Finding an agro-ecological niche for juncea canola

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ABSTRACT

Grain yields of canola quality *Brassica juncea* (juncea canola) are reported to be more stable than those of *Brassica napus* (canola) at yields less than 1.5 t/ha probably due to its superior osmotic adjustment and tolerance of higher temperatures during flowering. Juncea canola is also reported to have greater pod-shattering resistance, which allows direct heading, and its smaller seed size theoretically make it cheaper to establish. Because of these features, juncea canola is promoted as a low risk alternative to canola in regions with low rainfall and hot, dry springs. However, current cultivars of juncea canola do not yield as well as canola at higher yield potentials, and as a result adoption of juncea canola is only likely in regions where the risk of achieving yields less than 1.5 t/ha is significant. Because yields of both species are predominantly water limited, and water supply in Australia's cropping regions is highly variable, decisions regarding adoption of juncea canola will be driven by regional production risk (*i.e.* frequency of outcomes) rather than production averages. Thus an assessment of potential agro-ecological fit needs to be made on a probabilistic basis. In order to achieve this, the crop production model APSIM 7.3 was used to generate attainable yield (not constrained by nitrogen, weeds, disease, frost and heat stress) probability distributions based on 50 years of climate data for locations throughout the canola growing regions of south-eastern Australia that have publicly available APSIM soil characterisations. Regions in which there was a greater than 50% chance of achieving yields less than 1.5 t/ha were proposed as being suitable for production of juncea canola. Regions that fitted this criterion generally receive less that 100 mm of winter rainfall (*i.e.* NSW west of Coonamble, Tottenham and Urana) and are generally more marginal than those previously identified by subjective methods as suitable for juncea canola. Although these regions represent a significant proportion of the eastern grain belt, early grower experiences suggest adoption of juncea canola is likely to be determined by factors other than production risk alone (e.g. establishment problems, ease of delivery and marketing).

Key words: juncea canola, APSIM, production risk

INTRODUCTION

The yield benefits of *Brassica* spp. break-crops to subsequent wheat crops have been widely reported (Kirkegaard 2008, Angus *et al.* these proceedings). These crops provide both passive and active root and crown disease control (e.g. Broad 2006; Motisi, 2009), and herbicide tolerant varieties (triazine, imidazolinone and glyphosate) allow for robust control of grass and broadleaf weeds using herbicides with modes of action different to those typically used during cereal phases. Whilst canola (*Brassica napus*) has been widely adopted and performs reliably in the medium to high rainfall zones of the cropping belt of south-eastern Australia, in the lower rainfall regions it is perceived as being expensive to plant and liable to fail in seasons with dry springs, thus making it risky. In response to the Millennium Drought, plantings of canola and other broad-leaf break crops in these regions have declined remarkably. Canola quality *Brassica juncea* (juncea canola) has been touted as a low risk alternative to *B. napus* in lower rainfall regions (Burton *et al.*, 2008). Grain yields of canola quality juncea canola are reported to be more stable than those of canola at yields less than 1.5 t/ha (Norton *et al.*, 2004) probably due to juncea canola's superior osmotic adjustment (Wright *et al.*, 1996; Niknam *et al.*, 2003) and tolerance of higher temperatures during flowering. Juncea canola is also reported to have greater pod-shattering resistance, which allows direct heading, and its smaller seed size theoretically make it cheaper to establish. Released cultivars of juncea canola (Oasis CL & Sahara CL) are also imidazolinone tolerant, allowing good control of *Bromus* spp., which are problem grass weeds of cereal crops in low rainfall regions. However, current cultivars of juncea canola do not yield as well as canola at higher yield potentials, and as a result adoption of juncea canola is only likely in regions where the risk of achieving yields less than 1.5 t/ha is significant.

Because yields of both species are predominantly water limited, and water supply in Australia's cropping regions is highly variable, decisions regarding adoption of juncea canola will be driven by regional production risk (*i.e.* frequency of outcomes) rather than production averages. Thus an assessment of potential agro-ecological fit needs to be made on a probabilistic basis.

We used existing and publicly available databases of soil and climate with the APSIM-Canola simulation model (Keating *et al.*, 2003) to identify regions within the cropping belt of south-eastern Australia which may be best suited to production of juncea canola in preference to canola.

MATERIALS AND METHODS

Locations for the analysis (Table 1) were selected to represent a gradient in *Brassica* spp. yield potential (largely driven by growing season rainfall) across important grain-growing regions of south-eastern Australia based on the existence of accurate soil characterisations (APSoil database, Table 1 – Dalgliesh *et al.*, 2009) and patched point meteorological weather stations (Jeffrey *et al.*, 2001). Western Australia was not included in this analysis due to a lack of measured characterisations of sufficient spatial resolution in areas of low to medium rainfall in the APSoil database.

The canola module of the cropping systems model APSIM (Keating *et al*., 2003; http://www.apsim.info/apsim/ verified July 2011) has been demonstrated to adequately simulate soil water balance, crop growth and yield in south-eastern Australia (Robertson and Holland 2004; Robertson and Kirkegaard 2005). Other key APSIM modules deployed in the analysis were SoilWat (soil water balance), SoilN (soil nitrogen dynamics) SurfaceOM (surface residue dynamics) and Manager (specifying management rules).

Experimentally, there is often no significant difference in yield between juncea canola and short-season canola cultivars. In many cases there is a greater range within cultivars of a species than between the two species (McCaffrey *et al.*, 2010). Consequently, it was considered futile to parameterise the two species in APSIM-Canola based on physiological differences and attempt to compare simulated yields at multiple locations. Instead it was decided to use the empirical observation that juncea canola yields as well or better than canola when yields are less than 1.5 t/ha (Norton *et al.* 2004). A 'short-season brassica' cultivar representing both juncea canola and short season canola was parameterised using site mean phenology observations from Walpeup and Tamworth. This cultivar parameterisation was then used to simulate water-limited attainable grain yields across the nominated locations. The simulations assumed that nitrogen was not limiting and that there was no effect of disease, extremes of temperature or weeds. Crops were sown at 40 plants/m² at all locations following 15 mm or more rainfall over a three day period from 25 April to 1 June and if these criteria were not met by the end of this period a crop was sown 'dry' such that a crop was grown in every year of the simulation. The simulation was run for 50 years from 1959 to 2008 and median yield for this period calculated. It was assumed that the distribution of yields from this period is representative of future yield *i.e*. the probability of achieving median yield in the future is assumed to be 50%.

Regions in which in which median grain yields was less than 1.5 t/ha (i.e. there was a greater than 50% chance of achieving yields less than 1.5 t/ha) were proposed as being suitable for production of juncea canola. This criterion was used to manually map regions suitable for juncea canola production.

RESULTS

Using this modelling approach, areas identified as suitable for juncea canola production extend from west of Wee Waa in northern NSW through Warren and Ungarie, across the southern Mallee of Victoria, and bound the upper south-east, Mid-North and central Eyre Peninsula of South Australia (Figure 1).

Table 1. Locations and APSoil file numbers used in the regional analysis

State	Location	APSoil No.	State	Location	APSoil No.
NSW	Ardlethan	699	SA	Caliph	MM144
NSW	Barellan	699	SA	Cleve	316
NSW	Burren Junction	125	SA	Eudunda	CL021
NSW	Condobolin	688	SA	Farrell Flat	283
NSW	Coonamble	247	SA	Jamestown	CU28
NSW	Deniliquin	181	SA	Karoonda	386
NSW	Hillston	696	SA	Kimba	EE052
NSW	Lake Cargelligo	690	SA	Lameroo	MM040
NSW	Mathoura	181	SA	Lock	318
NSW	Merriwagga	697	SA	Minnipa	352
NSW	Narrandera	700	SA	Morchard	604
NSW	Nyngan	246	SA	Mt. Cooper	323
NSW	Tottenham	200	SA	Nildottie	MM051
NSW	Trangie	684	SA	Port Germein	601
NSW	Ungarie	702	SA	Quorn	605
NSW	Urana	212	SA	Waikerie	360
NSW	Walgett	125	Vic	Hopetoun	714
NSW	Warren	248	Vic	Hopetoun	716
NSW	Wee Waa	97	Vic	Kerang	733
Qld	Dirranbandi	155	Vic	Manangatang	734
SA	Buckleboo	312	Vic	Swan Hill	719
			Vic	Walpeup	725

DISCUSSION

The coincidence of the boundary between areas suitable for juncea canola and canola with the 100 mm winter rainfall isohyet indicates that rainfall distribution is the overriding factor determining yield potential and juncea canola suitability. However, soil type can have an effect within regions, as indicated by the different yields achieved at Hopetoun on either a sand (APSoil No. 716) or clay soil type with sub-soil constraints (APSoil No. 714). Thus within regions there may be soil types of either higher or lower yield potential which may be suited to juncea canola or canola accordingly. This is most likely to be the case in Victoria and South Australia, where soil textural differences are more extreme *e.g*. on the dune-swale systems of the Mallee regions in both these states.

There is reasonable agreement with the regions suitable for juncea canola identified by this approach and those identified for NSW by Haskins *et. al* (2009) using expert opinion (Figure 1). However, this study indicates that there may be significantly less potential for juncea canola in Victoria and the Eyre Peninsula of South Australia than that suggested by Norton *et al.* (2009).

Despite a significant area within the grain growing regions of south-eastern Australia being suitable for production of juncea canola based on potential yield analysis, yield stability alone is not the overriding factor determining grower uptake of juncea canola. Juncea canola appears to be more vulnerable to establishment problems (Browne 2010), and growers in the northern Wimmera of Victoria who have adopted the species plant at very high seed rates (10 kg/ha, B. Batters, Elders St. Arnaud pers. comm.), negating the establishment cost advantage juncea canola has over canola due to its seed size. Also, recently released short season canola varieties appear to have a significant yield advantage over juncea canola at the 1.5 t/ha yield level (Browne 2009). These factors combined with reduced marketing and delivery options available for juncea canola will hinder uptake in the regions identified in this study, unless breeding progress of juncea canola can keep pace with that of canola.

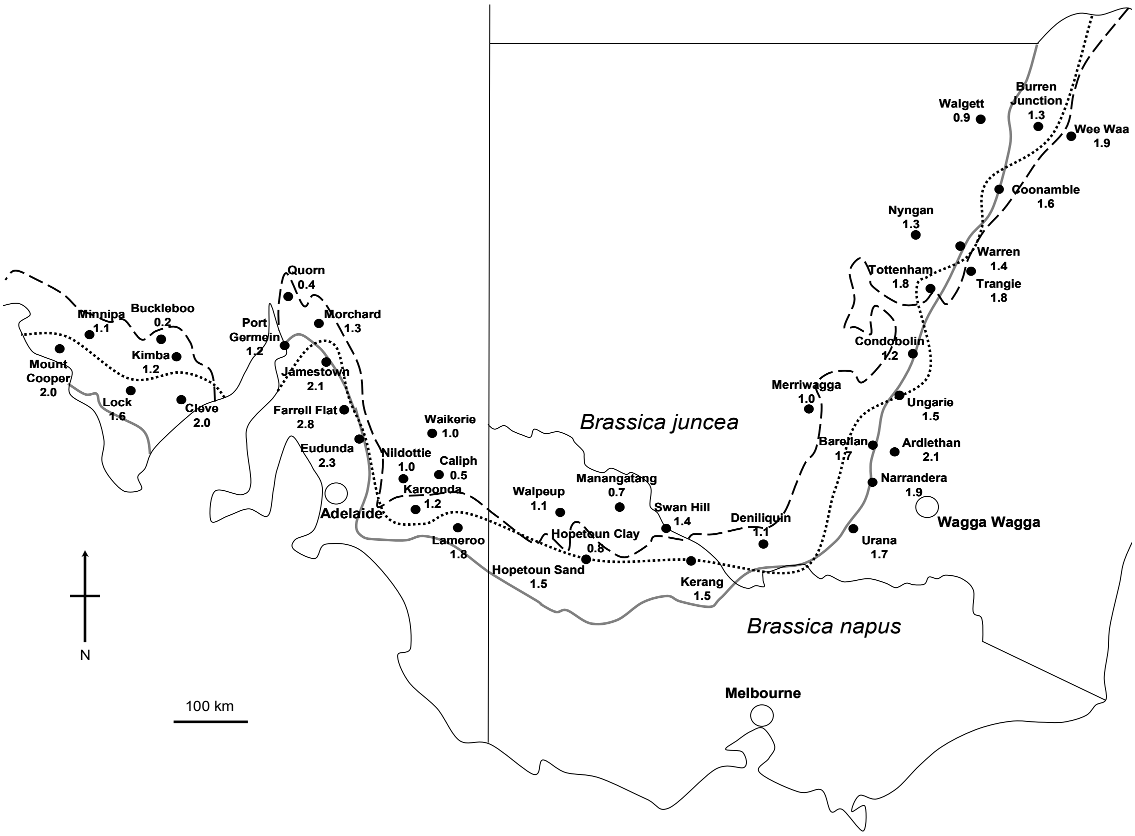

Fig. 1. Locations in south-eastern Australia used in the simulation. Median simulated short-season brassica grain yield is given below each location. Median yields in the area inland of the dotted line (┈) are less than 1.5 t/ha and thus may be more suited to juncea canola. The 100 mm average winter rainfall isohyet (1961-1991) is indicated by the dashed line (- - -). The region previously suggested as suitable for juncea canola (Haskins *et al.* 2009; Norton *et al.* 2009) is indicated by the grey line (—).

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