RESEARCH

FLAXSEED RESPONSE TO N, P, AND K FERTILIZATION IN SOUTH CENTRAL CHILE

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ABSTRACT

Flaxseed (*Linum usitatissimum* L.) is a minor crop in Chile. There is interest to increase the number of crops on the current rotation in South Central Chile and also to increase oilseed feedstocks for salmon feed. There is little information published about seed yield and oil content response to N, P, and K fertilizers on flaxseed in Chile. The objective of this study was to determine the effect of N, P, and K fertilization on flaxseed yield, oil content, and composition. The study was conducted at two locations during two growing seasons (environments), in Chillán 2004-2005, 2005-2006, and in Osorno 2004-2005, 2006-2007. Treatments were four levels of N (0, 100, 200, and 300 kg N ha^{-1}), three levels of P (0, 100, and 200 kg P_2O_5 ha^{-1}), and two levels of K (0 and 150 kg K_2O ha^{-1}). The design was a randomized complete block with a factorial arrangement of three factors (N, P, and K) and four replicates. According to the results, flaxseed yield improved as N rates increased. Physical optimum rate (rate at which maximum seed yield is obtained) was different depending on the location and year. Nitrogen rate increased oil content and yield up to 200 kg N ha^{-1}. Oil composition was not affected by N, P, and K rates, or their interactions. The P and K nutrients did not have an effect on seed yield, oil content, oil yield, and oil composition.

Key words: seed yield, oil content, oil composition, α-linolenic acid.

INTRODUCTION

Flaxseed (*Linum usitatissimum* L.), one of the 100 species in the *Linum* genus, belongs to the Linaceae family (Hocking *et al*., 1987), and originates from Europe and Southern Asia (Casa *et al*., 1999). Flax stems are used for fiber and the seed for oil. Oil has been used primarily to manufacture paint and varnishes (Charlton and Ehrensing, 2001), and to make linoleum floor tiles (Metrycki, 2004).

The world area cultivated with flaxseed is 3 016 940 ha with an annual average seed yield of 852 kg ha^{-1} (FAO, 2007). Canada, India, China, and the USA are the main world producers. Canada and the USA have 93% of the total exported volume (FAO, 2007). The European Union is the main importer of flaxseed in the world (DIMEAGRO; 2007).

There are only 50 ha of flax cultivated for fiber in Chile and these are found mainly in the Los Lagos Region. Most of the flaxseed and flaxseed oil consumed is imported from Argentina where the cultivated area was 28 000 ha in the 2006/2007 growing season (DIMEAGRO, 2007). Chile has increased its flaxseed oil imports in the last two years.

Flaxseed is rich in oil (41%), protein (20%), dietary fiber (28%), contains 7.7% moisture and 3.3% ashes (Morris, 2005). It has a high percentage of essential fatty acids, 75% polyunsaturated fatty acids, 57% alpha-linolenic acid, which is an omega-3 fatty acid, and 16% linoleic acid, which is an omega-6 fatty acid (Morris, 2005).

Essential fatty acids play a role in cell membrane synthesis by making them flexible (Connor, 2000; Lee and Lip, 2003). They are also precursors for eicosanoids and prostaglandins, a group of metabolites that affect several biological processes such as platelet aggregation, blood clotting, and blood vessel contraction (Simopoulos, 1999; Lee and Lip, 2003). These metabolites play a role in skin regeneration and cholesterol metabolism (Jenkins *et al*. 1999). Other studies have demonstrated that flaxseed has other molecules that can reduce the risk of cancer, such as secoisolariciresimol diglycoside (SDG) and dietary fiber (Zhou y Blackburn, 1997; Jenkins *et al*., 1999; Nesbitt *et al*., 1999; Sauer *et al*., 2000).

Flaxseed is consumed whole or as flour (Morris, 2005). It can also be included in the ration of laying hens to produce eggs high in omega-3 (Nash *et al*., 1996),

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chickens (Ajuyah et al., 1993), and pigs (Romans *et al*., 1995).

Flaxseed is grown as an annual crop and its seed yield is highly related to N and water availability. N is the most important nutrient in plant nutrition (Hofman and Cleemput, 2004). It is a component of proteins and chlorophyll needed for plant growth (Lawlor *et al*., 1998; Lawlor, 2002), and is the most important nutrient in flaxseed production, especially when grown under irrigation (Hocking *et al*., 1987). Excessive N fertilization can promote vegetative growth reducing seed production (Franzen, 2004). When water availability is not limited, N deficiency is the main cause of seed yield reduction (Sánchez and Flores, 1999).

Most reports on the N response of flaxseed are local and not necessarily related to the general response. Many of the results are also contradictory (Hocking *et al*., 1997). Diepenbrock and Iwersen (1989) indicated that fertilizing with 40 to 60 kg N ha^{-1} is enough to reach acceptable seed yields. Hocking et al. (1987) recommended rates from 20 to 60 kg N ha^{-1}, while in Australia reports indicate that maximum seed yield was obtained with 80 kg N ha^{-1}. In the USA and Canada, the recommendation is to fertilize with 90 kg N ha^{-1} depending on soil fertility (Franzen, 2004). In Argentina, an increase in seed yield was observed from 40 to 120 kg N ha^{-1} (Sánchez and Flores, 1999). The potential seed yield for flax in the most important producing countries is about half of what is observed in Chile. Therefore, seed yield response to N is probably much different than the one reported for Canada and the USA.

The objective of this study was to evaluate the effect of N, P, and K fertilization on seed yield, oil content, oil yield, and oil composition of flaxseed cultivated in South Central Chile.

MATERIALS AND METHODS

Experiments were conducted during the 2004-2005 and 2005-2006 growing seasons at El Nogal Experimental Station of the Universidad de Concepción, Chillán, Chile (36°35' S, 72°04' W and 140 m.a.s.l.), Bío-Bío Region. During the 2004-2005 and 2006-2007 growing seasons, experiments were carried out at the Fundo San Francisco, Osorno (40º22' S, 73º04' W and 72 m.a.s.l.), Los Lagos Region.

Soil in Chillán is from the Arrayan Series (medial, thermic Humic Haploxerands) with leveled topography and good drainage (Stolpe, 2006). The climate at this location is classified as temperate Mediterranean, with an annual rainfall of 1000 mm (Del Pozo and Del Canto, 1999). In Osorno, the soil is from the Osorno Series (ashy, mesic Typic Haploxerand). The climate at this location is classified as cold Mediterranean with an annual rainfall of 200 to 1500 mm (Dirección Meteorológica de Chile, 2008).

The monthly mean temperature and rainfall, chemical and physical soil analysis of each location as well as growing season are described in Table 1.

The experimental design was a randomized complete block with a factorial arrangement with four rates of N fertilization (0,100, 200, and 300 kg N ha^{-1}), three levels of P fertilization (0, 100, and 200 kg P_2O_5 ha^{-1}), two rates of K fertilization (0 and 150 kg K_2O ha^{-1}), and four replicates. The N fertilizer was applied as urea, P was applied as triple superphosphate, and K as KCI. All fertilizers were applied and incorporated at sowing. Seeding dates were 24 August and 9 September for Chillán 2004-2005; 2005-2006, and 22 September and 12 September for Osorno 2004-2005; 2006-2007.

In Chillán, the soil was tilled twice and a rototiller was used to prepare the seeding bed. Trifluralin [2,6-dinitro-N, N-dipropyl-4-(trifluoromethyl)benzenamine] (2 L ha^{-1}) preplant incorporated was applied 4 days before seeding. At the 4-leaf stage or 10 cm plant height, MCPA (0.75 L ha^{-1}) was applied. The crop was irrigated twice at the end of the growing season. In Osorno, the experiment was conducted in a no-till soil without irrigation. Herbicide, MCPA (0.75 L ha^{-1}), was applied at the 4-leaf stage for broadleaf weed control.

Seeding rate was 35 kg ha^{-1} and the cv. Nekoma (released by North Dakota State University) was used (Hammond *et al*., 2004). Seed was hand broadcasted into four furrows 5 m long and spaced 20 cm apart. Plants were swathed and left in a greenhouse to dry for 4 days before threshing. Swathing and threshing were conducted during the last week of January or the first week of February when 90% of the capsules were brown.

Seed yield was evaluated using 2 m from the two center rows of each experimental unit. Biomass samples from plants in each plot were collected at the bud and flowering stages. Then 0.1 g of dried, ground plant tissue was analyzed by the Kjeldahl procedure to determine total plant N content (including N in proteins) in the biomass. The 1000-seed weight was done by counting 1000 seeds in a seed counter and then weighing them. Test weight was determined with a 0.1 L volume of clean seed from each experimental unit. These last two variables were evaluated only in Chillán 2004-2005; 2005-2006, and in Osorno 2004-2005.

Seed oil content was determined on 40 mL of clean dried seeds with an NMR (Nuclear Magnetic Resonance Analyzer, Newport 4000, Oxford Institute Limited, Oxford, UK) at the Department of Plant Sciences, North Dakota State University. Oil content was measured on a dry weight basis. This is standard procedure for

Table 1. Mean monthly temperature, rainfall, and soil analysis of four locations in Chillán 2004-2005; 2005-2006; and Osorno 2004-2005; 2006-2007.

	Chillán		Osorno	
	2004 - 2005	2005 - 2006	2004 - 2005	2006 - 2007
	Monthly mean temperature (ºC)			
August	9.2	9.4	-	-
September	11.2	10.5	9.1	8.9
October	12.3	13.3	10.6	10.3
November	15.4	16.6	13.2	12.3
December	17.9	18.3	14.7	14.7
January	19.6	20.0	15.5	16.2
	Monthly rainfall (mm)			
August	87.0	250.9	-	-
September	57.4	37.0	56.7	106.4
October	83.3	19.0	26.8	144.2
November	45.0	19.3	85.1	41.9
December	59.8	37.2	30.7	100.7
January	0.0	24.9	89.2	18.9
	Soil analysis			
pH	6.20	6.20	4.20	5.03
Organic matter, %	5.20	4.60	7.60	5.79
$N\text{-}NO_3$, mg kg^{-1}	2.50	6.50	9.30	10.00
P-Olsen, mg kg^{-1}	38.00	55.30	27.70	18.70
K available, mg kg^{-1}	448.30	419.30	200.90	262.60

determining oil content of oilseeds (Robertson and Morrison, 1979). Two replicates of each treatment at each location and season were analyzed. The oil yield was obtained multiplying seed yield by oil content.

Gas chromatography (GC) of fatty acid methyl esters (FAME) was performed with a gas chromatographer (Varian 3900) equipped with a flame ionization detector (FID). Analyses were conducted on a CP-WAX 52 CB, 30 m x 0.25 mm column with an external diameter of 0.39 mm and 0.25 µm filling particle size. Analysis was conducted with set temperatures between 120 and 240 ºC in three stages: 120 ºC for 3 min; increasing temperature by 3 ºC min^{-1} up to 210 ºC and maintaining that temperature for 55 min; and finally the temperature was increased by 15 ºC min^{-1} up to 240 ºC for 65 min. The detector temperature was set at 300 ºC, whereas the injector temperature was set at 200 ºC with a flow of 1 mL min^{-1}. Standard curves of methyl oleate, methyl linoleate, and methyl linolenate were used to confirm response factors for the GC FID that matched those previously reported by Ackman, 2002.

Statistical analysis

Statistical analysis was conducted by using standard procedures for a randomized complete block design (RCBD) with a factorial arrangement (Steel and Torrie, 1980). Nitrogen, P, and K effects were considered fixed for all analyses. Each location-year combination was defined as an 'environment' and was considered a random effect in the statistical analysis. Residual mean squares were compared for homogeneity between environments for each trait. A combined ANOVA was performed on environments found to be homogeneous. Mean separation was performed by applying F-protected LSD comparisons at $P \leq 0.05$ level of significance. The estimated variance of pairwise mean differences and the corresponding degrees of freedom were calculated to estimate the correct LSD values using SAS System (SAS Institute, 2005). Linear and quadratic regression models were evaluated for each dependent variable and the interactions between them. The regression models and all parameter estimates were significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Seed yield

ANOVA detected significant differences for the effects of N, N x Environment, N x P x Environment, and K x P for seed yield (Table 2). Nitrogen fertilization

Table 2. Sources of variation, degrees of freedom, mean squares, and significance for seed yield, 1000-seed weight, test weight, oil content, and oil yield for four levels of N, three levels of P, two levels of K, and their interactions.

Source of variation	df	Seed yield	df	1000-seed weight	Test weight	df	Oil content	Oil yield
Environment	3	40 094 573	2	16.84	374.4	3	261.4	2 653 804
Rep (Env)	12	641 033	8	0.07	2.7	5	7.9	55 259
N	3	13 275 812*	3	1.09*	11.7	3	14.3*	841 264 *
N x Env	9	1 242 122**	6	0.34*	12.9**	9	2.7*	161 003 *
P	2	307 710	2	0.21	2.1	2	1.5	1908
P x Env	6	643 761	4	0.20	4.2	6	0.3	35 371
K	1	681 141	1	0.04	0.5	1	1.4	25 449
K x Env	3	806 134	2	0.83**	12.9**	3	0.9	9725
N x P	6	4 129 737	6	0.20	1.2	6	1.3*	35 050
N x P x Env	18	722 673*	12	0.30**	3.0**	18	0.5	64 953
N x K	3	704 915	3	0.45	7.1	3	0.7	21 855
N x K x Env	9	157 955	6	0.25*	1.9	9	0.9	13 275
K x P	2	415 407**	2	0.21	4.8	2	1.0	26 780
K x P x Env	6	27 753	4	0.18	5.8*	6	0.6	33 804
N x P x K	6	335 125	6	0.18	6.4	6	0.5	10 732
N x P x K x Env	18	270 631	12	0.17*	4.5*	18	0.5	56 145
Error	276	226 877	184	0.09	1.9	75	0.8	51 442
CV (%)		22.5		5.12	2.1		2.1	27

*, **: Significant at $P \leq 0.05$ and 0.01. df: degrees of freedom. Env: environment. Rep: replicate. CV: coefficient of variation.

rates increased seed yield with an optimal physical rate variable depending on location and year (Figure 1). The interaction observed with the environments was mainly due to differences in seed yield magnitude. The optimal physical rate for both Chillán and Osorno environments was 222 kg N ha^{-1} and 291 kg N ha^{-1}, respectively. However, the Chillán environment in 2005-2006 had a much lower seed yield than that obtained at the other environments due to bird damage before harvest, and reducing N requirements.

The response to N in this study indicated that N requirements to optimize seed yield in flaxseed is similar to that of canola grown in Chile. Nitrogen demand of canola in Chile is 5.4 kg N for 100 kg of seed. A canola seed yield of 4500 kg ha^{-1} would require 243 kg N ha^{-1} (Acevedo, 2003). Other studies indicate that N uptake in flaxseed is 150 to 200 kg N ha^{-1} (Hocking *et al*., 2002), which is similar to the response obtained in this study.

Seed yield increase was 1411 kg ha^{-1} comparing the treatment with 300 kg N ha^{-1} and the control treatment (0 kg N ha^{-1}) in Chillán 2004-2005. This difference was also observed in the analysis of biomass N content at three different phenological stages. At the bud stage, N content was 3% for the control treatment and 4.61% for the treatment with 300 kg N ha^{-1}. At 50% flowering, N content was 1.3% and 2.39% for the control and the treatment with 300 kg N ha^{-1}, respectively. In Osorno, the difference in seed yield between the maximum rate applied and the control treatment was only 586 and 660 kg ha^{-1} for the 2004-2005 and 2006-2007 growing seasons, respectively. Since N was entirely applied at seeding, the higher rainfall in Osorno may have leached greater amounts of NO_3 from the root zone, thus making it less available for the needs of the crop. Zagal *et al*. (2003) indicate that NO_3 leaching in canola (*Brassica napus* L.) grown in South Central Chile may reach 20 kg N ha^{-1} when the rate is split into three applications, and is much greater when it is entirely applied at seeding.

Sánchez and Flores (1999) reported an increase in seed yield with increasing N rates. However, the optimal physical rate was 107 kg N ha^{-1}, which is much lower than the one obtained in this study for both locations. However, the Sánchez and Flores (1999) study results are from one location and a single season in the province of Buenos Aires, Argentina, with a lower yield potential.

The main effects of P and K were not significant, thus indicating that there was no seed yield response to P or K fertilization at any of the four tested environments. However, there was a significant response on seed yield for the interaction between P and K ($P \leq 0.05$) (Table 2). Seed yield increased when P rates were increased from 0 to 200 kg P_2O_5 ha^{-1}, but only when K was not applied (Figure 2). If the crop was fertilized with 150 kg K_2O ha^{-1}, seed yield increased only from 0 to 100 kg P_2O_5 ha^{-1} and decreased rapidly with higher P fertilization rates (Figure 2). Seed yield difference between the control treatment

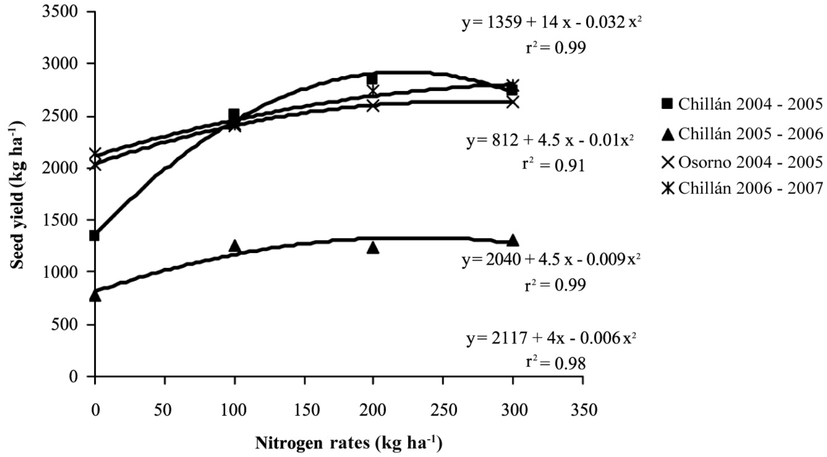

Figure 1. Seed yield response to N fertilization at four locations. Regression line indicates best fit model to the mean of four environments.

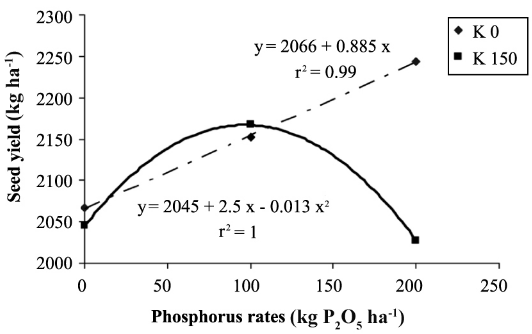

Figure 2. Interaction between P and K for flaxseed yield in four environments (Chillán 2004-2005; 2005-2006, and Osorno 2004-2005; 2006-2007). K0 = 0 kg K_2O ha^{-1} and K150 = 150 kg K_2O ha^{-1}.

(P = 0 kg P_2O_5 ha^{-1}) and the treatment with 200 kg P_2O_5 ha^{-1} was only 177 kg ha^{-1}. Given these results, the recommendation for P fertilizer in flaxseed would be at least 100 kg P_2O_5 ha^{-1} without the addition of K fertilization in soils with medium or low levels of P-Olsen (8-16 mg kg^{-1}). Experiments were conducted in soils with high P-Olsen levels (> 16 mg kg^{-1}) and K extractable (200 mg kg^{-1}) (Table 1) where a response in seed yield is difficult to obtain. The few existing studies on the response of seed yield with P and K have not shown significant responses (Hocking and Pinkerton, 1993; Franzen, 2004).

Seed weight and test weight

ANOVA detected significant differences for the effects of N, N x Environment, K x Environment, N x P x Environment, and N x K x P x Environment for 1000-seed weight (Table 2). Nitrogen fertilization increased the 1000-seed weight between the control treatment and treatments with 100 and 200 kg N ha^{-1} (Table 3). Significant interaction with the environments was a magnitude of effect because seed weight was greater in the Chillán 2005-2006 and Osorno 2004-2005 environments. Previous studies in flaxseed indicate that 1000-seed weight is not the yield component most affected by N deficiency, but the number of capsules and seeds m^{-2} (Hocking and Pinkerton, 1991; Sánchez and Flores, 1999). Another study indicates that 1000-seed weight increases with N applications greater than 160 kg N ha^{-1} (Sánchez and Flores, 1999), while Sarandon *et al*. (1996), Hocking and Stapper (2001) did not find any differences in seed weight of canola by increasing N rates.

ANOVA detected significant differences for the effects of N x Environment, K x Environment, and N x K x P x Environment for test weight (Table 2). Test weight did not increase as N rates increased. The interactions observed are due mainly to differences in magnitude in the environments. In other words, test weight was higher for fertilization treatments in some of the environments.

Oil content and oil yield

ANOVA detected significant differences for the effects of N, N x Environment, and N x P for oil content and N and N x Environment for oil yield ($P \leq 0.05$) (Table 2). Increasing rates of N decreased oil content (Figure 3) from 417 g kg^{-1} to 402 g kg^{-1}. A decrease in oil content with high N rates has been reported before in flaxseed (Dybing, 1965; Hocking, 1995; Hocking *et al*., 1997) and other oilseed crops such as sunflower (*Helianthus annuus* (L.) (Steer and Seiler, 1990), and canola (Starner *et al*., 1999). The reduction in oil content with high N availability occurs because of a "dilution effect". As N promotes vegetative growth, delaying grain fill and maturity, other

Table 3. Interaction between N fertilization and environment for 1000-seed weight and test weight.

	Chillán		Osorno	
N rate	**2004 - 2005**	**2005 - 2006**	**2004 - 2005**	**Mean**
kg ha^{-1}	1000-seed weight (g)			
0	5.20	5.75	6.05	5.66
100	5.44	6.19	6.27	5.93
200	5.40	6.30	6.10	5.90
300	5.45	6.14	6.00	5.84
LSD (0.05) N x Env		0.41		0.25
	Test weight (kg hL^{-1})			
0	69.44	66.65	65.03	67.08
100	68.90	67.22	66.19	67.48
200	69.65	68.01	66.35	67.74
300	70.07	68.69	64.70	68.00
LSD (0.05) N x Env		2.53		NS

Env: environment. NS: not significant.

components such as protein and starch are accumulated in the seed diluting the oil (Hocking and Pinkerton, 1991). The dilution effect is also observed for oil yield (Figure 4). Oil yield increased from 0 to 200 kg N ha^{-1}, decreasing at 300 kg N ha^{-1}. According to the regression model, the rate to optimize oil yield is 217 kg N ha^{-1}.

The interaction between N and P indicated that oil yield increased up to 200 kg N ha^{-1}. The response was similar for all levels of P except when the N rate was 300 kg N ha^{-1} and no P was applied, thus decreasing oil yield (Figure 3). This response was similar to that obtained for seed yield. The reduction in oil content and yield at high and low levels of N and P, respectively can be due to a reduction in the biosynthesis of fatty acids, as a result of lower ATP available for the high energy needs of fatty acid synthesis (Taiz and Zeiger, 2002).

Oil composition

There was no effect of none of the nutrients and their interactions on oleic, linoleic, and alpha-linolenic acids (Table 4). Dybing (1965) reported a decrease in alpha-linolenic acid as N rates were increased in flaxseed in a greenhouse study with controlled NO_3 solutions from 14 to 224 mg L^{-1}.

CONCLUSIONS

According to the results obtained, N increased seed yield in all environments. Oil content and oil yield increased up to 200 kg N ha^{-1}. Oil composition was not affected by N fertilization. Fertilization with P and K did not affect seed yield, oil content, oil yield, and oil composition. This response was expected since the experiments were conducted in soils with high levels of both nutrients.

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Table 4. Effect of N rates in flax oil composition. Mean values of three levels of P (0, 100, and 200 kg P_2O_5 ha^{-1}), two levels of K (0 and 150 kg K_2O ha^{-1}), and four environments (Chillán 2004-2005; 2005-2006, and Osorno 2004-2005; 2006-2007).

Nitrogen rate	Oleic acid	Linoleic acid	alpha-linolenic acid
N kg ha^{-1}	% of oil		
0	20.01	19.78	50.82
100	19.35	20.09	51.08
200	19.63	20.07	51.40
300	20.00	19.78	51.98
	NS	NS	NS
CV %	17.7	23.6	3.9

NS: ANOVA did not detect significance for the main effect or interactions.

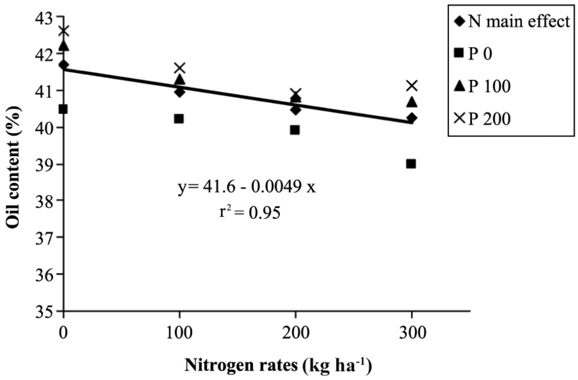

Figure 3. Main effect of N and N x P interaction for seed oil content. Mean values in four environments. (Chillán 2004-2005; 2005-2006, and Osorno 2004-2005; 2006-2007). Regression line indicates best fit linear regression model. Levels of P = 0, 100, and 200 kg P_2O_5 ha^{-1}.

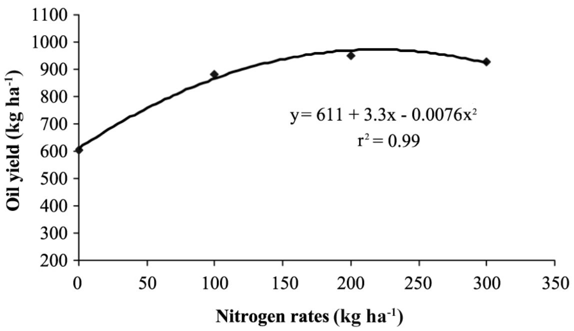

Figure 4. Oil yield response to N fertilization at four locations. Regression line indicates best fit model to the mean of four environments (Chillán 2004-2005; 2005-2006, and Osorno 2004-2005; 2006-2007).

RESUMEN

Respuesta a la fertilización N, P y K en lino oleaginoso en la zona centro sur de Chile. El lino oleaginoso (*Linum usitatissimum* L.) es un cultivo menor en Chile. En la zona centro sur existe interés por ampliar las alternativas para la rotación de cultivos, así como la necesidad de satisfacer la demanda por semillas oleaginosas para la alimentación de salmones. En Chile no hay información relacionada con la respuesta del lino frente a la fertilización. El objetivo del estudio fue evaluar el efecto de N, P y K sobre el rendimiento de semillas y contenido de aceite en lino cultivado en dos localidades: Chillán (temporadas 2004-2005 y 2005-2006) y Osorno (temporadas 2004-2005 y 2006-2007) (ambientes). Los tratamientos fueron cuatro dosis de N (0, 100, 200 y 300 kg N ha^{-1}), tres dosis de P (0, 100 y 200 kg P_2O_5 ha^{-1}) y dos dosis de K (0 y 150 kg K_2O ha^{-1}). El diseño fue de bloques completos al azar con un arreglo factorial de tres factores (N, P, y K) y cuatro repeticiones. De acuerdo a los resultados, el rendimiento de semillas de lino mejoró a medida que se incrementó la dosis de N, la dosis óptima física (dosis con la cual se obtiene el máximo rendimiento) fue distinta según localidad y temporada. El contenido y rendimiento de aceite aumento hasta 200 kg N ha^{-1}. El N no afectó la composición de los ácidos grasos del aceite. El P y el K no influyeron en el rendimiento de semillas, contenido y rendimiento de aceite, composición del aceite y peso de mil semillas.

Palabras clave: rendimiento de semilla, contenido de aceite, composición de aceite, ácido α-linolénico

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