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Both incidence and severity of white rust disease reflect host resistance in *Brassica juncea* germplasm from Australia, China and India

C.X. Li [a], K. Sivasithamparam [b], G. Walton [c], P. Fels [c], M.J. Barbetti [a,c,*]

[a] *School of Plant Biology, Faculty of Natural and Agricultural Sciences, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia*

[b] *School of Earth and Geographical Sciences, Faculty of Natural and Agricultural Sciences, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia*

[c] *Department of Agriculture and Food Western Australia, Baron-Hay Court, South Perth, WA 6151, Australia*

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Abstract

White rust (*Albugo candida*) is a highly destructive disease of oilseed Brassicas such as *Brassica juncea* and *B. rapa*, and has caused serious yield losses in Australia, China and India on both species. The first commercial *B. juncea* varieties are now being deployed in Australia, but their response to Australian strains of *A. candida* is yet to be defined under Australian field conditions. To identify useful sources of host resistance for Australia, China and India, in *B. juncea,* three field trials were undertaken in Western Australia. Forty-four *B. juncea* genotypes, *viz*. 22 from India, 12 from Australia and 10 from China, were tested. Varying levels of host resistance to Australian strains of *A. candida* (race 2) were identified among the genotypes from the three countries. Genotypes CBJ-001, CBJ-003 and CBJ-004 from China consistently showed high levels of resistance to *A. candida* on leaves across the three trials. Overall, the genotypes from China showed the best resistance, followed by the genotypes from Australia, with those from India being the most susceptible. The most susceptible genotypes were RL1359, RH30 and Seetha from India. It is noteworthy that both the incidence and severity of disease reflected varying levels of host resistance in the germplasm from the three countries, irrespective of whether screening was undertaken in the field using natural or artificial inoculation. Differentiation of resistance among these genotypes was similar to that we reported previously for artificially-inoculated seedlings or adult plants under glasshouse conditions, indicating that a choice of options is available to plant breeders to reliably differentiate host resistance among genotypes to white rust in *B. juncea*.

Keywords: *Brassica juncea*; Germplasm; *Albugo candida*; White rust; Resistance; Screening

1. Introduction

White rust, caused by *Albugo candida*, is a common disease of many economically important cruciferous vegetables and oilseed crops. Significant yield losses from this disease have been reported on the oilseeds *B. rapa* and *B. juncea* and, to a lesser extent, on susceptible lines of *B. napus* (Harper and Pittman, 1974; Verma and Petrie, 1980; Barbetti, 1981; Fan et al., 1983; Mukherjee et al., 2001). It has been estimated that combined infection of leaf and inflorescence causes yield losses of up to 60% or more in India (Lakra and Saharan, 1989), and losses of up to 20% in Australia (Barbetti, 1981; Barbetti and Carter, 1986).

To date, more than 10 distinct biological races of *A. candida* have been identified and classified based on host specificity (Pound and Williams, 1963; Petrie, 1975; Hill et al., 1988). Race 2 is known to affect *B. juncea* (Petrie, 1994; Verma et al., 1999; Rimmer et al., 2000) and is confirmed to be present on *B. juncea* in Australia (Gurung et al., 2007). This disease appears as both local and systemic infections (Walker, 1957). Localized infections are shown as scattered zoosporangial pustules on cotyledons, leaves and/or stems, while systemic infection occurs in developing stems and pods and shows as deformed inflorescences commonly referred to as ‘‘stagheads’’ (Verma and Petrie, 1980).

While a number of chemicals and cultural means have been suggested for control this disease (Verma and Petrie, 1979; Barbetti, 1981, 1988a, b), the most efficient and cost effective

* Corresponding author at: School of Plant Biology, Faculty of Natural and Agricultural Sciences, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia. Tel.: +61 8 64883924; fax: +61 8 64887077.
E-mail address: mbarbett@cyllene.uwa.edu.au (M.J. Barbetti).

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way of disease management is through host resistance. Most commercial varieties of *B. juncea* in China and India are susceptible to this pathogen, while the response of Australian varieties is yet to be determined under Australian field conditions. Identification of sources of host resistance remains a key priority for Australia, China and India and is an important prerequisite to effectively manage this disease in all three countries (Anon., 1999, 2007a).

B. juncea is currently the predominant oilseed *Brassica* species sown in India (Kumar et al., 2000) and an important crop in some regions in China (Wang et al., 2007). Canola-quality *B. juncea* is being developed in Australia to extend oilseed *Brassica* production into the lower rainfall areas (Burton et al., 2003), as it is more drought resistant than *B. napus* (Downey, 1971; Woods et al., 1991; Oram et al., 2005). The area grown to *B. juncea* in Australia is now set to increase rapidly as the first canola-quality *B. juncea* cultivar, cv. Dune, has just been released there (Anon., 2007b). However, canola quality *B. juncea* has been developed as a new crop for Australia with little regard for the potential consequences from its susceptibility to white rust. It is essential therefore to rapidly identify useful sources of resistance in *B. juncea*, not only for Australia, but potentially also for China and India. The aims of the work reported in this paper were: firstly, to determine the differential host responses to white rust, in terms of disease incidence and severity, in genotypes of *B. juncea* from Australia, China and India, under Australian field conditions; secondly, to determine if these host responses were consistent across different field locations and where different inoculation techniques (natural and artificial inoculation) were used; thirdly, to compare the host field responses with those obtained in previous glasshouse studies.

2. Materials and methods

2.1. Germplasm

Seed was obtained from India, China and Australia through the Australian Centre for International Agricultural Research (ACIAR) programme. Forty-four genotypes of *B. juncea,* including 12 from Australia, 10 from China and 22 from India, were screened under the Western Australian field conditions against white rust disease (*A. candida*). There were some differences in the numbers of genotypes tested at each of the three locations/experiments and the exact genotypes tested are shown in Tables 1–3, for experiments 1, 2, and 3, respectively.

2.2. Field trial 1

Forty-three genotypes of *B. juncea* were tested in an experimental field block at the University of Western Australia, Crawley, Perth, Western Australia (31.99°S, 115.82°E) during the 2006 cropping season. Twenty seeds per genotype were sown in single rows of 1 m length and plants were not thinned after germination. Plants were irrigated by overhead sprinklers when rainfall was insufficient. There was 0.6 m spacing between rows. Rows of test genotypes were arranged in a randomized complete block design with five replications.

Plants were spray-inoculated twice with a white rust zoosporangial suspension, once at seedling on 22nd June and then again two weeks later. The *A. candida* inoculum source used for this trial was an Australian isolate of race 2 taken from infected plants in a *B. juncea* field screening trial at Mt Barker, Western Australia in the previous year. The infected leaves with *A. candida* pustules had been stored at −80 °C for about eight months prior to use. When required, the infected leaves containing white rust pustules were removed from the freezer storage and the zoosporangia were dispersed in deionized water and filtered through Mira cloth (Calbiochem, USA), to remove any plant debris. The concentration of the zoosporangial suspension was then adjusted using a hemacytometer slide (Superior®, Germany) to a concentration of 1×10^5 zoosporangia mL^{-1} before application to plants until run-off, using a hand-held atomizer.

Plants were assessed for disease reaction on 20th July [14 days post inoculation (dpi)] and then subsequently on four more occasions, on 1st August (26 dpi), 18th August (43 dpi), 6th September (62 dpi) and 26th September (82 dpi). Two aspects of the disease reaction on the individual genotypes were recorded, *viz*., the disease incidence as a percentage of leaves infected; and the disease severity as the percentage of leaf area covered by white rust pustules. Both disease incidence and disease severity were assessed using a 0–6 scoring system modified from Singh et al. (1999) and Mukherjee et al. (2001) as follows. For disease incidence, 0 = no symptoms or sign of pustules; 1 = 1–10%; 2 = 11–20%; 3 = 21–30%; 4 = 31–50%; 5 = 51–75%; 6 = >75% of leaves with white rust pustules. For disease severity, 1 = 1–10%; 2 = 11–20%; 3 = 21–30%; 4 = 31–50%; 5 = 51–75%; 6 = >75% leaf area covered by pustules. At the end of growing season, the total number of plants and the number of plants with staghead for each row of each genotype were counted and the percentage of plants with staghead per row was calculated.

2.3. Field trial 2

Thirty-eight genotypes of *B. juncea*, including 6 from Australia, 10 from China and 22 from India were tested for white rust resistance to natural infection in 2006 in the field in a nylon mesh covered screen house, at the University of Western Australia, Shenton Park Field Research Station, Shenton Park, Western Australia (31.96°S, 115.81°E). All test genotypes were grown in single rows of 1 m length and with 0.6 m spacing between rows as done for field trial 1. Plants were irrigated by overhead sprinklers when rainfall was insufficient. Rows of test genotypes were arranged in a randomized complete block design but with six replications. Plants were assessed for white rust disease reaction four times, *viz*, 2nd August, 25th August, 6th September and 26th September, during the growing season. Disease incidence, disease severity and the number of plants with staghead were recorded as described for field trial 1.