertilizing amount and matching [21-23]. Therefore, more trials should be established to study the effects of fertilization and nutrient management intensively on different species and clones at different sites over time in order to improve the conditions for eucalypts in southern China.

3.3 Irrigation

The widespread establishment of Eucalyptus plantations for commercial production of fibre and wood products throughout the world has been accompanied by concerns over possible excessive water use in several countries [20]. Lane et al.[20] measured the monthly, seasonal and annual water balance of Eucalyptus urophylla plantations in 40m × 40m plots at two sites with contrasting soil types on the Leizhou Peninsula and concluded that eucalypts did not use more water than other forest species and do not pose a threat to water resources in this region. Myers et al. [28] also reported that eucalypts are not inherently more profligate consumers of water than pines when soil water is not limiting. But the variety of species and environments studied do not allow generalized conclusions to be drawn.

It is believed that water is important to plants including eucalypts. While irrigation is rare in forest plantations it has potential for increasing productivity, particularly in more arid areas [12]. There is no report on effects of irrigation on eucalypt plantations in China probably due to the cost of irrigation, management difficulty and ecology concerns. Reports in other countries indicated that effects of irrigation were far larger than fertilization for eucalypts [18,34], and it should be considered when managing eucalypt short rotation forests sustainably in the longer term [13]. Hunter [18] reported that irrigation increased dry weight linearly across treatments and by 74% in the highest irrigation rate, and increased stem wood weight by 90% but branch and leaf weight by only 40%, while fertilizer increased dry weight by 23% and increased branch weight by a higher percentage than leaf weight. For plantations in Brazil. Stape et al. [34] reported fertilization beyond current operational rates (about 46 m^3 ha^{-1} $year^{-1}$) did not increase growth, whereas irrigation raised growth by about 30% (about 62 m^3 ha^{-1} $year^{-1}$). Published studies generally concluded that Eucalyptus species grown in dry season exhibit strong positive growth responses to increased water availability than those grown in wet season [9,34]. Therefore, research about irrigation should be studied extensively in future in order to improve potential productivity of eucalypts in China.

3.4 Thinning and Pruning

As the increasing interest and activity in utilization of logs of plantation-grown Eucalyptus species for higher-value products, silviculture has becoming especially important to achieve this goal. However, for the conventional approach to production of higher-value products, all of these matters are of little real significance without thinning and pruning [33,43]. Thinning has the express purpose of producing logs of larger diameter and many economic arguments can be mounted in favor of larger diameter logs [33]. There are relatively few published eucalypt thinning papers in China [6,11,14]. Zhang et al. [43] reported that lighter thinning did not substantially reduce total volume growth while concentrating growth on the dominant trees, whereas heavier thinning reduced total volume increment but further concentrated volume increment on the dominant trees.

Despite the "self-pruning" nature of many eucalypt species, pruning for Eucalyptus plantations is an imperative step if they are intended for conventional higher-value utilization [27-33]. It is not unreasonable to claim that pruning, by containing branch related defects to a central knotty core, increases the proportion of clear wood [33]. Experimental and observational evidence strongly supports that pruning should be undertaken while branches are small and alive [24,27,33]. Unfortunately, studies on pruning of eucalypts have not started in China.

3.5 Disease and Insects

With the expansion of eucalypt plantation in China in the last decade, pests and disease have become one of the major threats to the sustainability and economic viability of plantation forestry. Direct economic losses arising from pests and pathogens to plantations in China are now estimated to be around 500 million yuan per year [7], and the estimated annual cost of the pests' damage is from 60 to 140 million yuan [30]. In 1980, only 53 insect species had been recorded in China, but by in 1991 this number had increased to more than 206 and then 285 in 2001 [7,15-17].

In China, major pests include Buzura suppressaria Guenee, Strepsicrates conanae Oku, Patanga succincta Johan, Anomala corpulenta Motschulsky, Anoplophora glabripennis Motsch, Leptocybe invasa Fisher & La Salle, Termitidae and so on[35,42]. While major pathogens consist of Verticillium alboatru Reinke et Bert, Cylindrocladium guingueseptutum Boed & Keit, Pesalotiopsis SP, Endothia parasitca, Sepcoria morlolensis Penz & Sall, Macrophomina phaseolina (Tassi) Goid, Botryris cinerea Pers and Pseudomans solanaleurum (E.F. smith) etc. [35,42]. In order to reduce the impact of plantation diseases and pests, a number of strategies are available such as strict quarantine, periodic pest survey and integrated control [30]. However, the most important step is to make efforts to grow sustainable, healthy plantations that have good resistance to diseases and pests.

4 LOOKING FORWARD

The main target of sustainable management of eucalypt plantations is maintaining long-term productivity and high quality. As the eucalypt plantation area expands, more and more problems have appeared, for example, inappropriate plantation and management, increasing diseases and pests, severe erosion of red soils etc. To prevent these problems, we would recommend that:

(1) Practices such as grafting, flowering induction, controlled crossings and inexpensive non-destructive evaluation technologies should be generalized to accelerate development of improvement programs.

(2) More attention should be focused on utilization of plantation-grown Eucalyptus species for higher-value products, such as medium density fibreboard (MDF), oriented strand board (OSB) and laminated veneer lumber (LVL), other than pulpwood and fuelwood.

(3) More eucalypt clones available for mass distribution should be created and cultivated in order to keep up with the demand from plantation growers for new clones. While mosaic plantations of multiclonal and other species such as pines and Acacia should be considered to prevent site degradation and minimize large scale occurrences of forest diseases and insects.

(4) Comprehensive silviculture practices such as plantation spacing, fertilization, irrigation, thinning and pruning etc. should be carried out intensively over different species and clones for different cultivation goals at different sites over time to achieve Eucalyptus potential productivity. While species and clones should be properly matched to site-type. The rotation period of eucalypt needs to be extended from the current 4-6 to 6-8 years considering both the economic position of the forest farmers and the maintenance of site fertility.

REFERENCE

[1] Bai J, Xu J, Gan S. Genetic improvement of tropical eucalypts in China. pp. 64–70 in Turnbull JW Eucalypts in Asia Proceedings of an international conference held in Zhanjiang, Guangdong, People's Republic of China, 7–11 April 2003. Canberra, Australian Centre for International Agricultural Research Proceedings No. 111.

[2] Bernardo AL, Reis MGF, Reis GG, Harrison RB, Firme DJ. Effect of spacing on growth and biomass distribution in Eucalyptus camaldulensis, E. pellita and E. urophylla plantations in southeastern Brazil. Forest Ecology and Management 1998,104: 1–13

[3] Borralho NMG. The challenges and lessons from breeding Eucalyptus. pp. 79–89 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[4] Bouvet JM, Vigneron PH, Saya A. Trends in variance and heritabilities with age for growth traits in Eucalyptus spacing experiments. Silva Genetica 2003,52(3-4): 121–133

[5] Bueren MV. Eucalypt tree improvement in China. Australian Centre for International Agricultural Research, Impact Assessment Series Report No. 30,2004.

[6] Cai X, Liang J, Zheng J, Liang F. Study on the relation of tree crown indexes of Eucalyptus urophylla and thinning in Leizhou. Eucalypt Science & Technology 2007,24(1): 35–40 (in Chinese)

[7] Chang R, Zhou X. Relationship between five defensive enzyme activities of four Eucalyptus commercial clones and their resistance to the gall wasp, Leptocybe invasa, in South China. pp. 410–421 in The Fifth Session First Eucalypt Conference, Changsha, 8–10 November 2010

[8] Chen S. Effect of tree spacing on storm resistance of young Eucalyptus urophylla plantation. pp. 368–372 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[9] Coyle DR, Coleman MD. Forest production responses to irrigation and fertilization are not explained by shifts in allocation. Forest Ecology and Management 2005,208: 137–152

[10] Endo M. Social dimensional of silviculture, especially with regard to forest plantations. pp. 22–27 in Turnbull JW Eucalypts in Asia Proceedings of an international conference held in Zhanjiang, Guangdong, People's Republic of China, 7–11 April 2003. Canberra, Australian Centre for International Agricultural Research Proceedings No. 111.

[11] Feng W, Zhong M, Huang S, Chen S, Yang M, Wu Z. Research on breeding of Eucalyptus large-diameter wood and its economic benefits. Eucalypt Science & Technology 2006,23(2): 30–32 (in Chinese)

[12] Goncalves JLM, Stape JL, Laclau JP, Smethurst P, Gava JL. Silviculture effect on the productivity and wood quality of eucalypt plantations. Forest Ecology and Management 2004,193: 45–61

[13] Guo LB, Sims REH. Soil response to eucalypt tree planting and meatworks effluent irrigation in a short rotation forest regime in New Zealand. Bioresource Technology 2003,87:341–347

[14] Hong C. The technical approach and effect analysis of thinning on eucalypts. Journal of Fujian Forestry Science and Technology 2001,28(1): 28–31 (in Chinese)

[15] Huang B, Lv C, Meng Y, Zhang L. Effects of different planting density on the growth and volume of Eucalyptus urophylla. Guangxi Science 1997,4(3): 202–207 (in Chinese)

[16] Huang B, Lv C, Meng Y, Zhang L. Effects of different planting density on the growth, outout and wood properties of Eucalyptus urophylla. Scientia Silvae Sinicae 2000,36(1): 81–90 (in Chinese)

[17] Huang H, Huang Y, Fan J, Qian M, Lu H, Mo X, He P, Su B. Preliminary report of pest and disease of Eucalyptus in Guangdong. Eucalypt Science & Technology 2007,24(2): 34–36 (in Chinese)

[18] Hunter I (. Above ground biomass and nutrient uptake of three tree species (Eucalyptus camaldulensis, Eucalyptus grandis and Dalbergia sissoo) as affected by irrigation and fertiliser, at 3 years of age, in southern India. Forest Ecology and Management 2001,144:189–199

[19] Kusnandar D, Galwey NW, Hertzler GL, Butcher TB. Age trends in variances and heritabilities for diameter and height in Maritime Pine (Pinus pinaster AIT.) in western Australia. Silva Genetica 1998,47(2–3): 136–141

[20] Lane PNJ, Morris J, Zhang N, Zhou G, Zhou G, Xu D Water balance of tropical eucalypt plantations in south eastern China. Agricutural and Forest Meteorology 2002,124: 253–267

[21] Li B, Xu J, Yu Y, Lu Z,Li G, Ou S, Wu S, Wang W. Medium-term research on cultivation effect of density and fertilizaing to Eucalyptus for large-diameter timber in Leizhou peninsula. Guangdong Forest Science and Technology 2009,25(6): 14–21 (in Chinese)

[22] Li G, Xu J, Lu Z, Chen J. A study effect of density/spacing on tree growth and stand volume of Eucalyptus urophylla plantation for pulp wood. pp. 352–357 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[23] Lin S, Li S, Liao G, Lan P, Liao X. A study on fertilization of short rotation Eucalyptus plantations. Forest Research 1999,12(3): 275–282 (in Chinese)

[24] Liu Y, Xu J, Qian G, Wu W, Li B, Wu S. Study on cold-tolerant tree species/provenances introduction in northwestern Fujian of subtropical zone. pp. 67–73 in The Fourth Session Fifth Eucalypt Conference, Chongqing, 2009,27–29 October 2009 (in Chinese)

[25] McKenney DW. Australian tree species selection in China. Canberra, Canadian Forest Service Great Lakes Forestry Centre, ACIAR Projescts 8457 and 8848, Impact Assessment Series Report No. 8,1998.

[26] Mo X, Peng S, Long T, Chen W, Yang X. Important traits and combined evaluation of eucalypt clones. pp. 102–108 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[27] Montagu KD, Kearney DE, Smith RGB. The biology and silviculture of pruning planted eucalypts for clear wood production–a review. Forest Ecology and Management 2003,179: 1–13

[28] Myers BJ, Theiveyanathan S, O'Berien ND, Bond WJ Growth and water use of Eucalyptus grandis and pinus radiate plantations irrigated with effluent. Tree Physiology 1998,16:211–219

[29] Niu Y, Zhou W, Wen M, Lu Z, Xu J. Eucalypts fertilization and plantation spacing test. Tropical Forestry 2000,28(3): 86–92 (in Chinese)

[30] Pang Z. Insect pests of eucalypts in China. pp. 183–192 in Turnbull JW Eucalypts in Asia Proceedings of an international conference held in Zhanjiang, Guangdong, People's Republic of China, 7–11 April 2003. Canberra, Australian Centre for International Agricultural Research Proceedings No. 111.

[31] Pinkard EA, Neilsen WA. Crown and stand characteristics of Eucalyptus nitens in response to initial spacing: implications for thinning. Forest Ecology and Management 2003,172: 215–227

[32] Qi S. Brief introduction of eucalypt cultivation and utilization in China. pp. 37–41 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[33] Shield E. Utilization of plantation-grown Eucalyptus: new resources…new approaches. pp. 375–391 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[34] Stape JL, Binkley D, Ryan G, Fonseca S, Loos RA, Takahashi EN, Silva CR, Silva SR, Hakamada RE, Ferreira JMA, Lima AMN, Gava JL, Leite FP, Andrade HB, Alves JM, Silva GGC, Azevedo MR. The Brazil Eucalyptus potential productivity project: influence of water, nutrients and stand uniformity on wood production. Forest Ecology and Management 2010,259: 1684–1694

[35] Sun Y, Liu J. Current situation and control tactics of diseases and insect pests in Eucalyptus. Forest Pest and Disease 2004,23(5): 36–38 (in Chinese)

[36] Wei R. Merging ecological concerns into sustainable management of short-rotation forest plantations in south china: practices by Sino-forest Corp. pp. 51–63 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[37] Weng Q, Haung S, Zheng H. Plantation spacing on Eucalyptus urophylla. Guangdong Forest Science and Technology 1993,22(3): 8–12 (in Chinese)

[38] Xu D, Dell B. Nutrient management of eucalypt plantations in south China. pp. 269–288 in Wei R, Xu D Eucalyptus Plantation Research, Management and Development. Proceedings of the International Symposium held in Guangzhou, People's Republic of China. 1–6 September 2002 World Scientific Publishing Co. Pte. Ltd.

[39] Xu D, Dell B, Malajczuk N, Gong M. Effects of P fertilization on productivity and nutrient accumulation in a Eucalyptus grandis × E. urophylla plantation in southern China. Forest Ecology and Management 2002,161: 89–100

[40] Xu J. Sustainable innovation of genetic improvement and breeding for Eucalyptus tree species and high-effect management of cultivation technology on plantation. pp. 54–72 in Forty Festschrift for Establishment of Research Institute of Tropical Forestry, Chinese Academy of Forestry Guangdong, China, August 2002 (in Chinese)

[41] Yang M. Eucalypts research present situation and develop trend in China. pp. 1–10 in The Fourth Session Fifth Eucalypt Conference, Chongqing, 27–29 October 2009 (in Chinese)

[42] Yi G, Yu Z, Luo J. An investigation on Eucalyptus diseases and pests in Zhanjiang. Eucalypt Science & Technology 2005,22(2): 46–48 (in Chinese)

[43] Zhang R, Baker T, Neilson W. Growth responses to thinning in young Eucalyptus plantations in China and Australia. pp. 169–173 in Turnbull JW Eucalypts in Asia Proceedings of an international conference held in Zhanjiang, Guangdong, People's Republic of China, 7–11 April 2003. Canberra, Australian Centre for International Agricultural Research Proceedings No. 111.

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