Yield response of canola to N-fertilization in the semiarid *Argentinean pampa*

H. R. Mirassón[1], R. E. Brevedan[2], I. R. Palomo[2], S. S. Baioni[2], M. N. Fioretti[2]

[1]*Facultad de Agronomía, Universidad Nacional de La Pampa, 6300 Santa Rosa, Argentina.*
[2]*Departamento de Agronomía, Universidad Nacional del Sur y Centro de Recursos Renovables de la Zona Semiárida (CONICET). 8000 Bahía Blanca, Argentina. Email: ebreveda@criba.edu.ar*

Abstract

The effects of N-fertilization rates on yield of *Brassica napus* L. cv. Westar in the southwest of the Buenos Aires province, Argentina, was studied. Nitrogen was broadcast at 50 and 100 kg ha^{-1}. Nitrogen had a significant effect on dry matter and oil yield. There was an increase of 37 and of 46% with 50 and 100 kg N ha^{-1}, respectively, with respect to no-fertilization. The concentration of nitrogen and oil was not significantly affected by the nitrogen nutrition and the response varied with the stage of development of the plant.

Introduction

The semiarid Argentinean Pampa has been dominated by cereal grain production, chiefly wheat, and cattle raising. Low prices for cereal grains, coupled with increasing production problems in wheat monoculture systems cause producers to seek information about alternative oilseed crops.

The acceptance and production of another crop requires that it both has an agronomic benefit to the cropping systems and improve the farmers' economic position.

The two fundamental limitations to agricultural production in the region are water and nitrogen. It is difficult to imagine that in order to manage extensive exploitations of wheat and meat, one could economically manage water availability. More accessible, in economic terms is to modify the nitrogen level in the soil.

Canola is the most important winter-spring oilcrop, that is recognized as an alternative to temperate cereals in the winter-spring growing season of most temperate agricultural regions. There is a limited experimental evidence on the performance of canola in the semiarid Argentinean Pampa. As a consequence a series of experiments were started to obtain information about the response of the crop to nitrogen. Canola fits traditional cereal rotations, it matures earlier than cereals and offer potential for double cropping in the irrigated areas of this region and can be grown to disrupt the cycle of soil-borne cereal diseases. Canola has a relative high requirement for nitrogen and most soils in the region are usually poor on this element. For that reason an adequate use of nitrogen fertilizers is required for optimum economic yields and oil production (Mason and Brennan, 1998).

Our area of study lies between latitudes 36° and 39°S and longitudes 62° and 65°W, covering an area of more than 5 million hectares. It is mostly a flat area with sand sediments 0.4 to 2.0 m deep, resting on a thick layer of hardpan which crops out in several places. The soils are predominantly Entic Haplustolls. The parent materials of these soils are mainly eolic sediments (loess) with low clay and high silt content (Quiroga *et al*, 1998). Tough they are used for agricultural purposes their yield is limited by the lack of moisture associated with the granulometry of the material, the presence of the petrocalcic layer that restricts root development and the low level of nitrogen. The mean annual precipitation varies between 400 and 650 mm, with the greater rainfall occurring during spring and summer, and the mean annual temperature is between 15° and 17°C.

We report in this paper the effect of nitrogen on the productivity of canola grown on the southern semiarid Argentinean Pampa. Effects of nitrogen on dry matter, seed and oil yield, nitrogen concentration and accumulation were studied during two years.

Materials and Methods

The field experiments were conducted at Nueva Roma (38°29'33"S, 62°38'48"W) in the temperate semiarid Argentina. The soil is a Mollic Ustifluvent with 0.16% of total N, 15.9 ppm of extractable P (Bray and Kurtz I) and 4.39% of organic matter.

Temperature, rainfall and Class A pan evaporation were measured at a weather station located 100 m from the experimental site.

The experimental design was a randomized complete block. Individual plot size was 2.0 by 30 m. Nitrogen fertilizer treatments were applied as single applications of 0, 50 and 100 kg N ha^{-1} at sowing.

Canola cv. Westar was sown on the soil surface on June 6 in rows 0.15 m apart. Insect pests and weeds were controlled with recommended pesticides. Rainfall for the June to November period amounted to 230 mm.

Plots were harvested on November 26. All above-ground plant material was cut in each plot for plant biomass, yield, and nutrient analysis. Harvested plant material was air dried, weighed and the seed threshed. The clean seed was dried at 60°C and weighed. Subsamples of seeds were collected at harvest and the concentration of nitrogen was determined by microKjeldahl (Nelson y Sommers, 1973). Oil concentration in the seed was determined by the method of Madsen (1976). Seed oil and protein concentrations are expressed at 8.5% moisture.

Nitrogen fertilizer use-efficiencies were expressed as:

1. Agronomic efficiency (Smith *et al*, 1988).

(Seed yield of fertilized plants – Seed yield of unfertilized plants) / (N fertilizer applied)

2. Physiological efficiency (Smith *et al*, 1988)

(Seed yield fertilized – Seed yield unfertilized) / (N accumulated fertilized – N accumulated unfertilized)

3. Nitrogen use-efficiency (Stapper and Fischer, 1990)

(kg seed produced / kg N accumulated by shoots at maturity)

Results

The pattern of the results was similar in both years so, considering the more complete analysis carried out in the second year, only the results obtained in that year are considered here.

The fertilization treatment had no significant effect ($p \leqslant 0.05$) on the stand density (number of plants per m^2) of canola plants. As measured 30 days after sowing, independently of the amount of N applied the density of canola plants was similar in all treatments.

There were significant dry matter responses to nitrogen at almost every sampling time (Table 1) but differences between 0 to 50 kg N ha^{-1} were larger than the ones between 50 and 100 kg N ha^{-1}. The general effect of nitrogen was to conduce to a more vigorous growth and development. There was a significant dry matter response to N at each sampling time.

The largest N concentration was obtained with the highest N application for every sampling date (Table 2). There was also a continuous decline of N concentration during crop growth.

The largest plant N accumulation for each sampling date was obtained with the largest application of N (Table 3). On the other hand plant N accumulation increased during crop growth.

Seed and oil yields were significantly larger with larger applications of N (Table 4), but there were no significant differences in oil and protein concentrations under different N levels.

Agronomic efficiencies decreased with an increase of N application and were lower than the values obtained by Hocking *et al.* (1997) (Table 5). Physiological efficiencies were more uniform and were similar to the ones that were get by Hocking *et al.* (1997). The N use efficiency decreased with an increase of applied N (Table 5).

Table 1. Dry matter production of canola with three levels of nitrogen.

N applied	Weeks after sowing							
	8	10	12	14	16	18	20	22
	kg ha^{-1}							
000	196 b*	405 c	*753 b	1590 c	1846 c	2413 b	3194 c	4140 c
050	191 b*	683 b	1072 a	2041 b	2503 b	3215 a	4409 b	5830 b
100	241 a*	756 a	1131 a	2322 a	2892 a	3598 a	4894 a	6320 a

* Means within a column followed by different letters are significantly different ($p \leqslant 0.05$).

Table 2. Nitrogen concentration in whole plant of canola with three levels of nitrogen.

	Weeks after sowing		
N applied	14	18	22
kg ha^{-1}	%		
000	2.16 c*	1.77 b	1.09 b
050	2.71 b*	2.16 a	1.22 a
100	3.20 a*	2.25 a	1.30 a

* Means within a column followed by different letters are significantly different ($p \leqslant 0.05$).

Table 3. Nitrogen accumulation in whole plant of canola with three levels of nitrogen.

	Weeks after sowing		
N applied	14	18	22
	kg ha^{-1}		
000	34.3 c*	42.7 c	45.1 b
050	55.3 b*	69.4 b	71.1 a
100	74.3 a*	81.0 a	82.2 a

* Means within a column followed by different letters are significantly different ($p \leqslant 0.05$).

Table 4. Seed and oil yield and oil and protein concentration of canola with three levels of nitrogen.

N applied	Yield		Concentration	
	seed	oil	oil	protein
	kg ha^{-1}		%	
000	1449 c*	612,9 c	42,3 a	20,8 a
050	1982 b*	828,5 b	41,8 a	21,5 a
100	2118 a*	881,1 a	41,6 a	21,9 a

* Means within a column followed by different letters are significantly different ($p \leqslant 0.05$).

Table 5. Nitrogen fertilizer use efficiencies.

N applied	Agronomic efficiency	Physiological efficiency	N use-efficiency
kg ha^{-1}	kg seed kg^{-1} N applied	kg seed kg^{-1} plant N accumulated above N=0)	kg seed kg^{-1} plant N accumulated
000	NA**	NA	32 a
050	10 a**	21 a	28 a
100	07 a**	18 a	26 a

*NA: not applicable
**Means within a column followed by different letters are significantly different ($p \leqslant 0.05$).

Conclusions

The results establish that fertilization with N increased seed and oil yield. There was also a tendency to increase N concentration and decrease oil concentration with the application of N.

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