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POSSIBLE SOURCES OF CANOLA GERMPLASM AND CULTIVARS FOR THE GROWING CONDITIONS OF BRAZIL AND PARAGUAY

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ABSTRACT

Development of canola (*Brassica* spp.) cultivars suitable for subtropical and tropical grain production regions can be decisive for a major expansion of this oilseed´s cropping area to non-traditional regions of the world. In Brazil and in Paraguay, canola research and production started, and is more adopted in subtropical areas with high rainfall and frosts during the reproductive stages. Information concerning the availability of germplasm and cultivars for viable canola production in subtropical and tropical areas is scarce. This work scanned potential sources of canola germplasm and cultivars to fit as a cold season crop in the two-crops-a-year grain production systems of Brazil and Paraguay based on the worldwide experience of specialists seasoned in canola plant breeding and agronomy. Currently, the spring type *Brassica napus* L. hybrids, resistant to blackleg, with low day-length sensitivity, developed in Australia, seem to be the best, readily available alternative. Long term screening in the target growing regions is required to identify possible sources of germplasm with tolerance to severe frosts, and certain diseases associated with high humidity environments such as those incited by *Xanthomonas* spp. bacteria and *Alternaria* spp. fungi.

Keywords: *Brassica napus* L., photoperiod, adaptation, tropical, subtropical, latitude.

INTRODUCTION

Canola is a typical oilseed of temperate regions and its main research, development and commercial production efforts have been done at latitudes between 35º and 55ºN. In Brazil (BR) and Paraguay (PY) canola is grown at latitudes lower than 33º South, during the fall-winter months, a period of shorter days than those that characterize most canola production and cultivar development regions of the world. In all current and potential canola growing areas of these countries it is possible to grow two crops every year, optimizing investment in land, machinery and other available resources of the grain production systems. Canola research and production started, and is more adopted in Southern BR and in PY, in subtropical areas with rainfall above 1,500 mm distributed during all months of the year (climates type Cfa and Cfb, according to Köppen´s classification) (**Figure 1**). Canola is subject to frosts whose incidence and severity increase from the lower to the higher altitudes of the production areas (250 to 1.100 m). Currently, production is based only on spring type hybrids of *Brassica napus* L. var. oleifera, with low day-length sensitivity, with resistance to blackleg incited by the fungi *Leptosphaeria maculans* (Desmaz.) Ces. & De Not.

The canola growing area and production have been increasing, peaked at 59,100 ha in BR (2010), and 73,000 ha in PY (2011) with average grain yields around 1,600 kg.ha^{-1}. Brazil has 37 million hectares of land under grain production where soybean and maize are produced in the summer, which also allow growing a second crop, such as canola, in the same year, during the months of lower temperatures. Both in tropical environments (**Figure 1**), as well as in subtropical regions of the country, there are under-utilised land areas with a total of about 17 million hectares. Just in the state of Rio Grande do Sul (RS), about 2.1 million hectares of canola could be grown annually in rotation with wheat and other crops in the 5.1 million hectares of summer crop farming. Currently, all canola oil in these countries is used for human consumption. Increases in canola production could meet part of the requests of companies interested in sourcing large amounts of canola oil for biodiesel production in Europe.

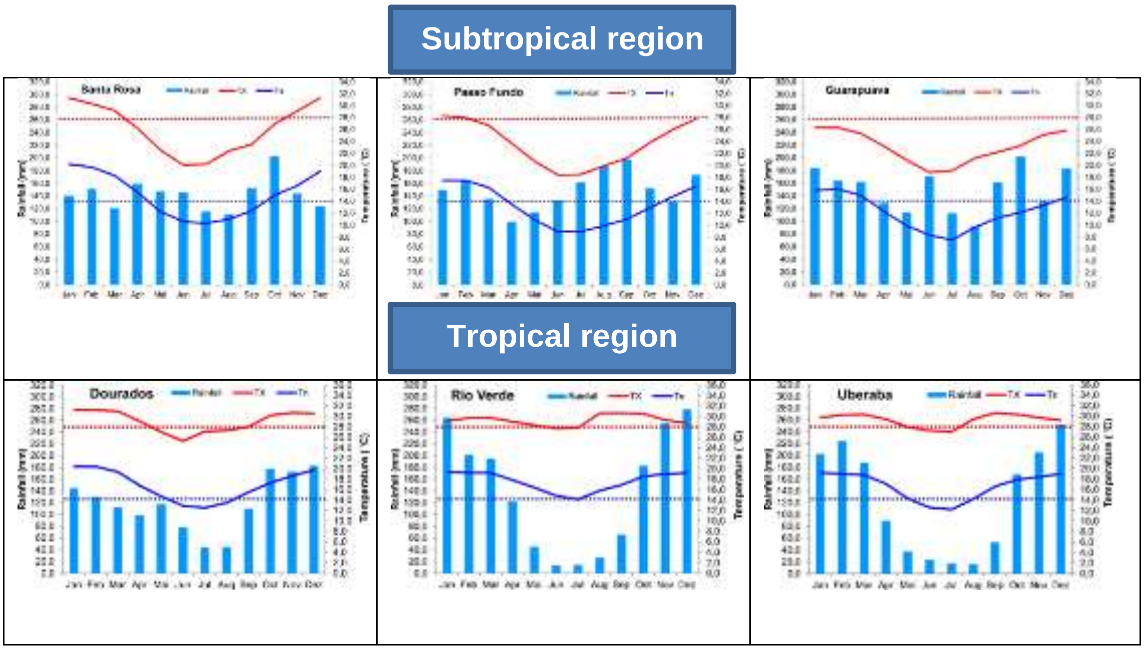

Figure 1. Monthly 30-year standard normal (1961-1990) of rainfall (mm), maximum (Tx), and minimum temperatures (Tm) (^{o}C), of representative municipalities of the **subtropical region**, which are cold and moist during the canola growing season (March to September), and representative of the **tropical region**, where rainfall decreases during the growing season (February to July) of tropical regions (INMET, 2009), Brazil.

METHODS

This paper is the result of consultation and exchange of information among professionals that have been involved and cooperate, since 2002, in activities that supply the hybrids deployed in the majority of the canola production areas of BR and PY. The first author has been involved with canola production since 1984, in Southern BR. Since 2002, coordinates a network of canola genotype trials and agronomic studies interacting and collaborating with of a large number of professionals, institutions, cooperatives and companies working on research and education, as well as providing training to canola producers and technical assistance professionals in BR and PY. The second author, since 1987, works as canola breeder of Pacific Seeds, Pty, Toowoomba, Queensland, Australia, and leads it's *Brassicas* breeding program. He visited and evaluated cultivar performance in a wide variety of commercial fields and trials where the hybrids from the breeding program were tested, as well as exchanged information and discussed adjustments for development and selection of suitable canola cultivars for South American countries with local technical personnel, as well as in most of the canola producing areas of the world.

RESULTS AND DISCUSSION

There are two types of canola cultivars. The winter-type cultivars require vernalisation (a period of about 40 days of temperatures below 6^{o} C) to flower, which is not adequately supplied even in the coldest areas of Southern BR. The spring-type cultivars do not require vernalisation to induce flowering and are more suited to Southern hemisphere regions were canola is produced in the coolest period of the year (winter).

Canola is traditionally a long-day type species, which means it flowers more quickly when grown under long day-length conditions. Spring cultivars grown in the Northern hemisphere have been developed at latitudes higher than 35^{o}. They are sown in spring and most of their development occurs when day-length is greater than 14 hours. When spring cultivars are grown in Canada they flower in approximately 40 days. In the Southern hemisphere, canola is sown in autumn and growing cycle occurs during winter, when day-length is less than 12 hours. If Canadian cultivars are grown under these conditions, the plant responds to the short days by having an extended vegetative period. The time from sowing until flowering can be longer than 100 days when Northern hemisphere developed cultivars are sown in the autumn in the Southern hemisphere. Thus, they would have a longer life-cycle than it would be viable for fitting into the cropping systems where canola is to be produced (**Figure 2**), along with summer crops (such as soybean and maize).

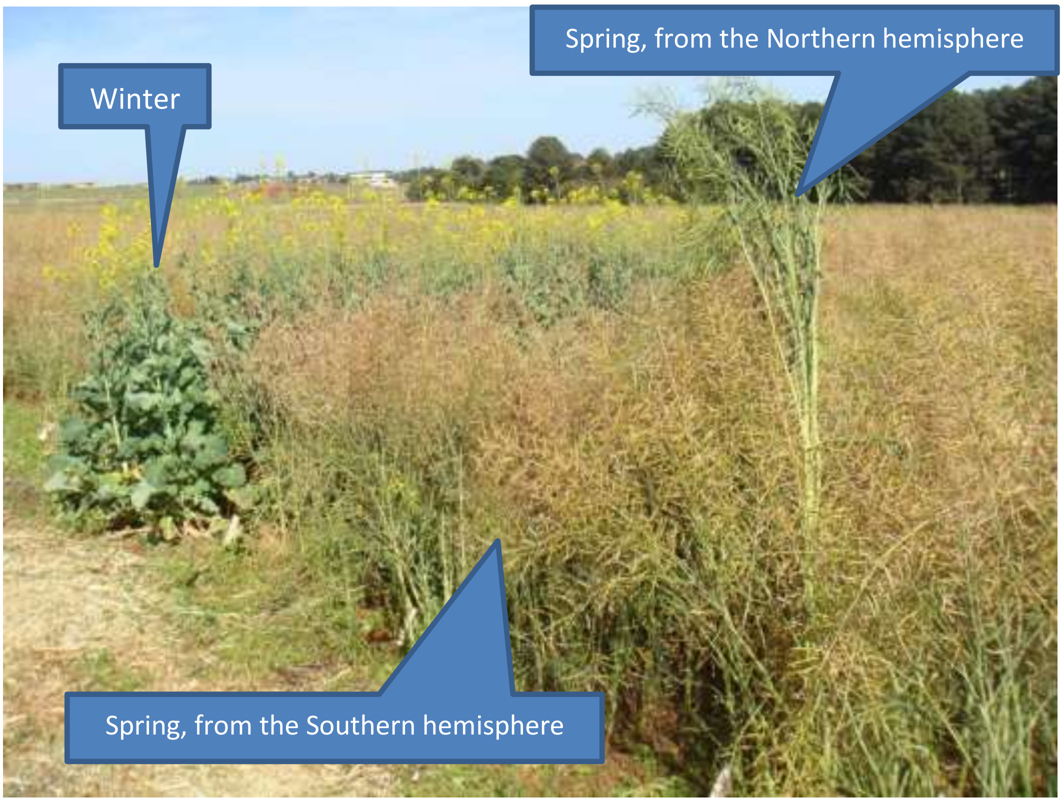

Figure 2. Cycle and morphology of three types of canola cultivars sown at the beginning of the recommended seeding period (mid April) at Passo Fundo, RS (the Southernmost state of Brazil) (Lat. 28° 15' 46'' S; altitude 687 m). (Photo by G.O. Tomm).

Worldwide, it is an exception to grow canola in a two-crops-a-year cropping systems such as in BR and PY, without transplanting (as done in Asia). The climatic conditions of the Northern hemisphere induce the development of winter-type and even spring-type cultivars that display an excessively long cycle (**Figure 2**). Thus, they would not allow growing a second crop a year in BR and PY. In other countries of the Southern hemisphere, such as Australia, the shortage of moisture during summer hinders growing a second crop a year without irrigation.

Australia is the only country that has established canola breeding programs in the Southern hemisphere. As spring canola is also cropped in the coolest period of the year, as in BR and PY, the cultivars are sown in autumn, and flower during winter. However, as altitudes in Australia are relatively low (below 300 m), spring canola is exposed to only a few relatively mild frosts, compared to those that occur every winter in Southern BR, especially at altitudes above 600 m (**Figure 2**).

In the Australian market, 50% of the area is cropped with cultivars that are tolerant to Triazine (TT), 25% with cultivars tolerant to Imidazolinone, trademark Clearfield (CL), 15% with cultivars tolerant to Glyphosate (RR), and only about 10% of the area is sown with cultivars that present no trait of tolerance to a specific herbicide ("conventional"). As RR soybean is widely adopted in the two-crops-a-year grain production systems of BR and PY, the introduction of Glyphosate tolerant canola cultivars would lead to higher cost and more complex control measures for volunteer canola plants in soybean crops. The lack of residual weed control of Glyphosate does not provide control of wild radish and volunteer ryegrass which occur, respectively, during the beginning and later in the growing season in Australia, limiting the benefit and adoption of RR canola cultivars. Very likely this would also be the case in BR and PY. Therefore, traits that enable the use of herbicides with long residual effect and provide effective control, especially of the most important broadleaf as well as grass weed species, such as CL and TT, tend to be of more relevance. Since the yield potential of current TT cultivars is 20% lower than similar "conventional" cultivars (control mechanism is part of the Photosynthetic pathway) their relevance and benefit is likely to be the case only where weeds controlled by Triazine are likely to reduce canola grain yield by more than 20%. As the selection of weed plants resistant to ALS-inhibitors, such as CL, is the most frequent among the herbicide groups mechanisms, cautious use, along with the adoption of all preventive agronomic practices, are required to maintain the effectiveness of the CL weed control.

The only public sector commercial canola breeding program in Australia was closed in June 2013. It was a joint venture of the University of Western Australia, Perth (20% ownership) with NPZ (60% ownership) and canola breeders. This program did not aim at "conventional" cultivars, and was directed towards the specific growing conditions of Western Australia. As in most of the countries, currently the universities and public research are only developing traits to be used by private companies that develop commercial cultivars. There are seven companies with canola breeding programs in Australia (**Table 1**). However, only Pacific Seeds is generating "conventional" canola hybrids, besides Nuseed´s and Cargill´s development of specialty oil "conventional" cultivars, for the relatively small amounts produced under contract to supply market niches.

The canola production region of Australia has dry summers and cool showery winters with limited severity of bacterial diseases, and of most fungal diseases, such as those caused by

Alternaria spp. Contrarily, in Southern BR and PY the incidence and severity of bacteriosis (**Figure 3A**) have been increasing in the last years, causing much concern and requiring control measures. The cool, showery and overcast conditions in winter, coupled with the longer vegetative phase provide ideal conditions for the development of blackleg disease. Additionally, the most violent strains of the disease are present in Australia, requiring and providing means for selection of cultivars with the broadest resistance currently known.

Table 1. Herbicide tolerance traits of commercial canola cultivars and correspondent companies currently breeding for them in Australia.

Company	Trait			Conventional	Additional details
	TT	RR	CL		
Pacific Seeds	X	X	X	X	For South America
Pioneer		X	X		
Nuseed	X	X		Only for specialty oils	
Bayer		X			
Cargill		X	X	Only for specialty oils	
Dow		X			
NPZ	X	X			Only for the specific conditions of Western Australia.

Cultivars tolerant to Triazine=TT, to Imidazolinone=CL, and to Glyphosate=RR

The cultivars for China are developed to fit a very particular rice-canola-rice cropping system with 14 months of plant growth in each year. Canola seedlings are raised during a month in seedbeds and transplanted to rice stubble. Rice seedlings are transplanted on the same land after removing most canola debris (source of energy). Inoculum sources of necrotrophic diseases, such as blackleg, are burnt and submersed, hindering their development. Thus, conditions to select for resistance to certain diseases are unlikely or unknown.

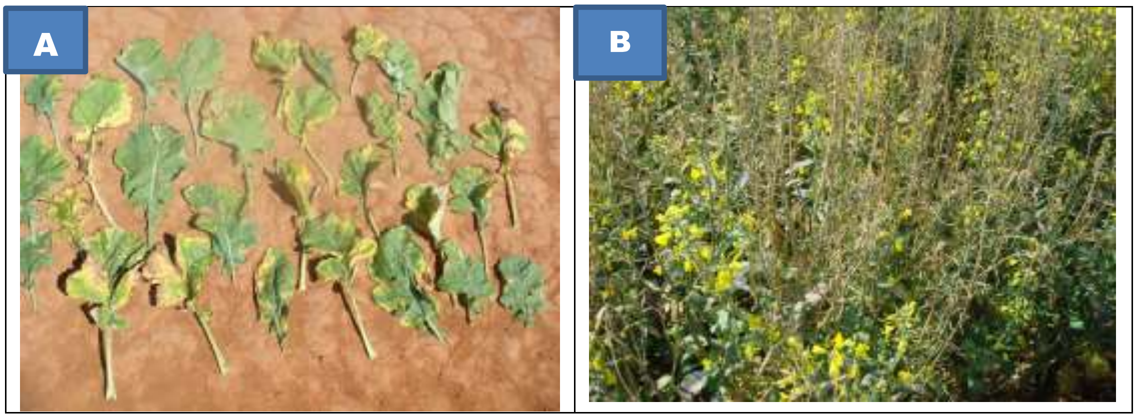

Figure 3. Symptoms of (**A**) bacteriosis on leaves, at Campo Novo do Parecis, MT (Lat. 13^o 40’ 31’’ S; alt. 572 m), on 5 May 2013, and (**B**) frost damage from air temperatures as low as minus 16^{o}C, in 2007 in Vacaria, RS (Lat. 28° 30' 44''S; alt. 971 m) (Photos by G.O. Tomm).

Canola reproductive stages occur in the summer in the Northern hemisphere and in the winter in the Southern hemisphere. In Australia, canola is produced in areas of relatively low altitudes, and consequently with low frost incidence and intensity. Therefore, in none of the current main production areas of the world, canola cultivars are subject to the cold and frost frequency and intensity during the reproductive stages (**Figure 3B**) such as those that are common in South American countries. Currently, for growers of Southern BR and PY the alternatives are restricted to the adoption of Best Management Practices aiming at reducing the percentage of grain yield losses due to frost in critical stages. They include distributing seeding time during a wider period, start seeding in the beginning of the recommended period, deploying hybrids with diverse life-cycle, as well as choosing cultivars that display a flowering period as long as suitable in the cropping system of the region.

Cultivars of *Brassica juncea* L. with low erucic acid and glucosinolates, adequate for the same uses as canola, called "Juncea canola" were developed for the drier areas, with lower grain yield potential, of Canada and Australia. Tomm *et. al.* (2012), in a field study aiming at identifying the lower latitude limit of canola adaptation, observed in Boa Vista, state of Roraima (Lat. 2º49'11" S, alt. 85 m) that *B. juncea* cultivars seem to be a promising oilseed crop alternative in environments where *B. napus* did not produce any grain yield, likely due to excessive heat during pollination. Currently, there is a restricted pool of germplasm suitable for developing commercial "Juncea canola" cultivars that meet other agronomic requirements, such as resistance to diseases. The limited area where these cultivars would likely present competitive advantages over *B. napus* canola cultivars renders their development as a not economical priority. Therefore, currently, and in the near future, it is unlikely that commercial "Juncea canola" cultivars suitable for low latitudes will be developed. However, our preliminary studies in the low latitudes of Brazil suggested that Juncea canola can become a relevant crop alternative for oilseed production, meeting canola oil and meal quality standards for the warmer tropical areas of BR, and likely for other countries as well.

CONCLUSIONS

Based on the best of our current knowledge:

Relevant genetic variability for tolerance to strong frosts is unknown and unlikely since we are unaware of environments which would impose such selection pressure;

Screening germplasm for diseases that are causing increasing losses in commercial canola production in BR and PY such as Bacteriosis and *Alternaria* spp. are the highest priority in cultivar development for canola production in BR and PY;

The continuation of current introduction of canola hybrids with diverse sets of blackleg resistance genes, selected under strong selection pressure to the broadest range of blackleg types, such as those ongoing in Australia, along with restrictions to the introduction and use of susceptible cultivars in BR and PY, likely will avoid losses and costs associated the control of this disease, especially while the canola cropping area is relatively small (<200,000 ha);

Availability of germplasm and commercial cultivars that fit in the two-crops-a-year cropping systems. and environmental conditions of agricultural areas of latitudes lower than 24^{o} South ("Tropical canola") is limited. It is more likely to be found in cultivars developed during the colder months and short-day environments of the Southern hemisphere, as those of Australia;

The identification of suitable genotypes requires testing genotypes in the target regions, since they provide the best conditions for the expression of the differences and characterization of these genotypes.

REFERENCES

INMET, 2009. **Normais Climatológicas do Brasil /1961-1990**. INMET - Instituto Nacional de Meteorologia. Brasília-DF. Available at http://www.inmet.gov.br/portal/index.php?r=clima/normaisClimatologicas. Access 5 Nov. 2013.

TOMM, G. O.; SMIDERLE, O.; RAPOSO, R. W. C. **Which is the lowest latitude for canola production?** In: INTERNATIONAL CROP SCIENCE CONGRESS, 6., 2012, Bento Gonçalves. [Proceedings...]. [S. l.: International Crop Science Society, 2012]. 1 pen drive. Oral presentation, Abstract 3198.