Mustard is Better Suited to the Warmer and Drier Semiarid Prairie than Canola

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Abstract

Canola is a risky crop in the warm and dry semiarid prairie. Mustard is reported to be less susceptible to stress, although very little evidence is available to support this view. Nitrogen is the second most important factor limiting potential yield on the semiarid prairie. Therefore, a three year field study over 14 site years was conducted to compare the adaptability of different canola and mustard cultivars, with special interest in canola quality mustard, under low, normal and high risk levels of N. Differences in Brassica spp. were noticed for growth duration, biomass production, seed yield and yield parameters. Seed yield of Cutlass was 15 and 32% higher than Quantum and Maverick cultivars, respectively. Canola quality mustard, J90-4316 produced seed yield similar to Quantum, but was lower than Cutlass, suggesting further breeding to improve agronomic quality of J90-4316 is needed. Mustards produced higher pods per plant and lower seeds per pod and seed weight compared to Quantum, while the lowest pods per plant, seeds per pod and seed weights were observed in Maverick. All Brassica spp. responded to N application by increasing growth duration, biomass and seed and yield component production. However, availability of water limits response of some of the parameters to higher levels N application. N application reduced oil content, but overall oil yield increased with N application. Interaction between B. spp. and N application or environment was also observed. Thus, the results suggest that mustards, especially, cutlass is better adapted to semiarid prairie than canola cultivars.

Introduction

Canola (*Brassica napus* L.) is a major oilseed crop on the Canadian prairie. However, major acreage of canola was confined to sub-humid regions of prairie. The area of canola in the semiarid brown soil zone expanded 19 folds in the past decade, from about 10,000 ha in 1990 to about 195,000 ha in 1999 (Anonymous 1999). Previous research has indicated that canola fail to express their full yield potential under hot and dry environments, similar to the semiarid prairie (Nuttal et al. 1992). Therefore, there is a need for an alternative to canola in the semiarid prairie.

Among Brassica species, Argentine canola (*B napus* L.), polish canola (*B. rapa* L.) and oriental mustard (*B. juncea* L.) are economically exploited for edible oil purpose. Polish canola, due to its shorter duration and smaller yield potential, can not take advantage of favourable conditions that may occasionally prevail in the region. Mustard is often considered to be better adapted to stressful environments than Polish or Argentine canola (Lewis and Thurling 1994; Hockings et al. 1997). However, the strict oil quality standards set by the canola council of Canada does not allow to crush mustards for edible oil purpose. Therefore, breeding efforts to improve oil and meal quality of mustard is in progress. The canola quality mustard cultivars, if proved more stress tolerant, not only will replace canola but also will increase area of oilseeds in the brown and dark brown soil zones of the prairie. Providing a range of environments, increases the ability to detect differences in the adaptability of Brassica spp. to the weather of the semiarid prairie.

Nitrogen fertilization is recognized as the second most important factor after water, limiting crop yields in the semiarid prairie (Campbell et al. 1992). Nitrogen affects crop growth through effects on radiation interception, photosynthesis and radiation use efficiency. Nitrogen is practically an important management practice that builds strong sink in crops that can help in pressurizing green leaf area to produce and divert more to sinks. Canola responds to nitrogen application by producing more leaf and stem biomass and delays maturity (Leleu et al. 2000). N fertilization may improve better water extraction from the soil by improved rooting characters.

The main objective of this paper was to compare different canola and mustard cultivars/lines for growth, development and seed yield under the semiarid conditions. The second objective was to assess the effect of N fertilizer on the responses of Brassica spp. to environmental conditions.

Materials and Methods

Field experiments were conducted at 14 site years during summers of 1996 to 1998. The experiments were scattered on nine different locations ranging from 49˚ 38' N to 51˚ 40' N in latitude and 105˚ 28' to 107˚ 48' in longitude. The experimental sites ranged from Dry Brown to Dark Brown Soil Climatic zones of Saskatchewan. All locations except Kenaston, located on the border of Dark Brown and Moist Dark Brown Soil Climatic zone, were considered marginal for canola production. The soil type ranged from heavy clay to loam, representing the range of soil textures mostly used for crop production in the region.

Adaptability of four cultivars/breeding lines of three Brassica spp. were studied in this project. An oriental mustard cv. ‘Cutlass’ and a canola quality mustard breeding line ‘J90-4316' were compared to an Argentine canola cv. ‘Quantum’, and a Polish canola cv. ‘Maverick’. Canola quality mustard cultivars are still under development. Therefore, J90-4316, an initial breeding line was included in the study. All crops were evaluated at low, normal and high risk N levels for Brown soil zone. Experimental sites included both fallow and stubble phases, although the design did not attempt to compare them. A four-replicate, split plot randomized complete block design was used, with Brassica cultivars/breeding lines as main plots and N levels as sub plots.

A Noble modified hoe drill or a Fabro plot seeder with a cone and spinner assembly for precise seed metering was used to seed crops in 20-cm rows at 2 to 2.5-cm depth. The plot size was 1.6 m x 8.0 m. Seed rate for each canola and mustard crop was targeted to put about 200 seeds m^{-2}. The seeder was capable of mid-row fertilizer banding. In early spring soil samples were taken at each site year to estimate available NO_3-N in the top 60 cm and P_2O_5 in the top 15 cm. Fertilizer recommendations, based on the estimates from each site samples for low, normal and high risk levels in the Brown soil zone, were used for N and P application (Anonymous, 1990) (Table 1). P was mid row banded with seeding either as ammonium phosphate (11-51-0) or as super phosphate (0-45-0). A small amount of N contained in the ammonium phosphate was all the N applied for low risk treatment. Remaining N to normal and high risk treatments was mid row banded or broadcasted either as urea (46-0-0) or as urea-ammonium sulphate blend (40-0-0-6).

The data was analyzed by using separate analysis of variance for each site using split plot design (SAS Institute, Inc. 1988). Year and locations were combined and termed as environment. After testing homogeneity of error variances with Bartlett's test, data was pooled and analyzed as split-split-plot analysis with environment as the main factor, cultivar as the sub factor and nitrogen level as the sub-sub-factor. The environment effect was considered random. Further more, mean seed yield and harvest index of each cultivar at each location was used for regression analysis.

Results and Discussion

- Based on 14 site year data, seed yield ranking was Cutlass>CQ1> Quantum>Maverick; about 33% difference between highest and lowest yielding genotypes (Table 1).
- Nitrogen application increased seed yield significantly. Normal and high risk N applications increased seed yield by 370 (36 %) and 490 (48 %) kg/ha compared to low risk N fertilization.
- Genotypes responded differently to Nitrogen application. Cutlass produced 210 kg/ha more seed than Maverick at low risk N and that increased to 390 and 590 kg/ha at normal and high risk N levels.
- Genotypes and N levels also affected biomass production. Only Maverick recorded lower biomass than other genotypes. Biomass response did not increase with N applied above normal risk.
- Oil content was generally lower in mustard than in canola genotypes. However, higher seed yield compensated for the difference and oil yield was higher in mustards than in canola.
- Nitrogen application reduced oil concentration in all genotypes.
- In general, mustard genotypes had higher pod number, lower number of seeds per pod and slightly lower seed weight, while Argentine canola produced lower number of pods, higher number of seeds per pod and heavier seeds (Table 2). However, lowest number of pods, seeds per pod and seed weight were observed in Polish canola.
- Nitrogen application increased pod number and seeds per pod, but, reduced seed weight slightly (Table 2).
- Water extraction was lower in Maverick. Although, water use by Cutlass was similar to Quantum, J90-4316 used slightly more water.
- Lower water extraction by Maverick compared to other cultivars was due to shallower root system as well as lower water extraction efficiency in each layer (Fig. 1 and 2).
- Nitrogen application slightly increased total water extraction by all genotypes. However, increasing N levels to high risk had no significant influence on water use.
- Effect of N application on water extraction was observed in most soil layers except in surface (Fig. 2) or close to surface layers (Fig. 1).
- Cutlass had about 22 and 13 % higher water use efficiency than Maverick and Quantum, respectively (data not presented).

- Water use efficiency increased with nitrogen application. However, increasing nitrogen to high risk levels increased water use efficiency only in the canola quality mustard (data not presented).

Summary

Average seed yield of Cutlass was about 16 % higher than Quantum, suggesting better adaption of mustards to the semiarid prairie. However, higher seed and oil yield in Cutlass than in Quantum is encouraging for the effort of developing canola quality Brassica juncea. Nitrogen application will improve the adaptability of canola and mustard to the region. Water extraction of mustard was similar to Argentine canola but was significantly superior in Polish canola.

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Table 1. Mean above ground biomass and seed yield of different canola and mustard genotypes in 14 site-years.

Entry	Low	Normal	High	Mean
	---------------------- Biomass (t ha^{-1})---------------------------------			
J90-4316	4.81	7.38	7.27	6.49
Cutlass	4.65	7.31	7.29	6.42
Quantum	4.84	6.91	7.36	6.37
Maverick	4.32	5.74	6.57	5.54
Mean	4.65	6.83	7.12	
$LSD_{(0.05)}$		1.01		
	------------------------- Yield (t ha^{-1}) ---------------------------------			
J90-4316	1.09	1.41	1.55	1.35
Cutlass	1.11	1.58	1.74	1.48
Quantum	0.99	1.37	1.49	1.28
Maverick	0.90	1.19	1.25	1.11
Mean	1.02	1.39	1.51	
$LSD_{(0.05)}$		0.09		
	--------------------------- Oil (g kg^{-1}) ---------------------------------			
J90-4316	449	442	435	442
Cutlass	443	437	428	436
Quantum	463	450	439	451
Maverick	479	469	457	468
Mean	459	450	440	
$LSD_{(0.05)}$		4.7		

LSD (P=0.05) for comparing nitrogen X genotype interaction effect.

Table 2. Mean yield parameters of different canola and mustard genotypes in 14 site years.

Source	Pod Number	Number of Seeds	Thousand Kernel Weight	Water Use Efficiency
	$plant^{-1}$	pod^{-1}	g	kg $hamm^{-1}$
<u>Genotype</u>				
J90-4316	41	14.9	2.22	4.35
Cutlass	38	16.1	2.38	4.94
Quantum	31	24.4	2.78	4.39
Maverick	19	19.8	2.06	4.04
Lsd (0.05)	3.6	0.5	0.03	0.33
2. Nitrogen				
Low	26	17.9	2.38	3.63
Normal	34	19.0	2.34	4.69
High	37	19.4	2.36	4.98
Lsd (0.05)	1.9	0.3	0.01	0.33

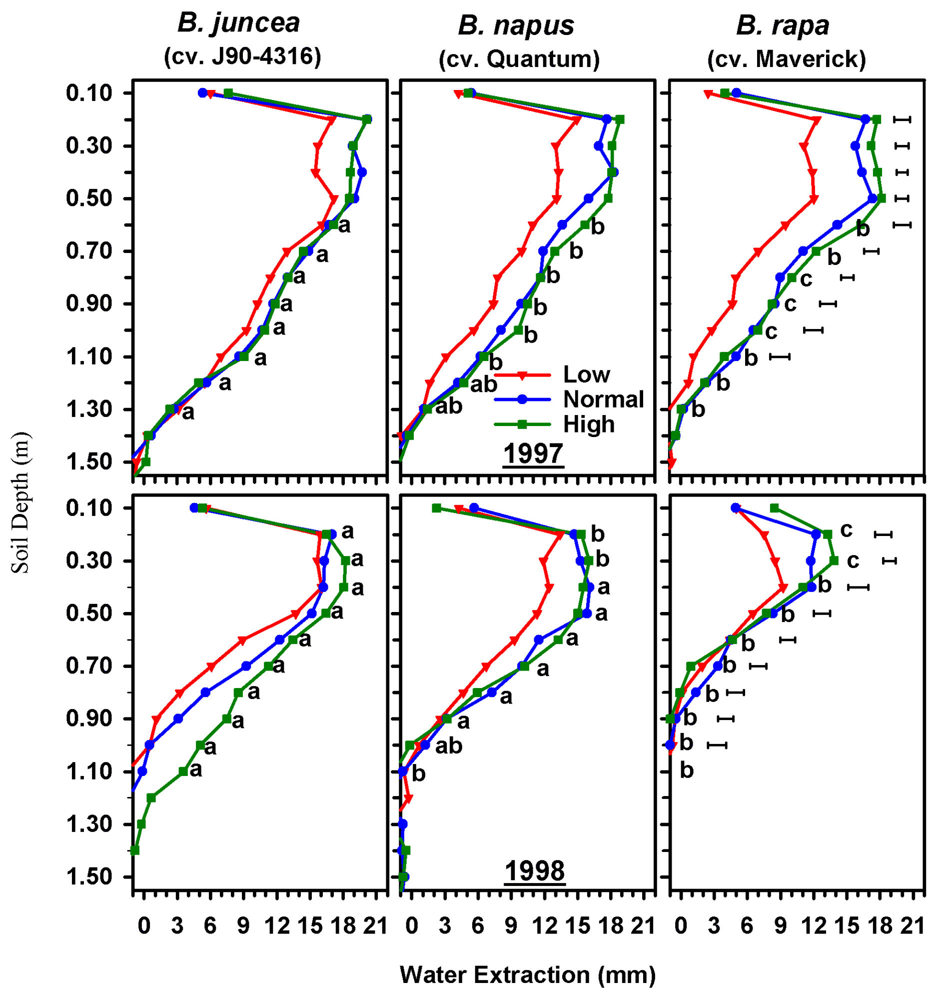

Fig. 1. Water extraction pattern of different Brassica species in response to N application at Swift Current. LSD bars at each depth compare significant N effect and different letters compare Species differences.

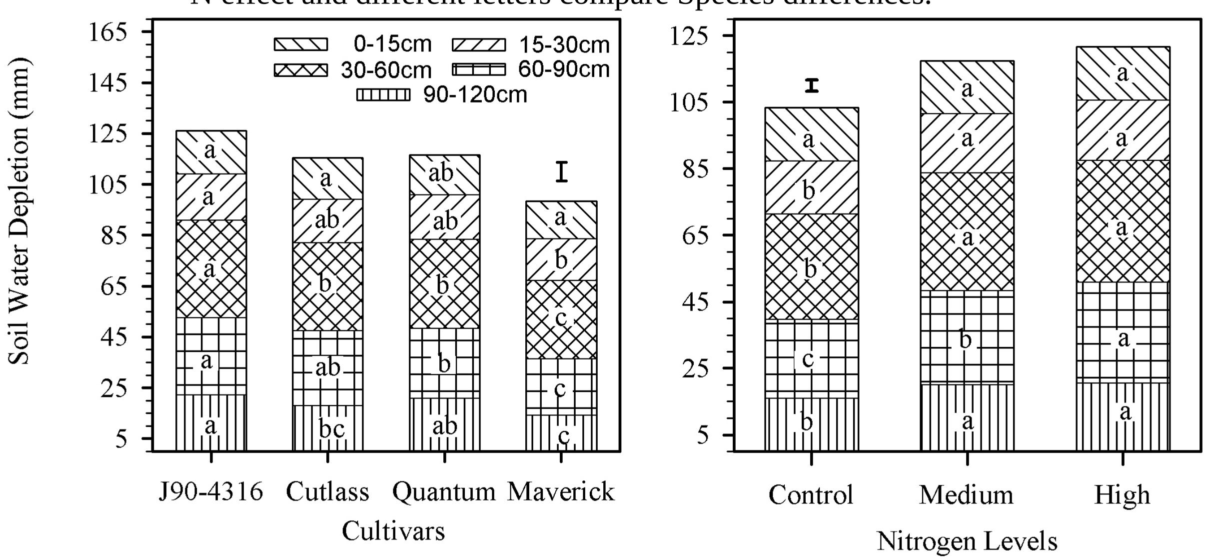

Fig. 2. Mean water extraction of 14 siteyears. a) Species difference b) N response. LSD bars compare total water extraction and letters compare water extraction in respective soil layer.