Effect of neonicotinoid seed treatments on flea beetle damage and performance of Argentina canola (*Brassica napus*) in 2003-2006

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ABSTRACT

Field experiments were conducted at AAFC Saskatoon in 2003-2006 to investigate the effect of neonicotinoid seed treatments on flea beetle damage and agronomic performance of Argentine canola, *Brassica napus*. Tests were done yearly on certified seed lots of a RR open-pollinated cultivar and LL hybrid cultivar. Each year, cultivars were planted in early May when soil temperatures averaged 5-10°C and in late May when temperatures averaged 15-20°C. Treatments included untreated seed, Foundation Lite® (fungicides only), Assail 50 SF® (400 g acetamiprid/100 kg seed), Gaucho CS FL® (400 g imidacloprid/100 kg seed), Prosper® (200 g and 400 g clothianidin/100 kg seed), Helix® (200 g thiamethoxam/100 kg seed) and Helix XTra® (400 g thiamethoxam/100 kg seed). Flea beetle damage and agronomic performance in early and late May plantings varied significantly depending on the year, cultivar and seed treatment. Flea beetle damage was higher in 2003 and 2004 than in 2005 and 2006. Shoot dry weights and shoot biomass after 14, 21 and 28 days were 1.4-1.8 times higher in the hybrid cultivar than in the open-pollinated cultivar. Seed yields were, on average, 11-17% higher in the hybrid cultivar than in the open-pollinated cultivar. Year by cultivar interactions indicated that the relative performance of the two cultivars varied significantly from year to year. However, cultivar by treatment interactions and year by cultivar by treatment interactions on damage and performance were not significant in most tests. Interactions indicated that treatment effects were similar in the two cultivars from year to year.

Early May plantings (seeded May 10-13)

Seed treatments had a significant effect on flea beetle damage in the two cultivars 14, 18 and 21 days after seeding. In each test, damage was highest in seedlings grown from untreated seed and seeds treated with Foundation Lite®. Flea beetle damage to untreated seedlings after 21 days was higher in 2003 (77-90% damage) than in 2004 (10-12% damage), 2005 (9-13% damage) and 2006 (18-19% damage). Helix XTra® provided the best protection in 2003, reducing damage in each cultivar to 26-30%. Assail®, Helix®, Prosper®200 and Prosper®400 reduced damage to 30-63%. Gaucho® reduced damage to 72-79%. All treatments containing a neonicotinoid insecticide reduced damage to 10% or less in 2004, 2005 and 2006. Over 4 years, Helix XTra® followed by Assail®, Prosper®400 and Helix® provided the best protection in the open-pollinated cultivar, reducing damage to 11-15%. Helix XTra® followed by Helix®, Assail® and Prosper®400 provided the best protection in the hybrid cultivar, reducing damage to 11-19%.

Seedling emergence after 14 days varied depending on the year and seed treatment. Emergence of untreated seed of the open-pollinated cultivar ranged from 17% in 2003 (dry conditions, >80% damage) to 82% in 2005 (very moist, 5% damage). Emergence of untreated seed of the hybrid cultivar ranged from 50% in 2003 (dry

conditions, 83% damage) to 78% in 2006 (very moist, 16% damage). Foundation Lite® had no significant effect on emergence of either cultivar in most tests. Seed treatments containing a neonicotinoid insecticide had a pronounced effect on emergence of each cultivar in 2003 when flea beetle damage in check plots averaged 80-83%. Compared to untreated seed, Gaucho®, Assail®, Prosper®200, Prosper®400, Helix® and Helix XTra® improved emergence of the open-pollinated cultivar by 47-60% and emergence of the hybrid cultivar by 17-23%. Treatments had little or no effect on emergence of either cultivar in 2004 and 2005 when flea beetle damage in check plots averaged 1-5%. In 2006 when damage averaged 12-15% in check plots, Gaucho®, Assail®, Prosper®400, Helix® and Helix XTra® had no effect on emergence of the hybrid cultivar but improved emergence of the open-pollinated cultivar by 9-12%. Contrary to patent claims, there was limited evidence that neonicotinoid seed treatments promote faster emergence when flea beetle damage averaged 5% or less. Over 4 years, emergence of the two cultivars averaged 72% with Assail®, 74-79% with Gaucho® and Prosper®200 and 77-80% with Prosper®400, Helix® and Helix XTra®.

Seedling establishment after 21 days varied depending on the year and seed treatment. Establishment of untreated seed of the open-pollinated cultivar ranged from 8% in 2003 to 84% in 2005. Establishment of untreated seed of the hybrid cultivar ranged from 18% in 2003 to 84% in 2006. Foundation Lite® had no significant effect on establishment of the two cultivars in each test. Neonicotinoid seed treatments had a substantial effect on establishment of each cultivar in 2003 when flea beetle damage averaged 77-90% in check plots. Compared to untreated seed, Prosper®200, Prosper®400, Helix® and Helix XTra® improved establishment by 56-67% in the open-pollinated cultivar and by 51-59% in the hybrid cultivar. When flea beetle damage averaged 10-19% in 2004, 2005 and 2006, Prosper®400, Helix® and Helix XTra® improved establishment of the open-pollinated cultivar by 6-22%. Tests indicate that the treatments promote stand establishment when flea beetle damage is below the economic threshold. With the exception of Helix XTra® in 2006, neonicotinoid seed treatments had no significant effect on establishment of the hybrid cultivar in 2004, 2005 and 2006. Establishment of the two cultivars over 4 years averaged 72-73% with Assail®, 75-82% with Gaucho® and 81-83% with Prosper®200, Prosper®400, Helix® and Helix XTra®.

In all tests, untreated seed and seeds treated with Foundation Lite® had the lowest shoot dry weight after 14, 21 and 28 days. Neonicotinoid seed treatments had a substantial effect on shoot weights in 2003 when flea beetle damage exceeded 80%. Compared to untreated seed, treatments improved shoot weights in each cultivar by 1.9-3.4 times after 14 days, by 2.9-9.3 times after 21 days and by 3.3-24.8 times after 28 days. Seeds treated with Helix XTra® ahd the highest weights and best shoot growth on most sampling dates. In 2006 when flea beetle damage averaged 18-19% in check plots, Prosper®400, Helix® and Helix XTra® improved shoot weights in each cultivar by 1.0-1.4 times after 14 days, by 1.1-1.7 times after 21 days and by 1.3-1.7 times after 28 days. In 2004 and 2005 when flea beetle damage averaged 9-13%, neonicotinoid seed treatments had no significant effect on shoot weights of each cultivar after 14 and 21 days. Prosper®400, Helix® and Helix XTra® improved shoot weights after 28 days by 1.4-1.6 times in the open-pollinated cultivar and by 1.1-1.4 times in the hybrid cultivar. Results support the patent claim that some neonicotinoid seed treatments promote shoot growth when flea beetle damage is very low. Over 4 years, seeds treated with Prosper®400, Helix® and Helix XTra® had the highest shoot weights after 14, 21 and 28 days. Compared to untreated seed, treatments improved shoot weights by 1.2-1.5 times after 14 days, by 1.3-1.7 times after 21 days and by 1.4-1.8 times after 28 days. Improvements in shoot growth were generally greater in the open-pollinated cultivar than in the hybrid cultivar.

Neonicotinoid seed treatments had a significant effect on shoot biomass after 14, 21 and 28 days. Untreated seed and seeds treated with Foundation Lite® had the lowest biomass. Neonicotinoid seed treatments had a pronounced effect on shoot biomass in 2003 when flea beetle damage reached 80-90% in check plots. Compared to untreated seed, treatments improved shoot biomass in each cultivar by 14-38 times after 14 days, by 23-640 times after 21 days and by 26-450 times after 28 days. Seeds treated with Helix or Helix XTra® had the highest biomass on each sampling date. In 2006 when flea beetle damage averaged 18-19% in check plots, Prosper®400, Helix® and Helix XTra® improved shoot biomass in each cultivar by 1.1-1.7 times after 14 days, by 1.2-2.0 times after 21 days and by 1.1-1.7 times after 28 days. In 2004 and 2005 when damage averaged 9-13%, neonicotinoid seed treatments had no significant effect on shoot biomass of either cultivar after 14 and 21 days. Prosper®400, Helix® and Helix XTra® improved shoot biomass after 28 days by 1.6-2.3 times in the open-pollinated cultivar and by 1.3-1.6 times in the hybrid cultivar. Results support the claim that some neonicotinoid seed treatments promote biomass accumulation when flea beetle damage is relatively low. Over 4 years, seeds treated with Prosper®400, Helix® or Helix XTra® had the highest biomass after 14, 21 and 28 days. Compared to untreated seed, treatments improved shoot biomass by 1.4-1.8 times after 14 days, by 1.4-1.9 times after 21 days and by 1.6-1.9 times after 28 days. Assail®, Gaucho® and Prosper®200 improved biomass after 28 days by 1.3-1.4 times in the open-pollinated cultivar and by 1.5-1.7 times in the hybrid cultivar.

Untreated seed and seeds treated with Foundation Lite® had the lowest yields in the open-pollinated and hybrid cultivars. All neonicotinoid seed treatments improved yield in 2003 when flea beetle damage reached 90% in check plots. Compared to untreated seed, yields in the open-pollinated cultivar increased by 6.5 times with Gaucho®, by 18-26 times with Assail®, Prosper®200, Prosper®400 or Helix® and by 37 times with Helix XTra®. Yields in the hybrid cultivar increased by 28 times with Gaucho®, by 38-46 times with Assail®, Prosper®200, Prosper®400 or Helix® and by 54 times with Helix XTra®. In 2004 and 2005 when flea beetle damage averaged 9-13% in check plots, Prosper®200, Prosper®400, Helix® and Helix XTra® improved yield in the open-pollinated cultivar by 5-30%. Treatments had no significant effect on yield of the hybrid cultivar in 2004 or 2005. In 2006 when flea beetle damage averaged 18-19%, treatments had no significant effect on yield of the open-pollinated cultivar. Prosper®400, Helix® and Helix XTra® improved yields in the hybrid cultivar by 11-13%.

Compared to untreated seed, yields in the open-pollinated cultivar over 4 years increased by 6-12% with Gaucho® or Assail®, by 19-22% with Prosper®200 or Prosper®400 and by 25-27% with Helix® or Helix XTra®. Compared to untreated seed, economic returns in the open-pollinated cultivar increased by $14.00/acre with Gaucho®, by $28.00/acre with Assail®, by $43.40/acre with Prosper®200, by $50.40/acre with Prosper®400, by $55.30/acre with Helix® and by $66.50/acre with Helix XTra®. Yields in the hybrid cultivar over 4 years increased by 12% with Gaucho®, by 17-19% with Assail®, Prosper®200 or Prosper®400 and by 24-27% with Helix® or Helix XTra®. Compared to untreated seed, economic returns in the hybrid cultivar increased by $30.80/acre with Gaucho®, by $41.30/acre with Assail®, by $46.90/acre with Prosper®200, by $52.50/acre with Prosper®400, by $58.10/acre with Helix® and by $66.50/acre with Helix XTra®.

Late May plantings (seeded May 25-28)

Seed treatments had a significant effect on flea beetle damage in each cultivar 14, 18 and 21 days after seeding. As in the early May plantings, damage was highest in seedlings grown from untreated seed and seeds treated with Foundation Lite®. Flea beetle damage to untreated seedlings after 21 days was higher in 2003 (38-39% damage) and 2004 (43-49% damage) than in 2005 (10-11% damage) or 2006 (13-14% damage). Prosper®400, Helix® and Helix XTra® provided the best protection in most tests. Treatments reduced damage to 4-9% in the open-pollinated cultivar and 5-10% in the hybrid cultivar. Prosper®400 and Helix XTra® provided the best protection over 4 years, reducing damage to 6-8% in each cultivar.

Seedling emergence after 14 days varied depending on the year and seed treatment. Emergence of untreated seed in the open-pollinated cultivar ranged from 72% in 2003 (dry conditions, 18% damage) to 86% in 2005 (very moist, 1% damage), Emergence of untreated seed in the hybrid cultivar ranged from 76% in 2003 (dry conditions, 21% damage) to 82% in 2006 (very moist, 11% damage). Foundation Lite® had no effect on emergence of the two cultivars in all tests. Seeds treated with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest emergence in each cultivar. Compared to untreated seed, treatments improved emergence by 6-14% when flea beetle damage averaged 18-36% in 2003 and 2004 and by 0-10% when damage averaged 12% or less in 2005 and 2006. Helix XTra® promoted faster emergence in 3/4 tests where flea beetle damage was below the economic threshold. Over 4 years, emergence of the open-pollinated and hybrid cultivars averaged 82-84% with Assail® and 86-88% with Gaucho®, Prosper®200, Prosper®400 or Helix XTra®.

Seedling establishment after 21 days varied among years and seed treatments. Establishment of untreated seeds of the open-pollinated cultivar ranged from 65% in 2003 (dry conditions, 38% damage) to 87% in 2005 (very moist, 10% damage). Establishment of untreated seeds of the hybrid cultivar ranged from 71% in 2003 (dry conditions, 39% damage) to 84% in 2005 (very moist, 11% damage). Foundation Lite® had no effect on establishment of the two cultivars in most tests. Seeds treated with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest establishment in most tests. Compared to untreated seed, treatments improved establishment by 17-23% in 2003 (38-39% damage), by 5-9% in 2004 (43-49% damage), by 1-6% in 2005 (10-11% damage) and by 3-10% in 2006 (13-14% damage). Prosper®200 and Prosper®400 promoted significantly higher establishment in 3/4 tests where flea beetle damage was below the economic threshold. Establishment of the two cultivars over 4 years averaged 84-85% with Assail® and 87-89% with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®.

In most tests, untreated seed and seeds treated with Foundation Lite® or Assail® had the lowest shoot dry weight after 14, 21 and 28 days. Neonicotinoid seed treatments had a significant effect on shoot weights in 2004 when flea beetle damage in check plots averaged 43-49% after 21 days. Compared to untreated seed, Prosper®200, Prosper®400, Helix® and Helix XTra® improved shoot weights in each cultivar by 1.3-1.8 times after 14 days, by 1.8-2.7 times after 21 days and by 3.1-4.2 times after 28 days. In 2003, when flea beetle damage averaged 38-39% in check plots after 21 days, Helix® and Helix XTra® improved shoot weights in each cultivar by 1.3-2.5 times after 21 days and by 2.4-3.9 times after 28 days. In 2005 when flea beetle damage averaged 10% in check plots after 21 days, neonicotinoid seed treatments had no significant effect on shoot weights in each cultivar after 14 and 21 days. Low or high rates of Prosper® and Helix® improved shoot weights after 28 days by 1.1-1.4 times in the open-pollinated cultivar and by 1.0-1.3 times in the hybrid cultivar. In 2006 when flea beetle damage averaged 13-14% after 21 days, neonicotinoid seed treatments had no effect on shoot weights in each cultivar after 14 days. Compared to untreated seed, treatments improved shoot weights in each cultivar by 1.3-1.6 times after 21 days and by 1.0-1.4 times after 28 days. Results support the claim that low or high rates of Prosper® and Helix® promote shoot growth after 21-28 days when flea beetle damage is above or below the economic threshold. Over 4 years, seeds treated with Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest shoot weights after 28 days. Compared to untreated seed, treatments improved shoot weight by 1.4-1.5 times in the open-pollinated cultivar and by 1.1-1.3 times in the hybrid cultivar.

In most tests, untreated seed and seeds treated with Foundation Lite® had the lowest shoot biomass after 14, 21 and 28 days. Neonicotinoid seed treatments had no significant effect on shoot biomass after 14 days in 2003 when flea beetle damage averaged 18% in check plots. Prosper®400, Helix® and Helix XTra® improved biomass when damage increased to 38-39% after 21 days. Compared to untreated seed, treatments improved shoot biomass in each cultivar by 2.5 times after 21 days and by 2.4-5.4 times after 28 days. Neonicotinoid seed treatments had a significant effect on shoot biomass in 2004 when flea beetle damage in check plots averaged 43-49% after 21 days. Seeds treated with Prosper®200, Prosper®400, Helix® and Helix XTra® had the highest shoot biomass on most sampling dates. Compared to untreated seed, treatments improved shoot biomass in each cultivar by 1.5-2.6 times after 14 days, by 2.4-3.4 times after 21 days and by 3.2-5.1 times after 28 days. Neonicotinoid seed treatments had no significant effect on shoot biomass of the two cultivars after 14 days in 2005 and 2006 when flea beetle damage averaged 18% or less. Prosper®200, Prosper®400, Helix® and Helix XTra® improved shoot biomass in each cultivar by 1.1-1.7 times after 21 days and by 1.1-1.5 times after 28 days. Results substantiate the claim that low or high rates of Prosper® and Helix® promote biomass accumulation after 21-28 days when flea beetle damage is above or below the economic threshold. Over 4 years, Prosper®400, Helix® and Helix XTra® improved shoot growth of each cultivar by 1.2-1.3 times after 21 days and by 1.4-1.8 times after 28 days.

Untreated seeds and seeds treated with Foundation Lite® had the lowest yield in each cultivar. Neonicotinoid seed treatments had a significant effect on yield in 2003 and 2004 when flea beetle damage in check plots averaged nearly 40%. Compared to untreated seed, yields in the open-pollinated cultivar in 2003 and 2004 increased by 23-59% with Assail®, Gaucho®, Prosper®200 or Prosper®400 and by 41-69% with Helix® or Helix XTra®. Yields in the hybrid cultivar increased by 11-30% with Assail®, Prosper®200, Prosper®400, Helix® or Helix XTra®. Assail® had no significant effect on yield of the open-pollinated cultivar in 2005 and 2006 when flea beetle damage in check plots averaged 10-14%. Other neonicotinoid seed treatments had a significant effect on yield of the open-pollinated cultivar. Compared to untreated seed, yields improved by 5-14% with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®. With the exception of Assail®, all neonicotinoid seed treatments promoted higher yields in the open-pollinated cultivar when flea beetle damage was above or below the economic threshold. In contrast, neonicotinoid seed treatments except for Helix® had no significant effect on yield of the hybrid cultivar in 2005 and 2006. Treatments promoted higher yield in the hybrid cultivar when flea beetle damage was above the economic threshold but not when damage was below the economic threshold. Over 4 years, yields in the open-pollinated cultivar increased by 12% with Assail®, by 18-22% with Prosper®200 or Prosper®400 and by 22-24% with Gaucho®, Helix® or Helix XTra®. Compared to untreated seed, economic returns in the open-pollinated cultivar increased by $28.70/acre with Assail®, by $40.60/acre with Prosper®200 and by $49.70-$53.90/acre with Gaucho®, Prosper®400, Helix® or Helix XTra®. Yields in the hybrid cultivar over 4 years increased by 6-9% with Gaucho®, Assail®, Prosper®200 or Prosper®400 and by 12-13% with Helix® or Helix XTra®. Compared to untreated seed, economic returns in the hybrid cultivar increased by $16.10/acre with Gaucho®, by $24.50-$25.20 with Assail®, Prosper®200 or Prosper®400 and by $35.00-$37.80 with Helix® or Helix XTra®.

Flea beetle emergence

Seed treatments had little or no effect on emergence of the next generation of flea beetles in August-October. Emergence varied greatly depending on the year and planting date. Emergence was higher in 2004 than in 2005 and 2006. In each year of testing, emergence was higher from canola seeded in late May than from canola seeded in early May. Seeding in early May rather than in late May reduced emergence of the fall generation of flea beetles by 29% in 2004, by 91% in 2005 and by 70% in 2006.

INTRODUCTION

The crucifer flea beetle, *Phyllotreta cruciferae* (Goeze), is a major pest of Argentine canola, *Brassica napus* L., in western Canada and northern Great Plains (Anonymous 1997). Adult beetles migrate into emerging canola fields in May when air temperatures reach approximately 14°C (Lamb 1983). Feeding damage to the seedlings results in mortality, reduced growth, delayed maturity, reduced grade and/or lower yield (Putnam 1977; Lamb 1984, 1988). Cultural practices and biological agents provide limited regulation of flea beetle populations (Wylie 1984; Milbrath *et al*. 1995), so canola producers are dependant on seed treatments and foliar-applied insecticides (Lamb and Turnock 1982; Weiss *et al*. 1991). An insecticidal spray is recommended when flea beetles damage more than 25% of the leaf surface (Anonymous 1997).

In 2001-2002, five seed treatments, containing a neonicotinoid insecticide, were registered in Canada for control of flea beetles in canola. Treatments containing imidacloprid (Gaucho CS FL®), acetamiprid (Assail 50 SF®), clothianidin (Prosper FL®) or thiamethoxam (Helix®, Helix XTra®) were registered at rates ranging from 150-600 g AI/100 kg seed. However, limited information was available on the efficacy of the treatments against flea beetles and the effects of application rate on efficacy and agronomic performance. Neonicotinoid insecticides have translaminar and/or systemic activity in plants and inhibit nervous conduction in insects by blocking the nicotinic acetycholine receptor (Tomizawa and Casida 2003). There are also recent reports indicating that neonicotinoids have a direct effect on vigour (Asrar *et al*. 2004), promoting faster emergence, greater plant stands, increased shoot/root growth and higher yields (Syngenta Crop Protection, 2006).

The objective of the present study was to evaluate the effect of neonicotinoid seed treatments on flea beetle damage and the performance of Argentine canola. Untreated and treated seed lots of an open-pollinated cultivar and hybrid cultivar were seeded in early May and in late May to evaluate the efficacy of the seed treatments under different growing conditions and flea beetle pressure. Agronomic assessments focused on the impact of the seed treatments on seedling emergence, stand establishment, shoot growth, biomass accumulation and seed yield.

EXPERIMENTAL METHODS

Field experiments

Field experiments were conducted in 2003, 2004, 2005 and 2006 at the Agriculture and Agri-Food Canada Research Farm at Saskatoon. Fertility requirements were based on yearly soil test recommendations for canola production. A fertilizer blend (N/P/K/S) was banded at 5-10 cm depth in fall. A granular formulation of trifluralin (Treflan QR 5® or Advance 10 G®) was applied at 11.0-11.3 kg/ha in October or at 6.9 kg/ha in early May. The herbicide was incorporated with a cultivator and harrows.

Seed treatments

Tests were conducted annually on certified seed lots of a RR open-pollinated cultivar 'SP Banner' and LL hybrid cultivar 'InVigor 2733.' Treatments included untreated seed, Foundation Lite® (fungicides only), Assail 50 SF® (400 g acetamiprid/100 kg seed), Gaucho CS FL® (400 g imidacloprid/100 kg seed), Prosper FL® (200 g and 400 g clothianidin/100 kg seed), Helix® (200 g thiamethoxam/100 kg seed) and Helix XTra® (400 g thiamethoxam/100 kg seed). Each field experiment had four replicates arranged in a randomized split-plot design with cultivars as main plots and seed treatments as subplots. Untreated seeds and treated seeds were planted in six-row subplots at 200 seeds per 6.1 m row, 0.30 m row-spacing and 1.5-2.0 cm depth with a four-cone, double-disc drill, equipped with on-row packers. In each year of testing, the two cultivars were seeded May 10-13 when soil temperatures averaged 10-15°C and May 25-28 when soil temperatures averaged 15-20°C.

Sampling procedures

Flea beetle damage to 20 cotyledons from each subplot was assessed 14, 17-18 and 21 days after seeding (DAS) using a 10-point rating scale that corresponded to the percentage of cotyledon surface eaten by flea beetles (Palaniswamy *et al*. 1992). The crucifer flea beetle, *P. cruciferae*, was the predominant species present. Numbers of seedlings along a centre row of each subplot were counted 14 and 21 DAS. Shoot growth was assessed by harvesting 10 plants randomly from the outer rows of each subplot 14, 21 and 28 DAS. Samples were placed in plastic bags, labeled and transported to the laboratory in coolers. Shoots were cleaned and weighed to determine shoot fresh weight on a per plant basis. Samples were dried at 60°C for 4-7 days to assess shoot dry weight. Shoot biomass, expressed in g/m-row, was calculated from numbers of seedlings/m-row and shoot fresh weights 14, 21 and 28 DAS. Emergence of the fall generation of flea beetles was monitored at weekly intervals from August 1 through October 15 with emergence cages (n = 3 cages/subplot). The four centre rows of each subplot were swathed and harvested at maturity with a small-plot combine. Samples were cleaned, dried and weighed to determine seed yield.

Statistical analyses

Data were analyzed using the General Linear Model procedure (SAS Institute, Inc. 1999). The Univariate procedure and Shapiro-Wilk statistic were used to evaluate variance and normality. To stabilize the variance among treatments, flea beetle damage was transformed using the arcsine square root function before analysis of variance (ANOVA). Shoot dry weight and shoot biomass were not transformed. Field data were analyzed as a split-split-plot design with years as main plots, cultivars as subplots and treatments as subsubplots. Comparisons were done on pooled data when associated interactions were not significant ($P \geq 0.05$). ANOVA or Fisher's protected LSD test ($P = 0.05$) was used to compare means among years, cultivars and seed treatments. Flea beetle damage was back-transformed for presentation.

RESULTS AND DISCUSSION

A. Tests seeded May 10-13

Yearly comparisons

Flea beetle damage, seedlings/row, shoot dry weight, shoot biomass and seed yield of Argentine canola varied significantly from year to year (Tables 1 and 2). Flea beetle damage after 21 days was higher in 2003 (59% damage) than in 2004 (6% damage), 2005 (5% damage) and 2006 (12% damage). Seedling counts after 14 and 21 days were higher in 2005 and 2006 than in 2003 and 2004. Stand establishment after 21 days averaged 52% in 2003, 76% in 2004, 87% in 2005 and 85% in 2006. Shoot dry weights and shoot biomass after 14, 21 and 28 days were highest in 2006 and lowest in 2003 and 2004. Seed yields ranged from 72.0 g/m^2 (12.8 bu/acre) with very high flea beetle damage in 2003 to 319.9 g/m^2 (56.9 bu/acre) with very low flea beetle damage in 2005.

Cultivar comparisons

Flea beetle damage was not significantly different in the open-pollinated and hybrid cultivars after 17-21 days (Table 1). Stand establishment over 4 years averaged 74% in the open-pollinated cultivar and 76% in the hybrid cultivar. Shoot dry weights and shoot biomass after 14, 21 and 28 days were 1.5-1.7 times higher in the hybrid cultivar than in the open-pollinated cultivar. The year by cultivar interaction on seedlings/row, shoot dry weight and shoot biomass was significant on all sampling dates and indicated that differences in emergence, establishment and shoot growth between the two cultivars varied from year to year. Seed yields averaged 205.0 g/m^2 (36.5 bu/acre) in the open-pollinated cultivar compared to 228.3 g/m^2 (40.6 bu/acre) in the hybrid cultivar.

Seed treatment comparisons

Seed treatments had a significant effect on flea beetle damage and performance of Argentine canola (Tables 1 and 2). The year by treatment interaction on damage, seedlings/row, shoot dry weight, shoot biomass and seed yield was significant on all sampling dates. Interactions indicated that differences among seed treatments varied from year to year. In contrast, the cultivar by treatment interaction on damage and performance was not significant on most sampling dates. Interactions indicated that treatment effects were consistent in the two cultivars. The year by cultivar by treatment interaction on seedlings/row and seed yield was significant and indicated that treatment effects on establishment and yield of the two cultivars varied yearly.

Flea beetle damage

Seed treatments had a significant effect on flea beetle damage 14 days after seeding in 2003, 2004, 2005 and 2006 (Table 3). Damage in each cultivar was highest in seedlings grown from untreated seed or seeds treated with Foundation Lite®. Damage to seedlings from untreated seed was higher in 2003 (80-83% damage) than in 2004 (1-3% damage), 2005 (5% damage) and 2006 (12-16% damage). Helix XTra® and Prosper®400 provided the best protection against high flea beetle damage in 2003. Treatments reduced damage to 6%. Assail® reduced damage to 14-20% whereas Helix®, Prosper®200 and Gaucho® reduced damage to 8-15%. Assail®, Gaucho® and low or high rates of Prosper® and Helix® provided similar protection against low flea beetle damage in 2004, 2005 and 2006. Treatments reduced damage to 4% or less. Over 4 years, Helix XTra®, Prosper®400, followed by Helix®, Prosper®200 and Gaucho®, provided the best flea beetle protection. Treatments reduced damage to 3-5% in each cultivar.

Seed treatments had a significant effect on flea beetle damage 17-18 days after seeding in 2003-2006 (Table 4). Untreated seed and seeds treated with Foundation Lite® had the highest damage in each cultivar. Damage to seedlings grown from untreated seed averaged 93% in 2003, 8% in 2004, 4-7% in 2005 and 14% in 2006. Helix XTra® provided the best protection in 2003, reducing damage to 10-12%. Helix®, Prosper®200 and Prosper®400 reduced damage in the two cultivars to 14-24%. Assail® and Gaucho® reduced damage to 24-39% and 57%, respectively. All treatments containing a neonicotinoid insecticide provided similar protection in 2004, 2005 and 2006. Treatments reduced damage to 5-7% in 2004, 1-2% in 2005 and 8-9% in 2006. Helix XTra®, followed by Prosper®400, Helix® and Prosper®200 provided the best protection in the two cultivars over 4 years. Treatments reduced damage to 6-10% after 17-18 days .

Seed treatments had a significant effect on flea beetle damage 21 days after seeding in 2003-2006 (Table 5). Damage to seedlings grown from untreated seed or seeds treated with Foundation Lite® averaged 77-97% in 2003, 10-12% in 2004, 9-13% in 2005 and 18-19% in 2006. Helix XTra® provided the best protection in 2003, reducing damage in the two cultivars to 26-30%. Assail®, Helix®, Prosper®200 and Prosper®400 reduced damage to 30-63%. Gaucho® reduced damage to 72-79%. All treatments containing a neonicotinoid insecticide reduced damage to 7% or less in 2004, 8% or less in 2005 and 10% or less in 2006. Over 4 years, Helix XTra® followed by Assail®, Prosper®400 and Helix® provided the best flea beetle protection in the open-pollinated cultivar, reducing damage to 11-15%. Helix XTra®, followed by Helix®, Assail® and Prosper®400 provided the best protection in the hybrid cultivar, reducing damage to 11-19%.

The effect of seed treatments on flea beetle damage to cotyledons of the open-pollinated cultivar after 14, 17-18 and 21 days are summarized in Figure 1. On each of the three sampling dates, Helix XTra®, followed by Assail®, Prosper® 400, and Helix® provided the best protection against flea beetle damage in the open-pollinated cultivar. Helix XTra® followed by Helix®, Assail® and Prosper®400 provided the best protection in the hybrid cultivar. (Fig. 2).

Emergence and establishment

Seedling counts after 14 days varied depending on the year and seed treatment (Table 6). Emergence of untreated seed of the open-pollinated cultivar averaged 17% in 2003, 64% in 2004, 82% in 2005 and 72% in 2006. Emergence of untreated seed of the hybrid cultivar averaged 50%, 70%, 77% and 78%, respectively. Untreated seed of the hybrid cultivar had 30% higher emergence than untreated seed of the open-pollinated cultivar when flea beetle damage exceeded 80% in 2003 and 6% better emergence when flea beetle damage averaged 16% or less in 2004 and 2006. In most tests, emergence of untreated seed and seeds treated with Foundation Lite® was not significantly different. Compared to untreated seed, Assail® improved emergence of the open-pollinated and hybrid cultivar by 48% and 17%, respectively, in 2003. Assail® had no effect on emergence of either cultivar in 2004, 2005 and 2006. Seeds treated with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest emergence in each cultivar. When flea beetle damage averaged 80-83% in check plots in 2003, treatments improved emergence of the open-pollinated cultivar by 47-60% and emergence of the hybrid cultivar by 17-32%. The treatments had no significant effect on emergence of either cultivar in 2004 and 2005 when flea beetle damage in check plots averaged 1-5%. In 2006 when damage averaged 12-16%, Gaucho®, Prosper®400, Helix® and Helix XTra® improved emergence of the open-pollinated cultivar by 9-12%. Treatments had no significant effect on emergence of the hybrid cultivar. Therefore, contrary to patent claims, there was no strong evidence to suggest that neonicotinoid seed treatments promote faster emergence of open-pollinated and hybrid Argentine canola when flea beetle damage averaged 5% or less. Emergence of the open-pollinated cultivar over 4 years averaged 72-74% with Assail® or Gaucho® and 79-80% with Prosper®200, Prosper®400, Helix® or Helix XTra®. Emergence of the hybrid cultivar over 4 years averaged 72% with Assail® and 77-79% with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®.

Seedlings/row after 21 days varied depending upon the year and seed treatment (Table 7). Establishment of untreated seed of the open-pollinated cultivar averaged 8% in 2003, 64% in 2004, 84% in 2005 and 76% in 2006. Establishment of untreated seed the hybrid cultivar averaged 18%, 74%, 82% and 84%, respectively. Establishment was 8-10% higher in the hybrid cultivar than in the open-pollinated cultivar in 2003, 2004 and 2006. Establishment of untreated seed and seed treated with Foundation Lite® was not significantly different in all tests. Seeds treated with Assail®, Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra® had the best establishment. When flea beetle damage averaged 77-90% in check plots in 2003, treatments improved establishment of the open-pollinated cultivar by 56-67%. When damage in check plots averaged 10-18% in 2004, 2005 and 2006, treatments improved establishment by 9-22%, 0-5% and 5-15%, respectively. Prosper®400, Helix® and Helix XTra® improved establishment of the open-pollinated cultivar in all tests including those where flea beetle damage averaged 18% or less in untreated check plots. Results support the patent claim that some neonicotinoid seed treatments promote stand establishment when flea beetle damage falls below the economic threshold. In the hybrid cultivar, Gaucho®, Prosper®200, Prosper®400, Helix® and Helix XTra® improved establishment by 51-59% when flea beetle damage averaged 90% in 2003 and by 2-6% when damage averaged 19% in 2006. However, most treatments had no significant effect on establishment of the hybrid cultivar when flea beetle damage averaged 12% or less in 2004 and 2005. Seeds treated with Prosper®200, Prosper®400, Helix® and Helix XTra® had the best establishment in each cultivar over 4 years. Establishment averaged 81-83%.

Seed treatments had a significant effect on emergence and establishment of open-pollinated Argentine canola in 2003-2006 (Fig. 3). Untreated seed and seeds treated with Foundation Lite® had the poorest emergence and establishment. Establishment over 4 years averaged 58% with untreated seed and 59% with Foundation Lite®. Emergence and establishment was higher with Assail® and Gaucho®. Establishment averaged 73% with Assail® and 75% with Gaucho®. Seeds treated with Prosper®200, Prosper®400, Helix® or Helix XTra® had the best emergence and establishment. Establishment averaged 81% with Prosper®200 and Helix® and 83% with Prosper®400 and Helix XTra®. Compared to untreated seed, low or high rates of Prosper® and Helix® improved emergence of the open-pollinated cultivar by 20-21% after 14 days and establishment by 23-25% after 21 days. In the hybrid cultivar, establishment averaged 64% with untreated seed, 61% with Foundation Lite® and 74% with Assail® (Fig. 4). Seeds treated with Gaucho®, Prosper®200, Prosper®400, Helix® and Helix XTra® had the best emergence and establishment. Stand establishment averaged 81-83% with the treatments. Compared to untreated seed, treatments improved emergence of the hybrid cultivar by 8-10% and establishment by 17-19%.

Shoot growth

Neonicotinoid seed treatments had no significant effect on the shoot dry weight of the two cultivars after 14 days in 2004 and 2005 when flea beetle damage averaged 5% or less (Table 8). Untreated seeds had the lowest shoot weight in 2003, when flea beetle damage averaged 80-83%. Compared to untreated seed, treatments containing a neonicotinoid insecticide improved shoot weights by 2.6-3.4 times in the open-pollinated cultivar and by 1.9-2.3 times in the hybrid cultivar. In 2006 when flea beetle damage averaged 12-16%, neonicotinoid seed treatments improved shoot weights by 1.2-1.4 times in the open-pollinated cultivar and by 1.0-1.3 times in the hybrid cultivar. Over 4 years, seeds treated with Helix XTra®, Helix® or Prosper®400 had the highest shoot weights in the open-pollinated cultivar after 14 days . Compared to untreated seed, treatments improved shoot weights by 1.3-1.5 times. Seeds treated with Helix XTra®, Assail®, Gaucho® or Helix® had the highest shoot weights in the hybrid cultivar. Treatments improved shoot weights by 1.2-1.3 times.

Neonicotinoid seed treatments had no significant effect on the shoot dry weight of the two cultivars after 21 days in 2004 and 2005 when flea beetle damage averaged 9-13% (Table 9). Untreated seed and seeds treated with Foundation Lite® had the lowest shoot weight in each cultivar in 2003 when flea beetle damage averaged 77-90% . Compared to untreated seed, neonicotinoid seed treatments improved shoot weights by 2.9-9.3 times in the open-pollinated cultivar and by 2.9-8.9 times in the hybrid cultivar. Seeds treated with Helix XTra® had the highest shoot weight. In 2006 when flea beetle damage averaged 18-19%, neonicotinoid seed treatments improved shoot weights by 1.2-1.7 times in the open-pollinated cultivar and by 1.1-1.4 times in the hybrid cultivar. Seeds treated with Helix XTra® had the highest shoot weight. Over 4 years, seeds treated with Helix XTra®, Prosper®400 or Helix® had the highest shoot weights in the open-pollinated cultivar after 21 days . Compared to untreated seed, treatments improved shoot weights by 1.4-1.7 times. Seeds treated with Helix and Helix XTra® had the highest shoot weights in the hybrid cultivar. Treatments improved shoot weights by 1.3-1.5 times.

Neonicotinoid seed treatments had a significant effect on shoot dry weights of the two cultivars after 28 days in all tests (Table 10). When damage averaged 77-90% in 2003, treatments improved shoot weights by 3.3-24.8 times in the open-pollinated cultivar and by 3.8-20.4 times in the hybrid cultivar. Seeds treated with Prosper®400, Helix® or Helix XTra® had the highest shoot weights. In 2006 when flea beetle damage averaged 18-19%, Prosper®400, Helix® and Helix XTra® improved shoot weights by 1.3-1.6 times in the open-pollinated cultivar and by 1.6-1.7 times in the hybrid cultivar. Assail®, Gaucho® and Prosper improved shoot weights of the hybrid cultivar by 1.4-1.7 times. In 2004 and 2005 when flea beetle damage averaged 9-12%, Prosper®400, Helix® and Helix XTra® improved shoot weights by 1.4-1.6 times in the open-pollinated cultivar and by 1.1-1.4 times in the hybrid cultivar. Results support the patent claim that some neonicotinoid seed treatments promote plant growth when flea beetle damage is very low. Over 4 years, Helix®, Helix XTra® and Prosper®400 improved shoot weights after 28 days by 1.4-1.7 times in the open-pollinated cultivar and by 1.6-1.8 times in the hybrid cultivar.

Seed treatments had a significant effect on the shoot dry weight of the open-pollinated cultivar in 2003-2006 (Fig. 5). Shoot dry weight of untreated seed and seeds treated with Foundation Lite® were not significantly different on most sampling dates. Compared to untreated seed, Assail®, Gaucho® and Prosper®200 improved shoot weights by 1.2-1.3 times after 28 days . Helix®, Helix XTra® and Prosper®400 had the highest shoot weights on most sampling dates. Treatments improved shoot weights by 1.4-1.8 times after 28 days . In the hybrid cultivar, untreated seed and seeds treated with Foundation Lite® had the lowest shoot weight (Fig. 6). Compared to untreated seed, Gaucho® and Prosper®200 improved shoot weights by 1.4-1.5 times after 28 days. Assail® and Prosper®400 improved shoot weights by 1.6 times. Helix® and Helix XTra® improved shoot weights by 1.7-1.8 times.

Biomass accumulation

Seed treatments had no significant effect on the shoot biomass of the two cultivars after 14 days in 2004 and 2005 when flea beetle damage averaged 5% or less (Table 11). Untreated seeds had the lowest shoot biomass in 2003 when flea beetle damage averaged 80-83%. Compared to untreated seed, neonicotinoid seed treatments improved shoot biomass by 18-38 times in the open-pollinated cultivar and by 14-20 times in the hybrid cultivar. In 2006 when flea beetle damage averaged 12-16%, neonicotinoid seed treatments improved shoot biomass by 1.4-1.7 times in the open-pollinated cultivar and by 1.1-1.4 times in the hybrid cultivar. Over 4 years, seeds treated with Helix XTra®, Helix® or Prosper®400 had the highest biomass in the open-pollinated cultivar. Treatments improved biomass by 1.7-1.8 times. Seeds treated with Helix XTra® or Gaucho® had the highest biomass in the hybrid cultivar. Compared to untreated seed, treatments improved biomass by 1.4 times.

Seed treatments had no significant effect on the shoot biomass of the two cultivars after 21 days in 2004 and 2005 when flea beetle damage averaged 9-13% (Table 12). Untreated seed and seeds treated with Foundation Lite® had the lowest biomass in 2003 when flea beetle damage averaged 77-90%. Compared to untreated seed, neonicotinoid seed treatments improved shoot biomass by 80-640 times in the open-pollinated cultivar and by 23-148 times in the hybrid cultivar. Seeds treated with Helix XTra® had the highest biomass. In 2006, when flea beetle damage averaged 18-19%, neonicotinoid seed treatments improved shoot biomass by 1.3-2.0 times in the open-pollinated cultivar and by 1.2-1.5 times in the hybrid cultivar. Seeds treated with Helix XTra® had the highest biomass. Over 4 years, seeds treated with Helix®, Prosper®400 or Helix XTra® had the highest shoot biomass in the open-pollinated cultivar after 21 days . Treatments improved biomass by 1.6-1.9 times. Seeds treated with Helix® or Helix XTra® had the highest biomass in the hybrid cultivar. Treatments improved biomass by 1.4-1.5 times.

Neonicotinoid seed treatments had a significant effect on the shoot biomass of the two cultivars after 28 days in all tests (Table 13). When flea beetle damage averaged 77-90% in 2003, treatments improved biomass by 26-450 times in the open-pollinated cultivar and by 43-410 times in the hybrid cultivar. Seeds treated with Prosper®400, Helix® or Helix XTra® had the highest biomass. In 2004 and 2005 when flea beetle damage averaged 9-12%, the treatments improved shoot biomass by 1.6-2.3 times in the open-pollinated cultivar and by 1.3-1.6 times in the hybrid cultivar. In 2006 when flea beetle damage averaged 18-19%, Prosper®400, Helix® or Helix XTra® improved shoot biomass by 1.6-1.7 times in the open-pollinated cultivar and by 1.1-1.4 times in the hybrid cultivar. The treatments had the greatest positive effect on biomass accumulation in the two cultivars when flea beetle damage was below the economic threshold. Over 4 years , the treatments improved biomass after 28 days by 1.6-2.0 times in the open-pollinated cultivar and by 1.8-1.9 times in the hybrid cultivar. Results indicated that Prosper®400, Helix® or Helix XTra® promote biomass accumulation when flea beetle damage is above or below the economic threshold.

Seed treatments had a significant effect on biomass accumulation in the open-pollinated cultivar in 2003-2006 (Fig. 7). The shoot biomass of untreated seed and seeds treated with Foundation Lite® were not significantly different on all sampling dates. Compared to untreated seed, Assail®, Gaucho® and Prosper®200 improved biomass by 1.3-1.4 times after 28 days . Helix®, Helix XTra® and Prosper®400 had the highest shoot biomass on all sampling dates. Treatments improved biomass by 1.6-1.9 times after 28 days . In the hybrid cultivar, untreated seed and seeds treated with Foundation Lite® had the lowest biomass (Fig. 8). Compared to untreated seed, shoot biomass after 28 days improved 1.5-1.6 times with Gaucho® or Prosper® 200, by 1.7-1.8 times with Assail® or Prosper®400 and by 1.8-1.9 times with Helix® or Helix XTra®.

Seed yield

Untreated seed and seeds treated with Foundation Lite® had the lowest yields in the open-pollinated cultivar in 2003-2006 (Table 14, Fig. 9). All neonicotinoid seed treatments had a significant effect on yield in 2003 when flea beetle damage averaged 77%. Compared to untreated seed, yields in 2003 increased by 6.5 times with Gaucho®, by 21 times with Assail®, by 18-26 times with low or high rates of Prosper®, by 25 times with Helix® and by 37 times with Helix XTra®. Low or high rates of Prosper® and Helix® improved yield by 19-30% in 2004 when flea beetle damage averaged 10% and by 5-10% in 2005 when damage averaged 13%. Neonicotinoid seed treatments had no significant effect on yield in 2006 when damage averaged 18%. Yields in the open-pollinated cultivar over 4 years increased by 6-12% with Gaucho® or Assail®, by 19-22% with low or high rates of Prosper® and by 25-27% with Helix or Helix XTra®.

Untreated seed and seeds treated with Foundation Lite® had the lowest yield in the hybrid cultivar (Table 14, Fig. 10). All neonicotinoid seed treatments improved yield in 2003 when flea beetle damage averaged 90%. Compared to untreated seed, yields improved by 28 times with Gaucho®, by 38-41 times with Assail®, Prosper®200 or Prosper®400 and by 46-54 times with Helix® and Helix XTra®. Seeds treated with Helix XTra® had the highest yield in 2003. Neonicotinoid seed treatments had no significant effect on yield of the hybrid cultivar in 2004 and 2005 when flea beetle damage averaged 9-12%. In 2006 when damage averaged 19%, Prosper®400, Helix® and Helix XTra® improved yields by 11-13%. Compared to untreated seed, yields over 4 years increased by 12% with Gaucho®, by 17-19% with Assail® and low or high rates of Prosper® and by 24-27% with Helix® or Helix XTra®. Seeds treated with Helix XTra® had the highest yield.

Neonicotinoid seed treatments had a significant effect on yield and economic returns of the open-pollinated cultivar (Table 15). Yields over 4 years averaged 32.1 bu/acre with untreated seed and 31.3 bu/acre with Foundation Lite®. Yields averaged 34.1 bu/acre with Gaucho® and 36.1 bu/acre with Assail®. Compared to untreated seed, treatments improved economic returns by $14.00/acre and $28.00/acre, respectively. Yields averaged 38.3 bu/acre with the low rate of Prosper® and 39.3 bu/acre with the high rate of Prosper®. Treatments improved returns by $43.40/acre and $50.40/acre, respectively. Yields averaged 40.0 bu/acre with Helix® and 40.8 bu/acre with Helix XTra®. Returns increased by $55.30/acre with Helix® and by $60.90/acre with Helix XTra®. The latter treatment improved yields significantly in 2003, 2004 and 2005 but not in 2006.

Neonicotinoid seed treatments had a significant effect on yield and economic returns of the hybrid cultivar (Table 16). Yields averaged 35.5 bu/acre with untreated seed and 34.4 bu/acre with Foundation Lite®. Yields averaged 39.9 bu/acre with Gaucho® and 41.4 bu/acre with Assail®. Treatments improved returns by $30.80/acre and $41.30/acre, respectively. Yields averaged 42.2 bu/acre with Prosper®200 and 43.0 bu/acre with Prosper®400. The low and high rate of Prosper® increased returns by $46.90/acre and $52.50/acre, respectively. Yields averaged 43.8 bu/acre with Helix® and 45.0 bu/acre with Helix XTra®. Helix® increased returns by $58.10/acre whereas Helix XTra® increased returns by $66.50/acre.

B. Tests seeded May 25-28

Yearly comparisons

Flea beetle damage, seedlings row, shoot dry weight, shoot biomass and seed yield of the two Argentine cultivars varied significantly from year to year (Tables 17 and 18). Flea beetle damage after 21 days was higher in 2003 and 2004 (18-20% damage) than in 2005 (8% damage) and 2006 (10% damage). Seedling counts after 14 and 21 days were lower in 2003 than in 2004, 2005 and 2006. Stand establishment after 21 days averaged 83% in 2003 and 86-88% in 2004-2006. Shoot dry weights and shoot biomass after 14, 21 and 28 days were lowest in 2004 and highest in 2005 and 2006. Seed yields ranged from 124 g/m^2 (22.2 bu/acre) in 2003 to 308.2 g/m^2 (54.9 bu/acre) in 2005.

Cultivar comparisons

Flea beetle damage was not significantly different in the open-pollinated and hybrid cultivars after 17-21 days (Table 17). Stand establishment averaged 86% in each cultivar after 21 days. Shoot dry weights and shoot biomass after 14, 21 and 28 days were 1.4-1.8 times higher in the hybrid cultivar than in the open-pollinated cultivar (Table 18). The year by cultivar interaction on seedlings/row, shoot dry weight, shoot biomass and seed yield was significant on each sampling date and indicated that differences in the performance of the two cultivars varied yearly. Seed yields averaged 208.7 g/m^2 (37.1 bu/acre) in the open-pollinated cultivar compared to 245.0 g/m^2 (43.6 bu/acre) in the hybrid cultivar.

Seed treatment comparisons

Seed treatments had a significant effect on flea beetle damage and performance of Argentine canola in late May plantings (Tables 17 and 18). The year by treatment interaction on damage, seedling counts, shoot growth and seed yield was significant on all sampling dates and indicated that treatment effects on damage and performance varied yearly. In contrast, the cultivar by treatment interaction on damage and performance was not significant and indicated that treatment effects were similar in the two cultivars. The year by cultivar by treatment interaction on all variables was also not significant indicating that treatment effects on the performance of each cultivar were consistent from year to year.

Flea beetle damage

Seed treatments had a significant effect on flea beetle damage 14 days after seeding in 2003, 2004 and 2006 (Table 19). In each cultivar, damage was highest in seedlings grown from untreated seed and seeds treated with Foundation Lite®. Damage to seedlings from untreated seed was higher in 2003 (18-21% damage) and 2004 (33-36% damage) than in 2005 (1-2% damage) or 2006 (11-12% damage). In most tests, flea beetle damage was lowest with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®. Treatments reduced damage in the open-pollinated cultivar to 3-4% in 2004, 4-6% in 2004, 1% in 2005 and 4-8% in 2006. Treatments reduced damage in the hybrid cultivar to 2-5% in 2003, 6-8% in 2004, 1-3% in 2005 and 5-7% in 2006. Over 4 years, treatments reduced damage in each cultivar to 4-6%.

Seed treatments had a significant effect on flea beetle damage 17-18 days after seeding in all tests (Table 20). Damage was highest with untreated seed and seeds treated with Foundation Lite®. Damage to seedlings from untreated seed was higher in 2003 (30-36% damage) and 2004 (37-42% damage) than in 2005 (5% damage) or 2006 (11-12% damage). In most tests, damage was lowest with Prosper®200, Prosper®400, Helix® or Helix XTra®. Treatments reduced damage in the open-pollinated cultivar to 2-4% in 2003, 7-10% in 2004, 2% in 2005 and 5-7% in 2006. Treatments reduced damage in the hybrid cultivar to 2-5% in 2003, 7-9% in 2004, 1-3% in 2005 and 7-8% in 2006. Over 4 years, high rates of Prosper® or Helix provided better protection that low rates in the hybrid cultivar but not in the open-pollinated cultivar. Treatments reduced damage in each cultivar to 4-6%.

Seed treatments had a significant effect on flea beetle damage 21 days after seeding in all tests (Table 21). Damage to seedlings grown from untreated seed of each cultivar averaged 38-39% in 2003, 43-49% in 2004, 10-11% in 2005 and 13-14% in 2006. In most tests, damage was lowest with Prosper®400, Helix® or Helix XTra®. Treatments reduced damage in the open-pollinated cultivar to 4-8% in 2003, 6-9% in 2004, 5-8% in 2005 and 8-9% in 2006. Treatments reduced damage in the hybrid cultivar to 6-10% in 2003, 7-8% in 2004, 5-8% in 2005 and 9% in 2006. Prosper®400 and Helix XTra® provided the best protection over 4 years. Treatments reduced damage in each cultivar to 8% or less.

Seed treatments had a pronounced effect on flea beetle damage in each cultivar after 14-21 days in 2003-2006 (Figs. 11 and 12). On each sampling date, Helix XTra®, Prosper®400, followed by Helix® and Prosper®200, provided the best protection against flea beetle damage in the open-pollinated cultivar. Helix XTra® and Prosper®400 provided the best protection in the hybrid cultivar.

Emergence and establishment

Seedlings/row after 14 days varied significantly depending on the year and seed treatment (Table 22). Emergence of untreated seed of the open-pollinated cultivar averaged 72% in 2003, 81% in 2004, 86% in 2005 and 77% in 2006. Emergence of untreated seed of the hybrid cultivar averaged 76% in 2003, 79% in 2004, 80% in 2005 and 82% in 2006. Emergence of untreated seed and seeds treated with Foundation Lite® was not significantly different in each test. Compared to untreated seed, Assail® improved emergence of the open-pollinated and hybrid cultivar by 9-10% in 2003. Assail® had no positive effect on emergence of either cultivar in 2003, 2005 and 2006. Seeds treated with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest emergence in each cultivar. Compared to untreated seed, treatments improved emergence by 9-14% in 2003, by 6-9% in 2004, by 0-10% in 2005 and by 3-10% in 2006. Improvements in emergence were greater in 2003 and 2004 when flea beetle damage in check plots averaged 18-36% than in 2005 and 2006 when flea beetle damage averaged 12% or less. In 2005 when flea beetle damage averaged 1-2%, treatments had little or no effect on emergence. Seeds treated with Prosper®200 had the highest emergence in the open-pollinated cultivar whereas seeds treated with Helix® or Helix XTra® had the highest emergence in the hybrid cultivar. In 2006 when damage averaged 11-12% in check plots, seeds treated with Helix XTra® or Gaucho® had the highest emergence in the open-pollinated cultivar. Seeds treated with Gaucho®, Prosper®200, Prosper®400 or Helix XTra® had the highest emergence in the hybrid cultivar. Compared to untreated seed, treatments improved emergence by 8-10%. Results suggest that some neonicotinoid seed treatments promote faster emergence when flea beetle damage is below the economic threshold. Emergence of the open-pollinated cultivar in 2003-2006 averaged 82% with Assail® and 86-88% with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®. Emergence of the hybrid cultivar over 4 years averaged 84% with Assail® and 86-88% with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®.

Numbers of seedlings/row after 21 days varied depending on the year and seed treatment (Table 23). Establishment of untreated seed of the open-pollinated cultivar averaged 65% in 2003, 83% in 2004, 87% in 2005 and 80% in 2006. Establishment of the hybrid cultivar averaged 71% in 2003, 83% in 2004, 84% in 2005 and 82% in 2006. Foundation Lite® had no effect on establishment of either cultivar in most tests. Compared to untreated seed, Assail® improved establishment of the two cultivars by 15-18% in 2003 and establishment of the open-pollinated cultivar by 17% in 2004. Assail® had no effect on establishment in the remaining tests. Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra® had a significant effect on establishment in most tests. Compared to untreated seed, treatments improved establishment of the open-pollinated and hybrid cultivars by 17-23% in 2003, by 5-9% in 2004, by 1-6% in 2005 and by 3-10% in 2006. In 2005 when flea beetle damage averaged 10-11%, seeds treated with Prosper®200 or Prosper®400 had the best establishment in the open-pollinated cultivar whereas seeds treated with Helix® had the best establishment in the hybrid cultivar. In 2006 when flea beetle damage averaged 13-14%, seeds treated with

Helix XTra®, Gaucho® or Prosper®200 had the best establishment in the open-pollinated cultivar. Seeds treated with Gaucho®, Prosper®200, Prosper®400 or Helix XTra® had the best establishment in the hybrid cultivar. Establishment of the two cultivars over 4 years averaged 84-85% with Assail® and 87-89% with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®.

Seed treatments had a significant effect on emergence and establishment of the open-pollinated Argentine cultivar in 2003-2006 (Fig. 13). Untreated seed and seeds treated with Foundation Lite® had the poorest emergence and establishment. Establishment over 4 years averaged 79% with untreated seed and 80% with Foundation Lite®. Establishment improved to 84% with Assail® and 87-89% with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®. Compared to untreated seed, the latter treatments improved emergence by 7-9% after 14 days and establishment by 8-10% after 21 days. Establishment of the hybrid cultivar over 4 years averaged 80% with untreated seed and seeds treated with Foundation Lite® (Fig. 14). Establishment averaged 84% in seeds treated with Assail® and 86-88% in seeds treated with Gaucho®, Prosper®200, Prosper®400, Helix® or Helix XTra®. Compared to untreated seed, the latter treatments improved emergence and establishment of the hybrid cultivar by 7-9%.

Shoot growth

Seed treatments had no significant effect on the shoot dry weight of the two cultivars after 14 days in 2003, 2005 and 2006 when flea beetle damage averaged 18% or less (Table 24). In 2004 when flea beetle damage exceeded 30%, seeds treated with Prosper®400, Helix® or Helix XTra® had the highest shoot weight in the open-pollinated cultivar. Compared to untreated seed, treatments improved shoot weights by 1.3-1.4 times. Seeds treated with Assail®, Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest shoot weight in the hybrid cultivar in 2004. Treatments improved shoot weights by 1.5-1.8 times. Results do not support the claim that neonicotinoid insecticides promote shoot growth after 14 days when flea beetle damage is below the economic threshold.

Shoot dry weights of the two cultivars after 21 days varied depending on the year and seed treatment (Table 25). Seed treatments had no effect on shoot dry weight of each cultivar in 2005 when flea beetle damage averaged 10-11%. Treatments had a significant effect on shoot dry weights in 2003, 2004 and 2006 when damage averaged 38-39%, 43-49% and 13-14%, respectively. In 2003, Helix® and Helix XTra® improved shoot dry weight by 1.3-1.7 times in the open-pollinated cultivar and by 1.7-2.5 times in the hybrid cultivar. In 2004, Assail®, Prosper®200, Prosper®400, Helix® and Helix XTra® improved shoot weights by 2.0-2.7 times in the open-pollinated cultivars and by 1.8-2.2 times in the hybrid cultivar. In 2006, Gaucho®, Prosper®200, Prosper®400, Helix® and Helix XTra® improved shoot weights by 1.3-1.5 times in the open-pollinated cultivar and by 1.3-1.6 times in the hybrid cultivar. Seeds treated with Helix® or Helix XTra® had the highest shoot weights over 4 years. Treatments improved shoot weights by 1.4-1.6 times in each cultivar. Improvements in shoot growth after 21 days occurred when flea beetle damage exceeded the economic threshold but not when damage was below the economic threshold.

Seed treatments had a significant effect on the shoot dry weight of the two cultivars after 28 days in all tests (Table 26). Seeds treated with Helix® or Helix XTra® had the highest shoot weights in 2003 when flea beetle damage averaged 38-39%. Compared to untreated seed, treatments improved shoot weights by 2.4-3.9 times in the open-pollinated cultivar and by 2.7-2.8 times in the hybrid cultivar. Seeds treated with Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest shoot weight in 2004, when flea beetle damage averaged 43-49%. Compared to untreated seed, treatments improved shoot weights by 3.1-4.2 times in the open-pollinated cultivar and by 3.2-3.8 times in the hybrid cultivar. Seeds treated with low or high rates of Prosper® and Helix® had the highest shoot weight in 2005 and 2006 when flea beetle damage averaged 10-14%. Treatments improved shoot weights by 1.1-1.4 times in the open-pollinated cultivar and by 1.0-1.3 times in the hybrid cultivar. Low or high rates of Prosper® and Helix® improved shoot weights over 4 years by 1.4-1.5 times in the open-pollinated cultivar and by 1.1-1.3 times in the hybrid cultivar. Results support claims that low or high rates of Prosper® and Helix® promote shoot growth of open-pollinated and hybrid canola after 28 days when flea beetle damage is above or below the economic threshold.

Seed treatments had a significant effect on the shoot dry weight of the open-pollinated cultivar in 2003-2006 (Fig. 15). Untreated seed and seeds treated with Foundation Lite® had the lowest shoot weight on most sampling dates. Compared to untreated seed, Assail® and Gaucho® improved shoot weights after 28 days by 1.1 and 1.3 times, respectively. Prosper®200 and Prosper®400 improved shoot weights by 1.4 times. Helix® and Helix XTra® improved shoot weights by 1.4 and 1.5 times, respectively. Untreated seed and seeds treated with Foundation Lite® also had the lowest shoot weights in the hybrid cultivar (Fig. 16). Compared to untreated seed, Assail®, Gaucho® Prosper®200 and Prosper®400 improved shoot weights by 1.1-1.2 times. Helix® and Helix XTra® improved shoot weights by 1.2 and 1.3 times, respectively.

Biomass accumulation

Seed treatments had little or no effect on the shoot biomass of the two cultivars after 14 days in 2003, 2005 and 2006 when flea beetle damage averaged 18% or less (Table 27). In 2004 when damage averaged 33-36%, seeds treated with Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest biomass in the open-pollinated cultivar. Compared to untreated seed, treatments improved shoot biomass by 1.5-1.8 times. Seeds treated with Assail® or Prosper®200 had the highest shoot biomass in the hybrid cultivar in 2004. Treatments improved shoot biomass by 2.3-2.6 times. Prosper®400, Helix® and Helix XTra® improved biomass of the two cultivars by 1.2-1.3 times over 4 years. Treatments enhanced biomass when flea beetle damage was above the economic threshold but not when damage was below the economic threshold.

Seed treatments had a significant effect on the shoot biomass of the two culitvars after 21 days in all tests (Table 28). In 2003 when flea beetle damage averaged 38-39%, seeds treated with Helix XTra® had the highest shoot biomass. Compared to untreated seed, Helix XTra® improved biomass by 2.5 times in the open-pollinated cultivar and by 3.4 times in the hybrid cultivar. In 2004 when damage averaged 43-49%, Assail®, Gaucho® and low or high rates of Prosper® and Helix® had the highest biomass. Treatments improved biomass by 2.5-3.4 times in the open-pollinated cultivar and by 2.4-2.7 times in the hybrid cultivar. In 2005 and 2006 when flea beetle damage averaged 10-14%, seeds treated with Prosper®200, Prosper®400, Helix® or Helix XTra® had the highest biomass in most tests. Treatments improved biomass after 21 days by 1.2-1.5 times in the open-pollinated cultivar and by 1.1-1.7 times in the hybrid cultivar. Seeds treated with Prosper®400, Helix® or Helix XTra® had the highest biomass over 4 years. Treatments improved biomass in each cultivar by 1.4-1.8 times. Treatments promoted higher biomass when flea beetle damage was above or below the economic threshold.

Seed treatments had a significant effect on the shoot biomass of the two cultivars after 28 days in all tests (Table 29). When flea beetle damage averaged 38-39% in 2003, seeds treated with Prosper®400, Helix® or Helix XTra® had the highest biomass. Compared to untreated seed, treatments improved biomass by 3.1-5.4 times in the open-pollinated cultivar and by 2.4-3.2 times in the hybrid cultivar. Seeds treated with Gaucho® and low or high rates of Prosper® and Helix® had the highest shoot biomass in 2004 when damage averaged 43-49%. Treatments improved biomass by 3.5-5.1 times in the open-pollinated cultivar and by 3.2-4.4 times in the hybrid cultivar. Seeds treated with low or high rates of Prosper® and Helix® had the highest shoot biomass in 2005 and 2006 when flea beetle damage averaged 10-14%. Treatments improved biomass by 1.2-1.5 times in the open-pollinated cultivar and by 1.1-1.4 times in the hybrid cultivar. Results substantiate the claim that low or high rates of Prosper® and Helix® promote biomass accumulation in Argentine canola when flea beetle damage is above or below the economic threshold.

Seed treatments had a significant effect on the shoot biomass of the open-pollinated cultivar in 2003-2006 (Fig. 17). Untreated seed and seeds treated with Foundation Lite® or Assail® had the lowest shoot biomass on most sampling dates. Compared to untreated seed, Gaucho® improved biomass after 28 days by 1.3 times. Prosper®200, Prosper®400 and Helix® improved biomass by 1.4-1.5 times whereas Helix XTra® improved biomass by 1.6 times. Untreated seed and seeds treated with Foundation Lite® had the lowest biomass in the hybrid cultivar (Fig. 18). Compared to untreated seed, Assail®, Gaucho®, Prosper®200 and Prosper®400 improved biomass by 1.1-1.2 times. Helix® and Helix XTra® improved biomass by 1.3 and 1.4 times, respectively.

Seed yield

Untreated seed and seeds treated with Foundation Lite® had the lowest yield in the open-pollinated cultivar in each test (Table 30, Fig. 19). All treatments containing a neonicotinoid insecticide had a significant effect on yield in 2003 and 2004 when flea beetle damage averaged 38-49%. Compared to untreated seed, yields in 2003 and 2004 increased by 34-36% with Assail®, by 23-59% with Gaucho® by 26-52% with low or high rates of Prosper® and by 41-69% with Helix® or Helix XTra®. Assail® had no significant effect on yield of the open-pollinated cultivar in 2005 and 2006 when flea beetle damage averaged 10-14%. Other neonicotinoid seed treatments improved yield significantly. Compared to untreated seed, yields in 2005 and 2006 increased by 8-11% with Gaucho®, by 6-12% with low or high rates of Prosper® and by 5-14% with Helix® or Helix XTra®. Yields in the open-pollinated cultivar over 4 years increased by 12% with Assail®, by 18-22% with low or high rates of Prosper® and by 22-24% with Gaucho®, Helix® or Helix XTra®. With the exception of Assail®, all neonicotinoid seed treatments promoted higher yields in the open-pollinated cultivar when flea beetle damage was above or below the economic threshold.

Untreated seed and seeds treated with Foundation Lite® had the lowest yield in the hybrid cultivar in 2003-2006 (Table 30, Fig. 20). With the exception of Gaucho®, all neonicotinoid seed treatments had a significant effect on yield in 2003 and 2004 when damage averaged 39-43%. Compared to untreated seed, yields increased by 15-20% with Assail®, by 11-23% with low or high rates of Prosper®, and by 17-30% with Helix® or Helix XTra®. With the exception of Helix®, neonicotinoid seed treatments had no significant effect on yield of the hybrid cultivar in 2005 and 2006 when flea beetle damage averaged 11-13%. Helix® increased yield by 7% in 2005. Compared to untreated seed, yields in the hybrid cultivar over 4 years increased by 6-9% with Gaucho®, Assail® and low or high rates of Prosper®. Yields increased by 12-13% with Helix® or Helix XTra®. Most neonicotinoid seed treatment improved yield in the hybrid cultivar when damage averaged 39-43%. However treatments had no significant effect on yield when damage averaged 11-13%.

Neonicotinoid seed treatments had a significant effect on yield and economic returns of the open-pollinated cultivar (Table 31). Yields over 4 years averaged 32.0 bu/acre with untreated seed and 33.8 bu/acre with Foundation Lite®. Yields averaged 36.1 bu/acre with Assail® and 39.5 bu/acre with Gaucho®. Compared to untreated seed, treatments improved economic returns by $28.70/acre and $52.50/acre, respectively. Yields with the low and high rate of Prosper® averaged 37.8 bu/acre and 39.1 bu/acre, respectively. Returns increased by $40.60/acre with Prosper®200 and $49.70/acre with Prosper®400. Yields with Helix® and Helix XTra® averaged 39.2 bu/acre and 39.7 bu/acre, respectively. Economic returns increased by $50.40/acre with Helix® and $53.90/acre with Helix XTra®. Gaucho® and Prosper®400 were the only treatments that improved yield significantly in each test.

Neonicotinoid seed treatments had a significant effect on yield and economic returns of the hybrid cultivar over 4 years (Table 32). Yields averaged $40.70 bu/acre with untreated seed and 40.8 bu/acre with Foundation Lite®. Yields averaged 43-44 bu/acre with Assail®, Gaucho® and low or high rates of Prosper®. Compared to untreated seed, treatments improved returns by $16.10-$25.20/acre. Yields averaged 45.7 bu/acre with Helix® and 46.1 bu/acre with Helix XTra®. Returns increased by $35.00/acre with Helix®

and by \$37.80/acre with Helix XTra®. With the exception of Helix®, neonicotinoid seed treatments had no significant effect on yield of the hybrid cultivar when flea beetle damage averaged 11-13% in 2005 and 2006.

Flea beetle emergence

Flea beetles emerged between early August and mid October (Fig. 21). The highest emergence occurred September 15 in 2004, September 21 in 2005 and August 15 in 2006. In each year of testing, emergence was significantly higher in plots seeded in late May than in plots seeded in early May. Emergence in early and late May plantings averaged 18.2 and 25.7 beetles/plant in 2004, 1.5 and 16.2 beetles/plant in 2005 and 6.4 and 21.8 beetles/plant in 2006. Data indicated that seeding in early May rather than in late May reduced emergence of the fall generation of flea beetles by 29% in 2004, 91% in 2005 and 70% in 2006. Factors contributing to this reduction are currently under investigation.

Compared to untreated seed, neonicotinoid seed treatments had no significant effect on flea beetle emergence in early May plantings in 2004, 2005 and 2006 and in late May plantings in 2004 and 2006 (Fig. 22). In the late May planting in 2005, emergence ranged from 22 beetles/plant in the check and Assail® treatments to 11 beetles/plant in the Helix® treatment.

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Table 1. Overall flea beetle damage and seedlings/row of open-pollinated and hybrid Argentine canola seeded in early May in 2003-2006.

Variable	Damage (% area)			Seedlings/row	
	14 DAS	17-18 DAS	21 DAS	14 DAS	21 DAS
year					
2003	28a	43a	59a	127.9a	104.5a
2004	2c	7b	6c	144.1b	152.9b
2005	2c	2c	5c	163.0c	173.2c
2006	5b	10b	12b	155.7c	169.3c
SE	1	2	2	3.8	3.4
cultivar					
op	9b	15a	20a	146.1a	148.0a
hybrid	10a	16a	21a	149.3b	152.0a
SE	1	1	1	1.5	1.9
F value					
Year (Y)	263.2***	162.0***	315.0***	33.1***	177.1***
Cultivar (C)	10.6**	2.6	2.3	4.8*	4.4
Y x C	0.7	1.1	1.6	16.1***	3.5*
Treatment (T)	330.4***	205.3***	100.7***	23.2***	60.8***
Y x T	143.8***	116.3***	27.9***	7.5***	21.0***
C x T	0.5	1.1	1.4	2.7*	2.0
Y x C x T	1.2	1.4	2.4**	2.0**	1.6*

a-b For each variable, means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, ANOVA, $P \geq 0.05$). Damage data were transformed (arcsine square root) before analysis. DAS, days after seeding. *, **, *** F value significant at P = 0.05, 0.01 and 0.001, respectively.

Table 2. Overall shoot dry weight, shoot biomass and seed yield of open-pollinated and hybrid Argentine canola seeded in early May in 2003-2006.

Variable	Shoot dry weight (mg/plant)			Shoot biomass (g/m-row)			Seed yield (g/m^2)
	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	
year							
2003	6.2b	18.8b	53.0a	1.1a	2.8a	11.2a	72.0a
2004	4.8a	12.4a	61.9a	0.9a	3.3a	16.1a	243.8b
2005	6.3b	27.8c	96.7b	1.7b	9.3b	33.6b	319.9c
2006	23.0c	92.5d	576.5c	7.6c	28.0c	172.6c	230.9b
SE	0.5	1.9	13.4	0.2	0.5	6.6	7.3
cultivar							
op	8.0a	30.4a	149.5a	2.2a	8.4a	43.3a	205.0a
hybrid	12.1b	45.4b	244.5b	3.4b	13.3b	73.4b	228.3b
SE	0.4	2.1	6.6	0.2	0.7	3.1	3.7
F value							
Year (Y)	669.3***	730.6***	716.3***	495.2***	1051.6***	267.5***	412.1***
Cultivar (C)	123.9***	52.7***	209.8***	50.3***	44.3***	92.3***	40.4***
Y x C	24.9***	14.7***	77.7***	16.7***	14.9***	35.9***	15.9***
Treatment (T)	14.6***	12.5***	10.6***	16.7***	16.5***	13.8***	57.3***
Y x T	6.6***	5.4***	3.4***	6.0***	5.8***	4.8***	12.9***
C x T	2.4*	0.4	1.5	2.4*	0.8	1.6	0.9
Y x C x T	3.1***	0.4	0.9	3.0***	0.7	1.1	2.4***

a-b For each variable, means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, ANOVA, $P \geq 0.05$). DAS, days after seeding. *, **, *** F value significant at P = 0.05, 0.01 and 0.001, respectively.

Table 3. Effect of seed treatments on flea beetle damage to cotyledons of open-pollinated and hybrid Argentine canola 14 days after seeding in early May in 2003-2006. [1]

		Damage - op (%)					Damage - hybrid (%)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	80a	1ab	5a	12a	25a	83a	3ab	5a	16a	26a
Foundation Lite®	-	86a	2a	3ab	13a	26a	82a	3a	4a	13a	26a
Assail 50 SF®	400	14bc	2ab	3bc	3b	5b	20b	2a-c	2b	4b	7b
Gaucho CS FL®	400	15b	1ab	1c	2b	5bc	13c	2a-c	2b	3b	5c
Prosper®	200	13b-d	1b	1c	3b	4bc	9de	2a-c	2b	3b	4c
Prosper®	400	6de	1b	1c	2b	3c	6ef	1c	2b	3b	3d
Helix®	200	8c-e	1b	2bc	3b	3c	10cd	2bc	2b	3b	4cd
Helix XTra®	400	6e	1b	1bc	2b	3c	6f	1c	2b	3b	3d
	SE	4	1	1	1	1	2	1	1	2	1

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

Table 4. Effect of seed treatments on flea beetle damage to cotyledons of open-pollinated and hybrid Argentine canola 17-18 days after seeding in early May in 2003-2006. [1]

		Damage - op (%)					Damage - hybrid (%)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	93a	8a	7a	14a	30a	93a	8a	4a	14a	30a
Foundation Lite®	-	98a	7ab	2b	14a	30a	95a	9a	5a	13a	31a
Assail 50 SF®	400	24c	6bc	1bc	9b	10c	39c	7ab	2bc	9b	14b
Gaucho CS FL®	400	57b	6ab	1c	8b	18b	57b	5b	1bc	8b	18b
Prosper®	200	21c	5c	1c	9b	9cd	24d	7ab	1bc	8b	10c
Prosper®	400	14cd	7ab	1bc	8b	7cd	22d	6ab	1c	8b	9c
Helix®	200	17cd	6bc	1bc	9b	8cd	20d	7ab	1bc	8b	9c
Helix XTra®	400	10d	6a-c	1c	8b	6d	12e	7ab	2b	8b	7c
	SE	6	1	1	1	2	5	1	1	1	1

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

Table 5. Effect of seed treatments on flea beetle damage to cotyledons of open-pollinated and hybrid Argentine canola 21 days after seeding in early May in 2003-2006. [1]

		Damage - op (%)					Damage - hybrid (%)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	77b	10a	13a	18a	30b	90a	12a	9a	19a	32a
Foundation Lite®	-	97a	11a	10b	17a	34a	90a	13a	11a	15b	32a
Assail 50 SF®	400	30d	4b	8b	10b	13de	39c	7b	5b	10c	15cd
Gaucho CS FL®	400	79b	4b	4c	10b	24c	72b	4b	4bc	10c	23b
Prosper®	200	61c	3b	2cd	10b	19d	63b	5b	4bc	10c	20bc
Prosper®	400	42d	4b	3cd	9b	14de	63b	4b	2d	10c	19cd
Helix®	200	44cd	3b	2cd	10b	15de	45c	4b	3cd	10c	15d
Helix XTra®	400	30d	4b	2d	10b	11e	26d	4b	3b-d	9c	11e
	SE	7	1	1	1	2	5	2	1	2	2

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

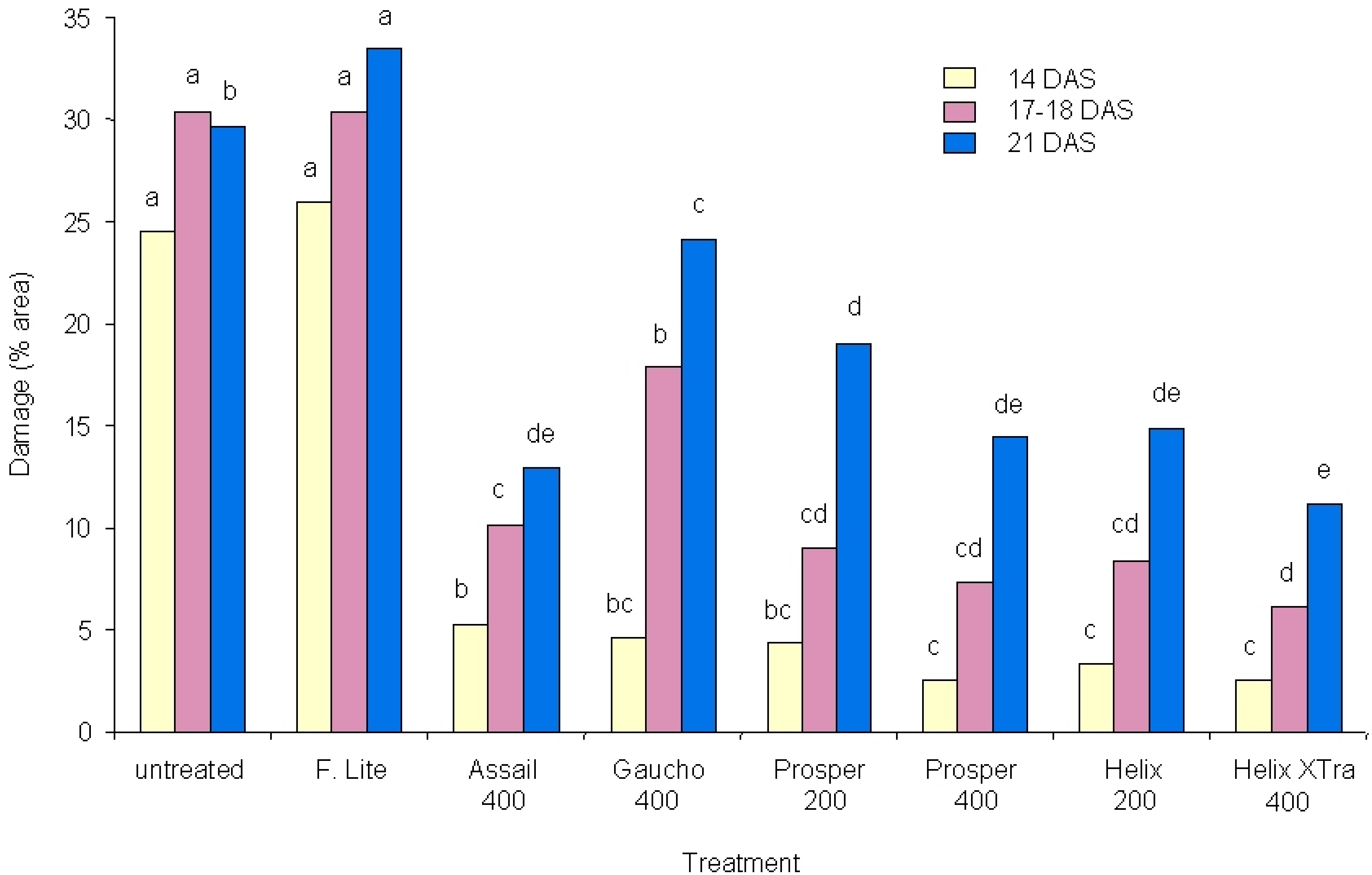

Figure 1. Flea beetle damage to cotyledons of untreated and treated open-pollinated Argentine canola 14, 17-18 and 21 days after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P > 0.05).

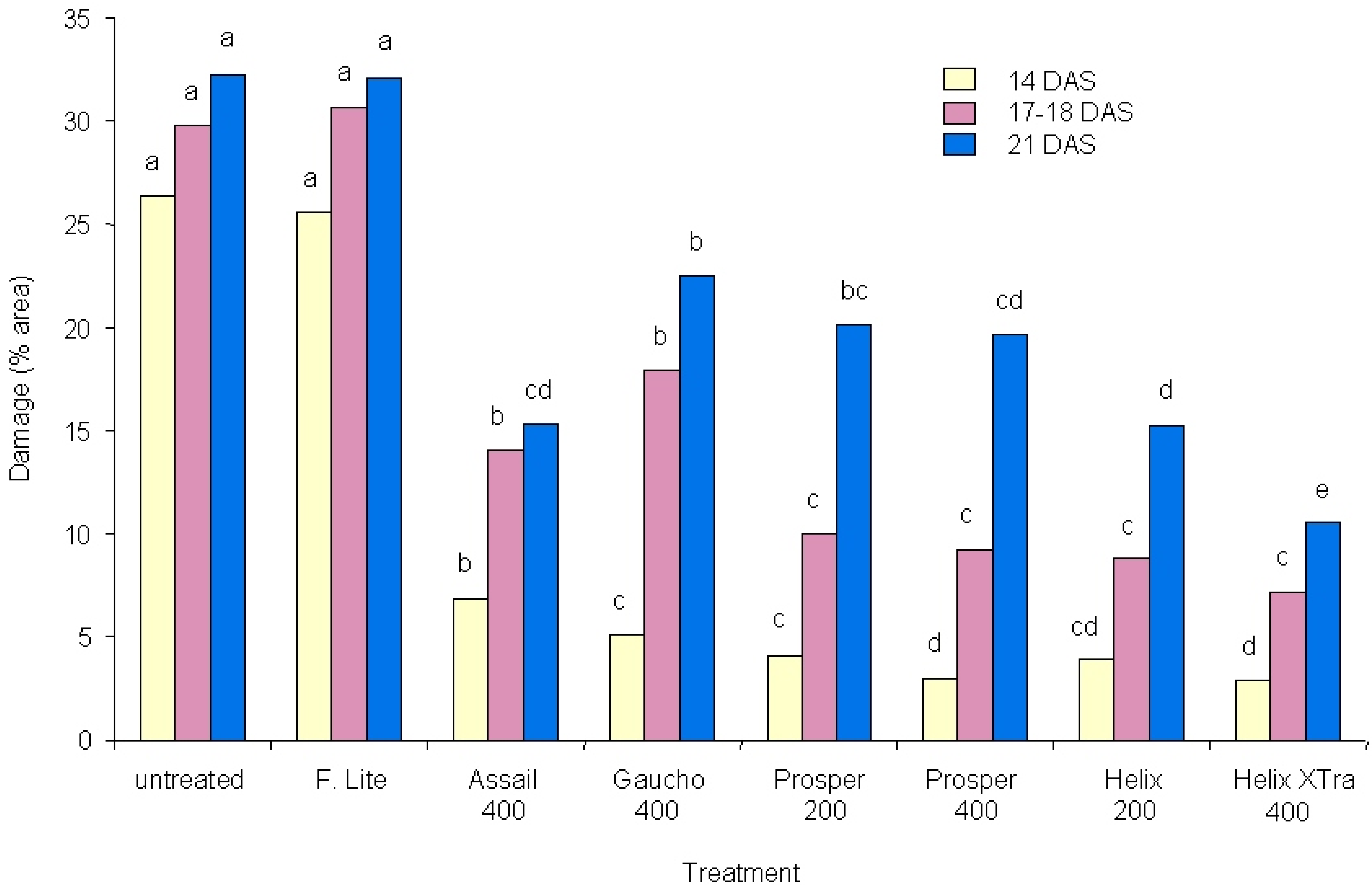

Fig. 2. Flea beetle damage to cotyledons of untreated and treated hybrid Argentine canola 14, 17-18 and 21 days after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P $\geq$ 0.05).

Table 6. Effect of seed treatments on numbers of seedlings/row of open-pollinated and hybrid Argentine canola 14 days after seeding in early May in 2003-2006. [1]

Treatment	Rate	Seedlings/row - op					Seedlings/row - hybrid				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	33.8a	127.5a	163.0ab	143.8ab	117.0a	100.5a	139.3ab	154.0ab	155.8a	137.4ab
Foundation Lite®	-	66.0b	136.3ab	159.0ab	139.8a	125.3a	97.5a	131.0a	150.3a	152.8a	132.9a
Assail 50 SF®	400	130.5c	146.0ab	148.0a	148.3a-c	143.2b	134.5b	130.8a	158.0ab	152.0a	143.8b
Gaucho CS FL®	400	128.0c	130.5a	172.0b	164.0c	148.6bc	151.3c	161.0b	159.3ab	163.8a	158.8c
Prosper®	200	144.0c	163.8b	174.5b	148.0a-c	157.6c	150.5c	151.5ab	161.3ab	160.5a	155.9c
Prosper®	400	148.5c	147.3ab	173.5b	167.5c	159.2c	163.5c	151.8ab	161.0ab	155.8a	158.0c
Helix®	200	136.0c	163.3b	172.3b	165.8c	159.3c	156.5c	130.8a	167.0ab	160.5a	153.7c
Helix XTra®	400	154.8c	150.0ab	167.3b	161.3bc	158.3c	150.8c	145.5ab	167.8b	152.3a	154.1c
	SE	14.1	14.8	7.8	9.7	6.0	7.3	13.1	8.1	7.6	4.7

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

Table 7. Effect of seed treatments on numbers of seedlings/row of open-pollinated and hybrid Argentine canola 21 days after seeding in early May in 2003-2006. [1]

		Seedlings/row - op					Seedlings/row - hybrid				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	15.8a	127.3a	168.0a	152.8ab	115.9a	36.8a	147.0a	164.5a	167.0ab	128.8a
Foundation Lite®	-	20.3a	135.3ab	166.3a	150.5a	118.1a	29.5a	137.0a	163.5a	160.8a	122.7a
Assail 50 SF®	400	104.5bc	155.5bc	165.3a	162.0a-c	146.8b	109.0b	142.0a	170.0a	171.3bc	148.1b
Gaucho CS FL®	400	97.0b	145.0a-c	179.5b	175.3cd	149.2b	130.3bc	176.3b	173.5a	176.8c	164.2c
Prosper®	200	128.8de	170.8c	179.3b	166.3bc	161.3c	144.8cd	160.8ab	175.3a	179.0c	164.9c
Prosper®	400	140.0de	159.5bc	179.8b	181.5d	165.2c	138.8cd	161.3ab	173.3a	173.3bc	161.6c
Helix®	200	126.5cd	171.0c	179.3b	171.0cd	161.9c	153.0d	140.0a	177.3a	178.3c	162.1c
Helix XTra®	400	150.3e	160.5bc	179.8b	170.8cd	165.3c	146.5cd	156.8ab	177.3a	173.3bc	163.4c
	SE	11.1	13.1	4.8	6.5	4.7	10.6	13.7	6.6	4.2	4.7

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

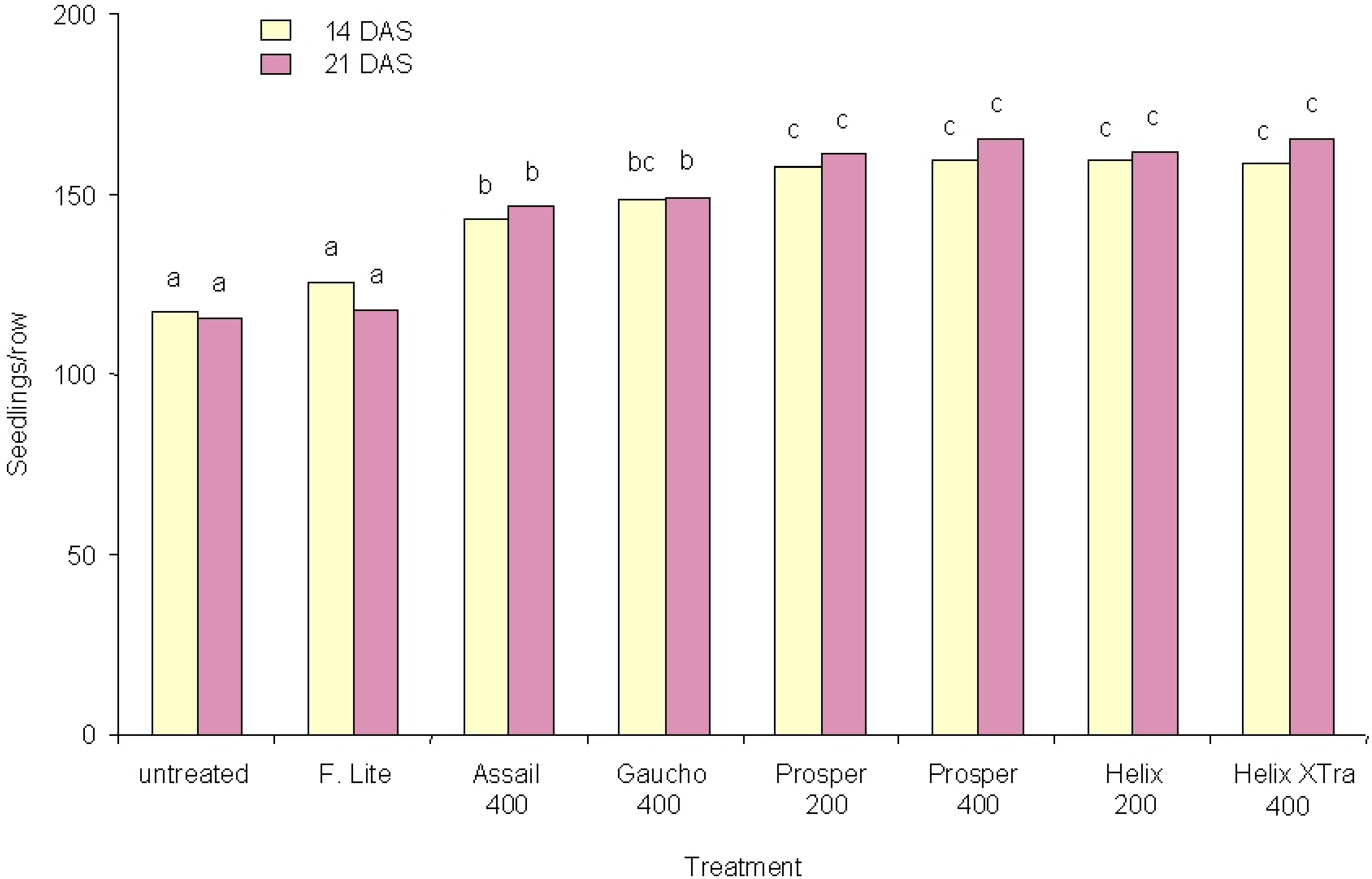

Fig. 3. Number of seedlings/row of untreated and treated open-pollinated Argentine canola 14 and 21 days after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P $\geq$ 0.05). Entries were seeded at 200 seeds per 6.1 m row.

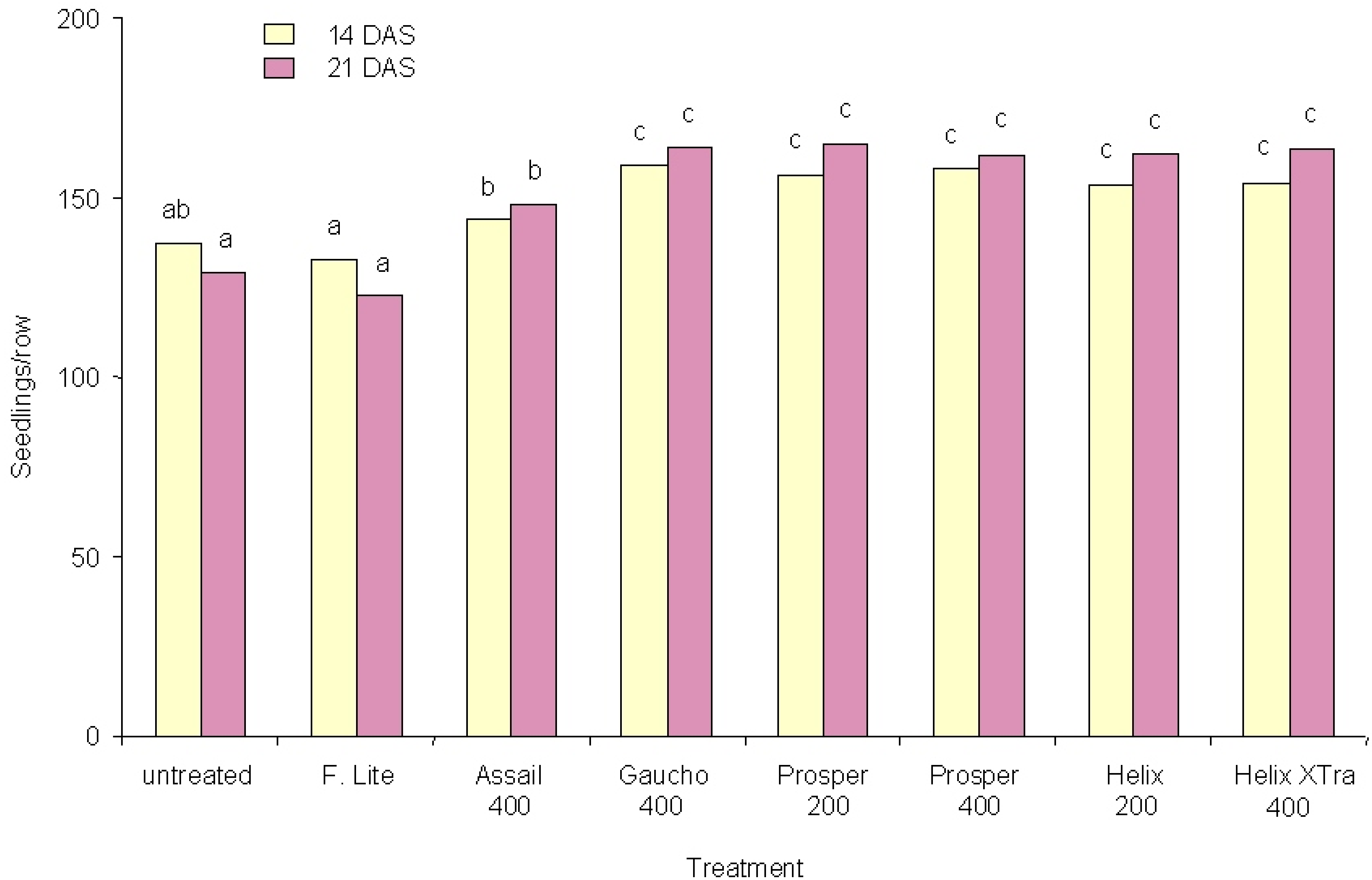

Fig. 4. Number of seedlings/row of untreated and treated hybrid Argentine canola 14 and 21 days after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Entries were seeded at 200 seeds per 6.1 m row.

Table 8. Effect of seed treatments on shoot dry weight of open-pollinated and hybrid Argentine canola 14 days after seeding in early May in 2003-2006. [1]

		Shoot dry wt. - op (mg/plant)					Shoot dry wt. - hybrid (mg/plant)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	2.0a	3.9a	4.9ab	14.3a	6.3a	4.0a	5.8ab	8.0b	24.5a	10.6ab
Foundation Lite®	-	2.5a	4.3a	5.3b	17.7a-c	7.4b	4.2a	5.1a	8.2b	24.3a	10.4a
Assail 50 SF®	400	5.7bc	3.9a	4.5ab	18.4bc	8.1bc	7.8b	6.1ab	6.8ab	31.6c	13.0de
Gaucho CS FL®	400	5.2b	4.0a	5.2ab	16.9ab	7.8bc	8.0bc	6.2ab	6.4a	30.5c	12.8de
Prosper®	200	5.7b-d	3.3a	4.6ab	18.6bc	8.0bc	7.7b	5.1a	8.1b	28.1bc	12.3cd
Prosper®	400	6.3cd	3.9a	4.9ab	19.2bc	8.6cd	8.8bc	5.1a	7.6ab	24.7a	11.5bc
Helix®	200	6.3cd	4.1a	4.2a	20.7c	8.8cd	9.2c	6.4b	8.0b	26.2ab	12.4cd
Helix XTra®	400	6.8d	4.3a	5.5b	20.4bc	9.3d	9.0bc	5.5ab	8.1b	31.7c	13.6e
	SE	0.5	0.5	0.5	1.8	0.5	0.7	0.6	0.7	1.7	0.5

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 9. Effect of seed treatments on shoot dry weight of open-pollinated and hybrid Argentine canola 21 days after seeding in early May in 2003-2006. [1]

		Shoot dry wt. - op (mg/plant)					Shoot dry wt. - hybrid (mg/plant)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	3.4a	10.9b	21.3a	56.7a	23.1a	4.9a	17.5b	36.3b	94.1a	38.2a
Foundation Lite®	-	4.3a	11.0b	22.2a	57.1a	23.7a	4.4a	13.4a	33.9b	97.4ab	37.3a
Assail 50 SF®	400	18.8cd	10.2ab	23.7a	76.1b	32.2bc	20.0bc	14.9ab	34.4b	120.7a-c	47.5b
Gaucho CS FL®	400	9.8ab	9.8ab	21.7a	77.3bc	29.6bc	14.0ab	14.7ab	28.1a	122.5bc	44.8ab
Prosper®	200	14.2bc	9.1ab	23.0a	65.7ab	28.0ab	26.4cd	15.0ab	33.3b	103.5a-c	44.5ab
Prosper®	400	22.5d	8.1a	23.9a	80.8bc	33.8c	25.0c	13.7a	31.3ab	108.7a-c	44.7ab
Helix®	200	23.1d	10.1ab	22.6a	77.2bc	33.3c	35.7de	16.1ab	32.5ab	115.7a-c	50.0bc
Helix XTra®	400	31.5e	9.5ab	22.2a	95.3c	39.6d	43.5e	14.9ab	34.6b	131.4c	56.1c
	SE	4.0	1.1	2.7	8.9	2.5	5.1	1.7	2.4	14.0	3.8

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 10. Effect of seed treatments on shoot dry weight of open-pollinated and hybrid Argentine canola 28 days after seeding in early May in 2003-2006. [1]

		Shoot dry wt. - op (mg/plant)					Shoot dry wt. - hybrid (mg/plant)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	3.9a	36.6a	54.5a	372.0ab	116.8ab	7.8a	72.3b	101.4a	482.5a	166.0a
Foundation Lite®	-	2.5a	37.1a	61.3ab	332.0a	108.2a	9.8a	53.4a	111.1ab	598.0ab	193.1ab
Assail 50 SF®	400	44.0c	36.3a	63.5a-c	421.3ab	141.3bc	71.4c	76.1b	115.3ab	808.4b	267.8cd
Gaucho CS FL®	400	12.9ab	49.2bc	73.1a-d	436.5ab	142.9bc	29.6ab	84.4b	124.3ab	679.8b	229.5bc
Prosper®	200	38.4bc	45.3ab	83.4cd	429.3ab	149.1b-d	54.5bc	75.5b	121.6ab	722.5b	243.5bc
Prosper®	400	52.3c	55.6c	85.8d	586.5c	195.1e	77.1c	83.2b	130.6b	797.5b	272.1cd
Helix®	200	46.3c	50.7bc	78.4b-d	488.5bc	166.0c-e	159.3d	103.1c	131.9b	812.8b	301.7d
Helix XTra®	400	96.9d	57.1c	80.4b-d	474.0bc	177.1de	141.1d	75.0b	130.9b	782.8b	282.4cd
	SE	12.7	4.3	9.9	63.8	16.5	16.6	7.6	12.3	105.0	26.8

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

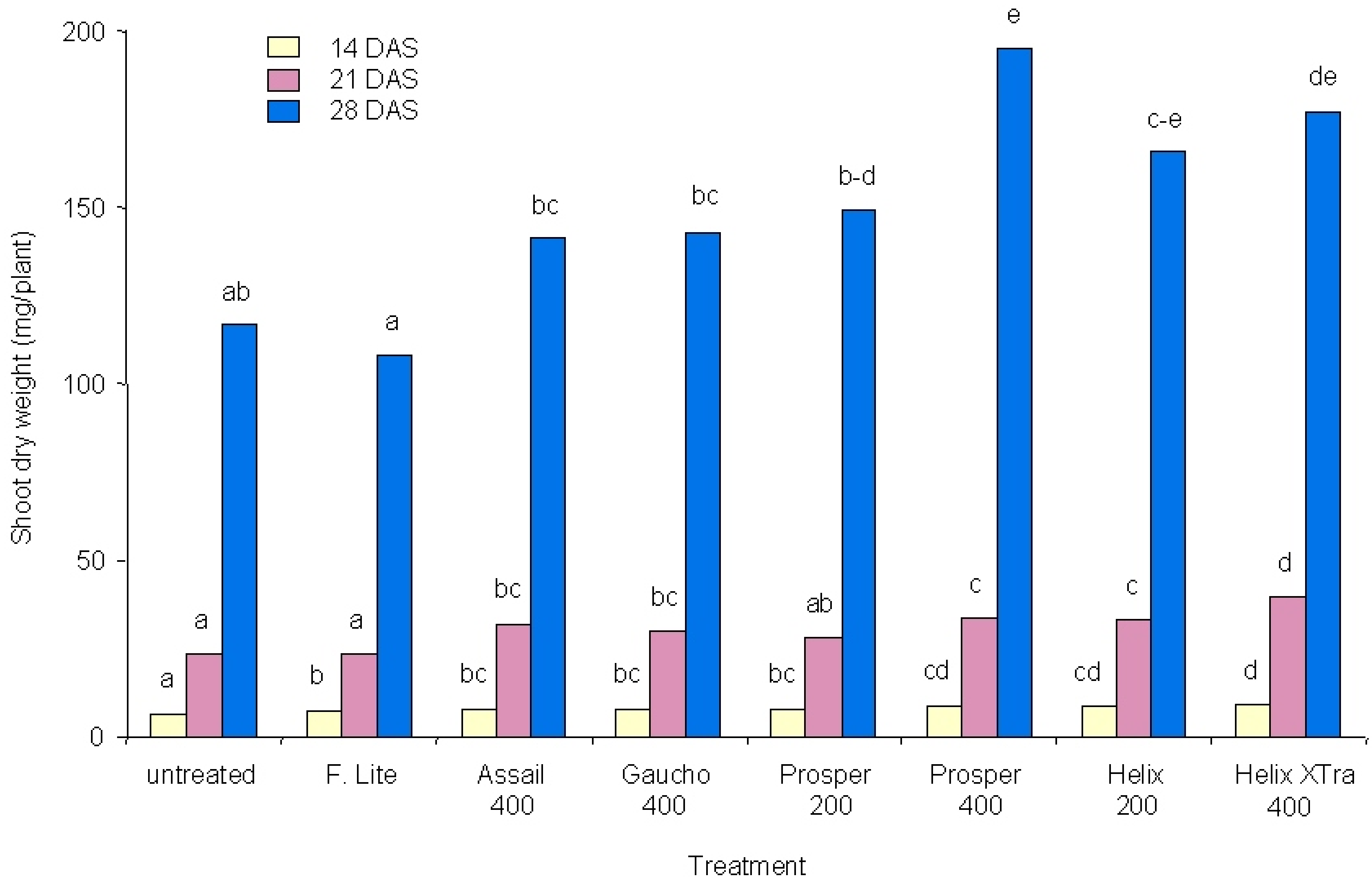

Fig. 5. Shoot dry weight of untreated and treated open-pollinated Argentine canola 14, 21 and 28 after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P > 0.05). Means are based on 160 plants.

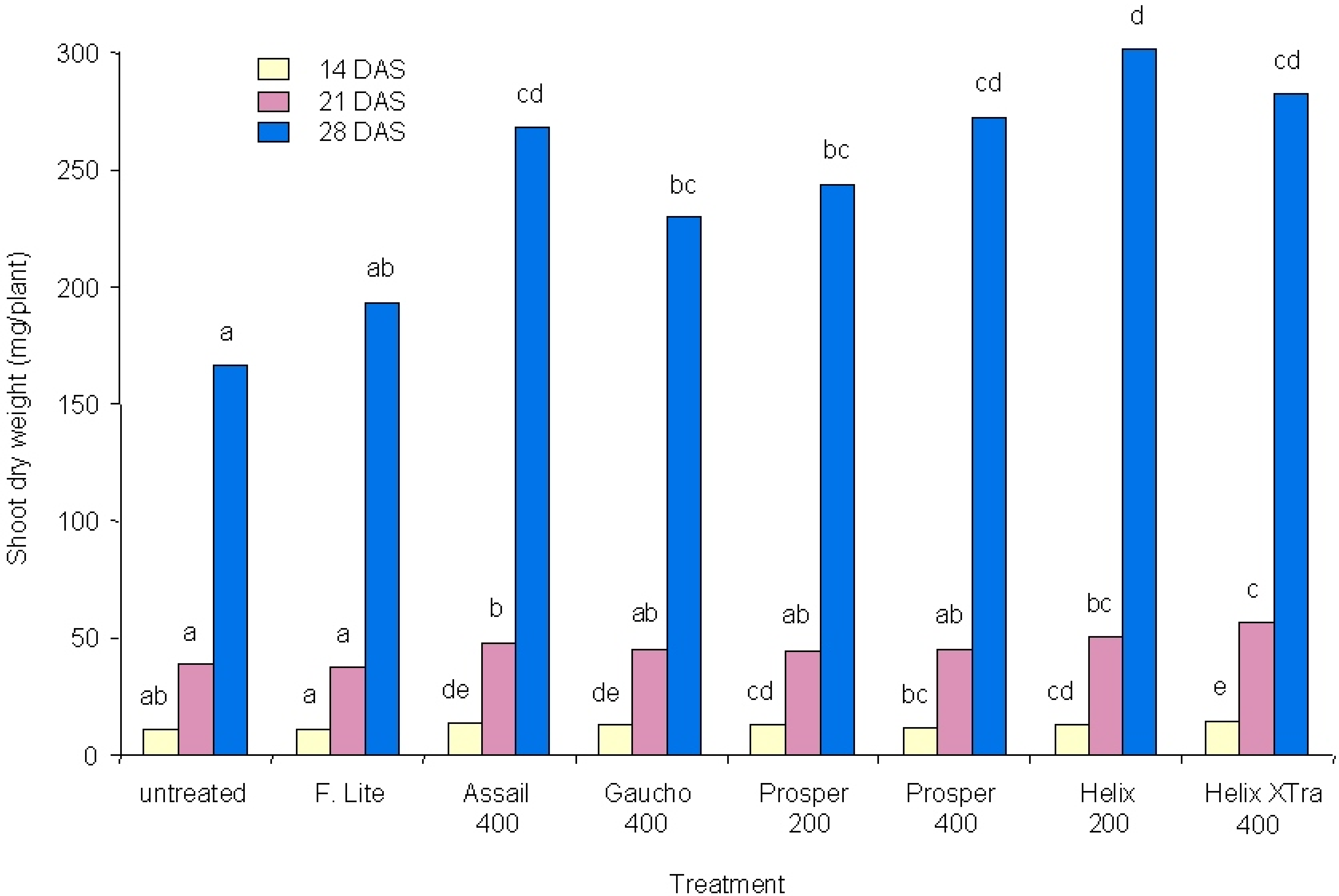

Fig. 6. Shoot dry weight of untreated and treated hybrid Argentine canola 14, 21 and 28 after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P > 0.05). Means are based on 160 plants.

Table 11. Effect of seed treatments on shoot biomass of open-pollinated and hybrid Argentine canola 14 days after seeding in early May in 2003-2006. [1]

		Shoot biomass - op (g/m-row)					Shoot biomass - hybrid (g/m-row)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	0.1a	0.6a	1.4ab	4.2a	1.5a	0.1a	1.0a	2.0a	7.7a	2.7a
Foundation Lite®	-	0.1a	0.7ab	1.4ab	5.0ab	1.8ab	0.1a	0.9a	2.2a	7.8a	2.7a
Assail 50 SF®	400	0.9bc	0.8ab	1.2a	5.8a-c	2.2bc	1.4b	1.1a	1.8a	10.4bc	3.7bc
Gaucho CS FL®	400	0.7b	0.7ab	1.5b	5.8bc	2.2b-d	1.4b	1.3a	1.9a	10.6c	3.8c
Prosper®	200	1.1cd	0.7ab	1.3ab	5.8bc	2.2c-e	1.6bc	1.0a	2.2a	9.6bc	3.6bc
Prosper®	400	1.3de	0.7ab	1.4ab	6.9c	2.6d-f	2.1d	1.0a	2.1a	8.1a	3.3b
Helix®	200	1.2cd	0.8b	1.2ab	7.3c	2.6d-f	2.0cd	1.1a	2.3a	9.0ab	3.6bc
Helix XTra®	400	1.5e	0.8ab	1.5b	7.0c	2.7f	2.0cd	1.0a	2.3a	10.4bc	3.9c
	SE	0.1	0.1	0.2	0.8	0.2	0.2	0.2	0.2	0.7	0.2

1 Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 12. Effect of seed treatments on shoot biomass of open-pollinated and hybrid Argentine canola 21 days after seeding in early May in 2003-2006. [1]

		Shoot biomass - op (g/m-row)					Shoot biomass - hybrid (g/m-row)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	0.01a	2.4ab	6.3a	14.9a	5.9a	0.06a	4.4a	11.3a-c	27.6a	10.8ab
Foundation Lite®	-	0.02a	2.5ab	6.8a	14.7a	6.0a	0.03a	3.3a	9.9a	27.9a	10.3a
Assail 50 SF®	400	2.4bc	2.8ab	7.1a	21.6bc	8.5bc	2.5ab	3.7a	12.0bc	37.5b	13.9c
Gaucho CS FL®	400	0.8a	2.4ab	7.5a	23.5b-d	8.5bc	1.4ab	4.4a	9.7a	38.8b	13.5c
Prosper®	200	1.6ab	2.6ab	8.1a	19.0ab	7.8b	3.8b	4.4a	11.3a-c	33.5ab	13.2c
Prosper®	400	3.3c	2.2a	8.3a	26.0cd	10.0c	3.5b	4.1a	10.7ab	33.4ab	12.9bc
Helix®	200	2.7bc	3.1b	8.0a	23.1bc	9.2bc	6.7c	4.1a	11.3a-c	37.0b	14.8cd
Helix XTra®	400	6.4d	2.7ab	7.9a	29.1d	11.5d	8.9c	4.0a	12.7c	41.0b	16.6d
	SE	0.8	0.4	1.0	2.7	0.8	1.2	0.8	0.9	4.1	1.1

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 13. Effect of seed treatments on shoot biomass of open-pollinated and hybrid Argentine canola 28 days after seeding in early May in 2003-2006. [1]

		Shoot biomass - op (g/m-row)					Shoot biomass - hybrid (g/m-row)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	0.1a	7.2a	17.6a	98.4ab	30.8ab	0.1a	16.1ab	33.1a	139.7a	47.3a
Foundation Lite®	-	0.1a	7.9a	19.7ab	87.3a	28.8a	0.08a	11.7a	38.5ab	165.7ab	54.0a
Assail 50 SF®	400	6.3bc	9.2a	20.2ab	120.7a-c	39.1bc	12.5bc	17.0ab	39.3ab	249.7c	79.7bc
Gaucho CS FL®	400	1.3ab	12.9bc	25.3bc	132.8bc	43.1cd	4.3ab	25.1cd	42.3ab	213.5bc	71.3b
Prosper®	200	6.2bc	12.2b	29.5b	124.6a-c	43.1cd	12.0bc	19.9bc	43.3ab	226.4bc	75.4bc
Prosper®	400	10.3c	15.5cd	31.1c	182.9d	60.0e	18.4c	23.9cd	46.4b	242.9c	82.9bc
Helix®	200	7.3c	14.8b-d	27.8c	147.2cd	49.3d	41.0d	26.4d	46.6b	246.9c	90.2c
Helix XTra®	400	22.5d	16.2d	28.6c	143.0cd	52.6de	36.8d	21.3b-d	47.9b	239.3c	86.3bc
	SE	2.7	1.4	3.5	19.3	5.0	4.7	2.6	5.2	31.5	8.1

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

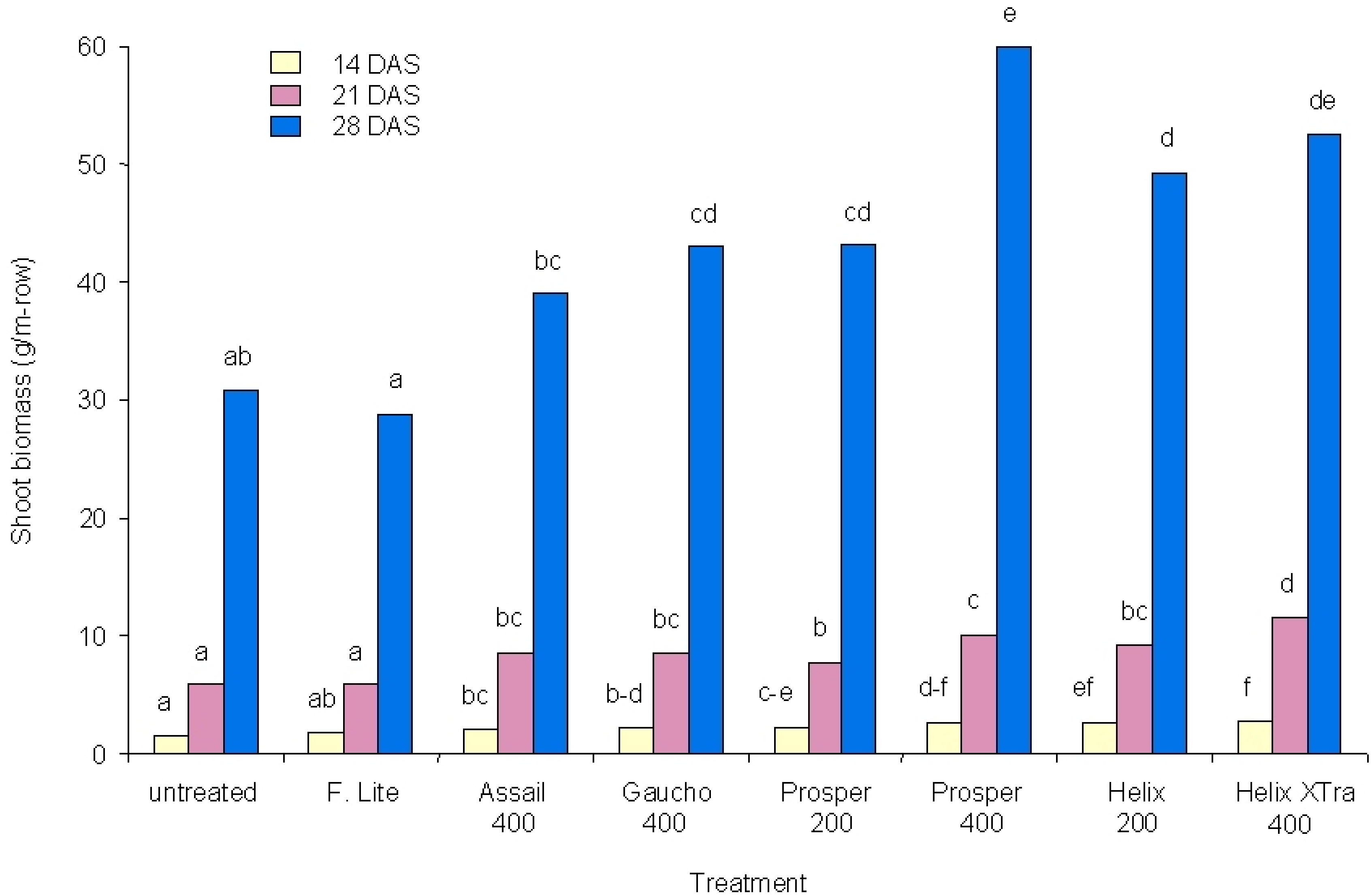

Fig. 7. Shoot biomass of untreated and treated open-pollinated Argentine canola 14, 21 and 28 days after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P > 0.05). Means are based on 160 plants.

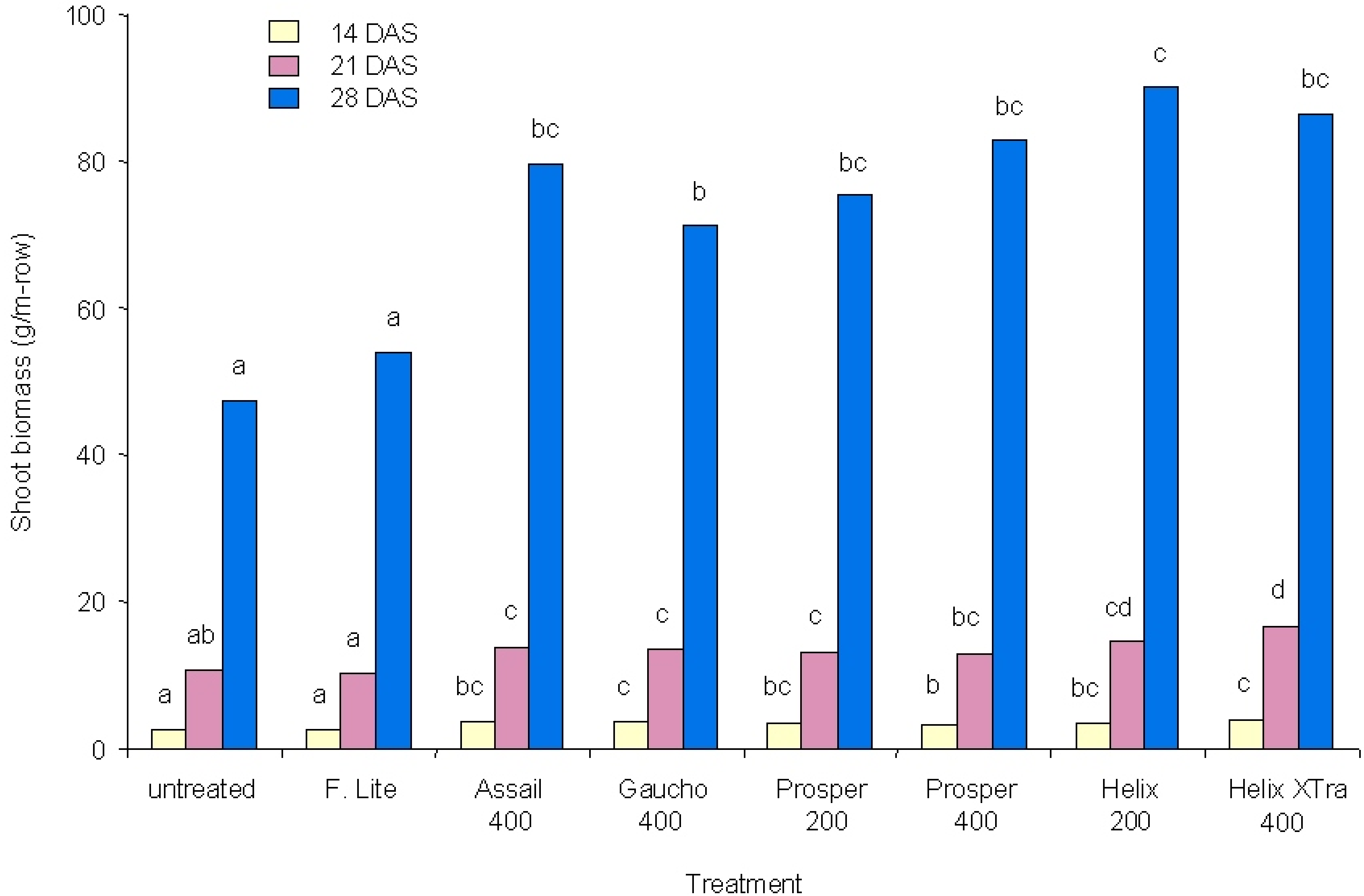

Fig. 8. Shoot biomass of untreated and treated hybrid Argentine canola 14, 21 and 28 days after seeding in early May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P > 0.05$). Means are based on 160 plants.

Table 14. Effect of seed treatments on seed yield of open-pollinated and hybrid Argentine canola seeded in early May in 2003-2006. [1]

		Yield - op (g/m^2)					Yield - hybrid (g/m^2)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	3.2a	227.3a	287.5ab	203.6ab	180.4a	2.9a	227.4ab	336.1ab	230.7a	199.3a
Foundation Lite®	-	1.6a	221.1a	283.0a	196.8a	175.6a	2.4a	206.7a	319.7a	243.7ab	193.1a
Assail 50 SF®	400	66.5cd	241.9a-c	295.5a-c	207.2ab	202.8c	109.0c	233.7ab	339.1ab	248.6a-c	232.6bc
Gaucho CS FL®	400	20.9b	235.0ab	295.3a-c	216.1ab	191.8b	80.5b	224.6ab	344.9b	245.8ab	224.0b
Prosper®	200	57.4c	271.1cd	315.1d	216.6ab	215.0d	119.0cd	242.4b	343.1b	242.7ab	236.8cd
Prosper®	400	85.0e	275.0d	302.1b-d	220.2b	220.6de	117.9cd	240.6b	342.1b	266.1c	241.7c-e
Helix®	200	79.7de	294.5d	306.4cd	218.4ab	224.7de	132.8d	242.3b	348.7b	260.9bc	246.2de
Helix XTra®	400	117.3f	266.4b-d	311.1cd	222.7b	229.4e	155.4e	251.5b	349.4b	255.0bc	252.8e
	SE	6.7	15.6	8.0	10.4	5.4	9.7	15.8	9.6	9.4	5.7

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$).

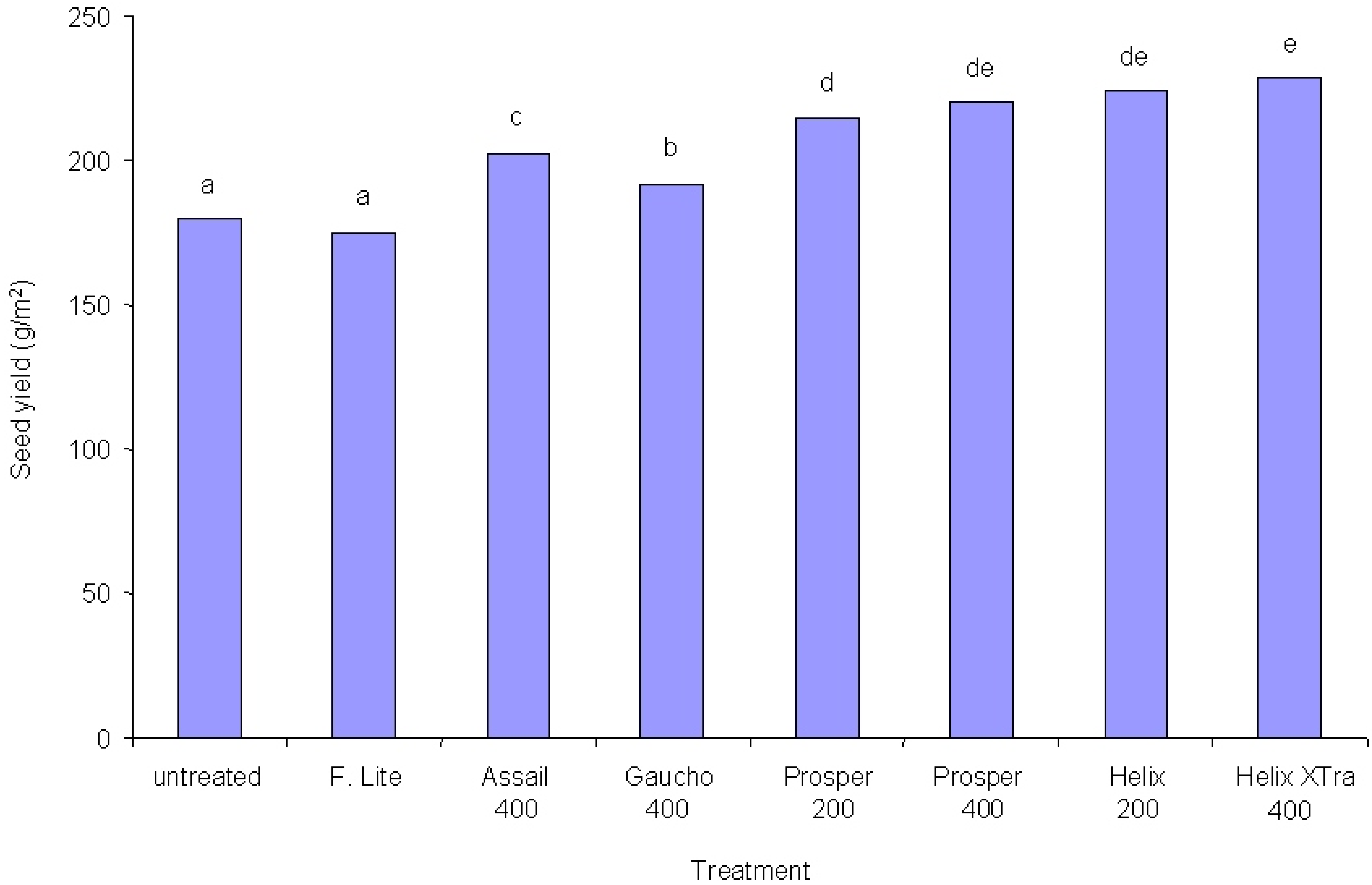

Fig. 9. Seed yield of untreated and treated open-pollinated Argentine canola seeded in early May in 2003-2006. Vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P > 0.05$).

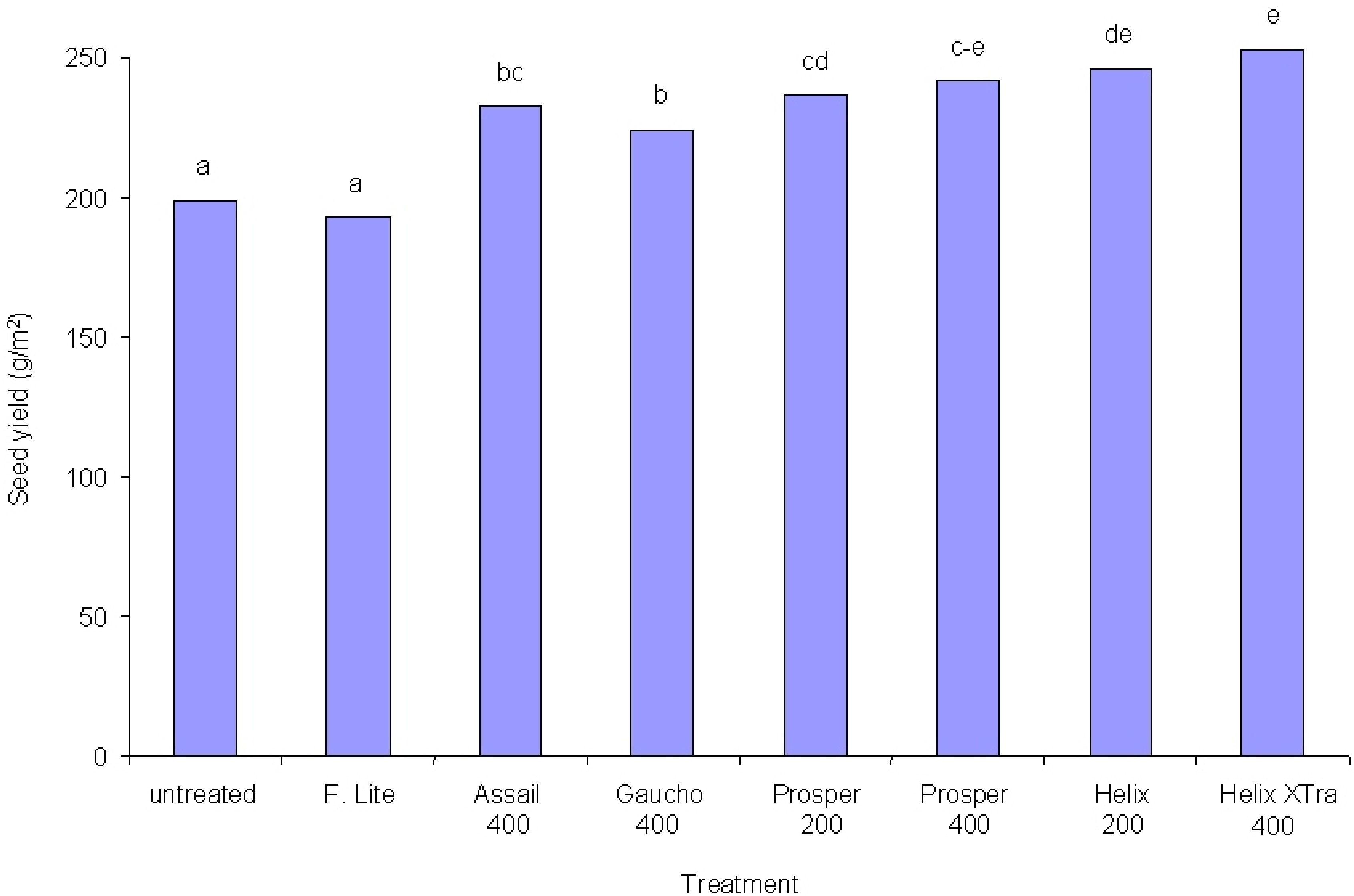

Fig. 10. Seed yield of untreated and treated hybrid Argentine canola seeded in early May in 2003-2006. Vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$).

Table 15. Effect of seed treatments on seed yield and economic returns of an open-pollinated Argentine cultivar seeded in early May in 2003-2006.[1]

		Yield (bu/acre)					Economic return ($/acre)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	0.6	40.4	51.2	36.2	32.1	-				
Foundation Lite®	-	0.3	39.3	50.4	35.0	31.3	-	-	-	-	
Assail 50 SF®	400	**11.8**	43.1	52.5	36.9	**36.1**	$78.40	$18.90	$9.10	$4.90	$28.00
Gaucho CS FL®	400	**3.7**	41.8	52.5	38.5	**34.1**	$21.70	$9.80	$9.10	$16.10	$14.00
Prosper®	200	**10.2**	**48.3**	**56.1**	38.6	**38.3**	$67.20	$55.30	$34.30	$16.80	$43.40
Prosper®	400	**15.1**	**49.0**	53.8	39.2	**39.3**	$101.50	$60.20	$18.20	$21.00	$50.40
Helix®	200	**14.2**	**52.4**	**54.5**	38.9	**40.0**	$95.20	$84.00	$23.10	$18.90	$55.30
Helix XTra®	400	**20.9**	**47.4**	**55.4**	39.6	**40.8**	$142.10	$49.00	$29.40	$23.80	$60.90
	LSD	2.5	5.8	3.0	3.9	1.9					

[1] Yield values in bold print significantly higher than untreated seed (Fisher's protected LSD test, $P \leq 0.05$). Economic return relative to untreated seed based on $7.00/bu canola.

Table 16. Effect of seed treatments on seed yield and economic returns of a hybrid Argentine cultivar seeded in early May in 2003-2006.[1]

		Yield (bu/acre)					Economic return ($/acre)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	0.6	40.5	59.8	41.1	35.5	-	-	-	-	-
Foundation Lite®	-	0.4	36.8	56.9	43.4	34.4	-	-	-	-	-
Assail 50 SF®	400	**19.4**	41.6	60.4	44.3	**41.4**	$131.60	$7.70	$4.20	$22.40	$41.30
Gaucho CS FL®	400	**14.3**	40.0	61.4	43.8	**39.9**	$95.90	-	$11.20	$18.90	$30.80
Prosper®	200	**21.2**	43.1	61.1	43.2	**42.2**	$144.20	$18.20	$9.10	$14.70	$46.90
Prosper®	400	**21.0**	42.8	60.9	**47.4**	**43.0**	$142.80	$16.10	$7.70	$44.10	$52.50
Helix®	200	**23.6**	43.1	62.1	**46.4**	**43.8**	$161.00	$18.20	$16.10	$37.10	$58.10
Helix XTra®	400	**27.7**	44.8	62.2	**45.4**	**45.0**	$189.70	$30.10	$16.80	$30.10	$66.50
	LSD	3.6	5.8	3.5	3.5	2.0					

[1] Yield values in bold print significantly higher than untreated seed (Fisher's protected LSD test, $P \leq 0.05$). Economic return relative to untreated seed based on $7.00/bu canola.

Table 17. Overall flea beetle damage and seedlings/row of open-pollinated and hybrid Argentine canola seeded in late May in 2003-2006.

Variable	Damage (% area)			Seedlings/row	
	14 DAS	17-18 DAS	21 DAS	14 DAS	21 DAS
year					
2003	8b	12b	20a	165.8a	165.8a
2004	14a	17a	18b	168.8ab	175.2c
2005	1c	3d	8d	172.7c	174.1bc
2006	7b	8c	10c	169.9bc	171.5b
SE	1	1	1	1.7	1.5
cultivar					
op	7b	10a	14a	168.9a	171.3a
hybrid	8a	10a	14a	169.6a	172.0a
SE	1	1	1	1.5	1.2
F value					
Year (Y)	89.0***	145.0***	128.6***	5.9*	15.8***
Cultivar (C)	8.3*	0.3	0.1	0.2	0.3
Y x C	2.0	0.3	0.8	5.8*	6.4**
Treatment (T)	143.6***	191.5***	254.2***	26.0***	43.2***
Y x T	28.0***	32.7***	54.9***	2.3**	5.1***
C x T	1.2	1.4	0.5	0.4	0.3
Y x C x T	1.1	0.8	0.7	1.7*	1.1

a-b For each variable, means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, ANOVA, $P \geq 0.05$). Damage data were transformed (arcsine square root) before analysis. DAS, days after seeding. *, **, *** F value significant at P = 0.05, 0.01 and 0.001, respectively.

Table 18. Overall shoot dry weight, shoot biomass and seed yield of open-pollinated and hybrid Argentine canola seeded in late May in 2003-2006.

Variable	Shoot dry weight (mg/plant)			Shoot biomass (g/m-row)			Seed yield (g/m^2)
	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS	
year							
2003	10.8b	53.9b	212.5b	2.8b	13.1b	48.5b	124.8a
2004	9.2a	22.9a	76.0a	2.2a	6.8a	17.5a	250.4c
2005	11.2b	87.1d	1245.3d	4.4c	28.0d	389.7d	308.2d
2006	16.4c	64.4c	523.7c	5.0d	15.9c	119.5c	224.0b
SE	0.4	3.0	33.7	0.1	0.8	10.1	5.9
cultivar							
op	9.8a	44.8a	377.6a	2.9a	12.2a	102.6a	208.7a
hybrid	14.0b	69.4b	651.1b	4.3b	19.7b	184.9b	245.0b
SE	0.3	2.1	11.1	0.1	0.7	5.2	3.4
F value							
Year (Y)	119.2***	158.2***	479.2***	208.6***	223.0***	559.3***	333.2***
Cultivar (C)	236.1***	133.4***	608.1***	256.0***	112.2***	248.8***	115.6***
Y x C	6.3**	12.3***	181.1***	13.5***	12.7***	102.2***	12.6***
Treatment (T)	2.4*	14.3***	13.5***	8.1***	18.6***	15.4***	13.9***
Y x T	2.1**	2.7***	2.1**	2.3**	2.3**	3.5***	2.7***
C x T	0.7	1.5	0.8	0.9	1.2	0.9	1.7
Y x C x T	1.0	0.6	0.9	0.9	0.7	0.7	1.1

a-b For each variable, means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, ANOVA, ≥ 0.05). DAS, days after seeding. *, **, *** F value significant at P = 0.05, 0.01 and 0.001, respectively.

Table 19. Effect of seed treatments on flea beetle damage to cotyledons of open-pollinated and hybrid Argentine canola 14 days after seeding in late May in 2003-2006. [1]

		Damage - op (%)					Damage - hybrid (%)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	18a	33b	1a	12a	16a	21a	36a	2ab	11a	18a
Foundation Lite®	-	20a	40a	1a	11ab	18a	24a	32a	2ab	10a	17a
Assail 50 SF®	400	5b	10c	1a	8bc	6b	7b	8b	2ab	7b	6b
Gaucho CS FL®	400	3b	6d	0.4a	5e	3cd	4b-d	8b	2ab	6b	5cd
Prosper®	200	4b	6d	1a	5de	4c	4b-d	7b	1b	7b	5b-d
Prosper®	400	3b	4d	1a	4e	3d	3cd	6b	1b	6b	4d
Helix®	200	4b	6d	1a	8cd	5bc	5bc	7b	3a	6b	5bc
Helix XTra®	400	2b	5d	1a	6c-e	4cd	2d	7b	2ab	5b	4d
	SE	3	2	1	1	1	2	2	1	1	1

1 Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

Table 20. Effect of seed treatments on flea beetle damage to cotyledons of open-pollinated and hybrid Argentine canola 17-18 days after seeding in late May in 2003-2006. [1]

		Damage - op (%)					Damage - hybrid (%)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	30a	37b	5a	11a	21a	36a	42a	5a	12a	24a
Foundation Lite®	-	33a	46a	4a	11a	24a	37a	40a	4ab	11ab	23a
Assail 50 SF®	400	9bc	15c	4a	11a	10b	9bc	11b	4ab	9bc	8b
Gaucho CS FL®	400	10b	9d	2b	8b	7c	10b	11bc	2cd	8cd	8b
Prosper®	200	4cd	10d	2b	6b	5d	5b-d	7d	3bc	8cd	6c
Prosper®	400	3d	7d	2b	6b	4d	2e	8cd	1d	7cd	4d
Helix®	200	4d	7d	2b	7b	5d	4c-e	9b-d	2cd	8cd	6c
Helix XTra®	400	2d	7d	2b	5b	4d	2de	8cd	2cd	7d	5d
	SE	3	3	1	1	1	3	2	1	1	1

[1] Means within columns followed by the same letter are not significantly different (Fisher’s protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

Table 21. Effect of seed treatments on flea beetle damage to cotyledons of open-pollinated and hybrid Argentine canola 21 days after seeding in late May in 2003-2006. [1]

Treatment	Rate	Damage - op (%)					Damage - hybrid (%)				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	38a	49a	10ab	14a	28a	39a	43a	11a	13a	26a
Foundation Lite®	-	42a	44a	10a	12ab	27a	40a	43a	10ab	11b	26a
Assail 50 SF®	400	18c	12b	11a	10bc	13b	23b	10b	11a	10bc	13b
Gaucho CS FL®	400	28b	11bc	10ab	8d	14b	24b	10b	9ab	9bc	13b
Prosper®	200	15c	9b-d	9ab	10cd	11c	15c	8bc	8b	9c	10c
Prosper®	400	8d	8cd	5c	8d	7de	10d	7c	5c	9c	8de
Helix®	200	8d	9b-d	8b	9cd	8d	9d	8bc	8b	9c	9cd
Helix XTra®	400	4d	6d	6c	8d	6e	6d	7c	5c	9c	7e
	SE	3	3	1	1	1	3	2	1	1	1

1 Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

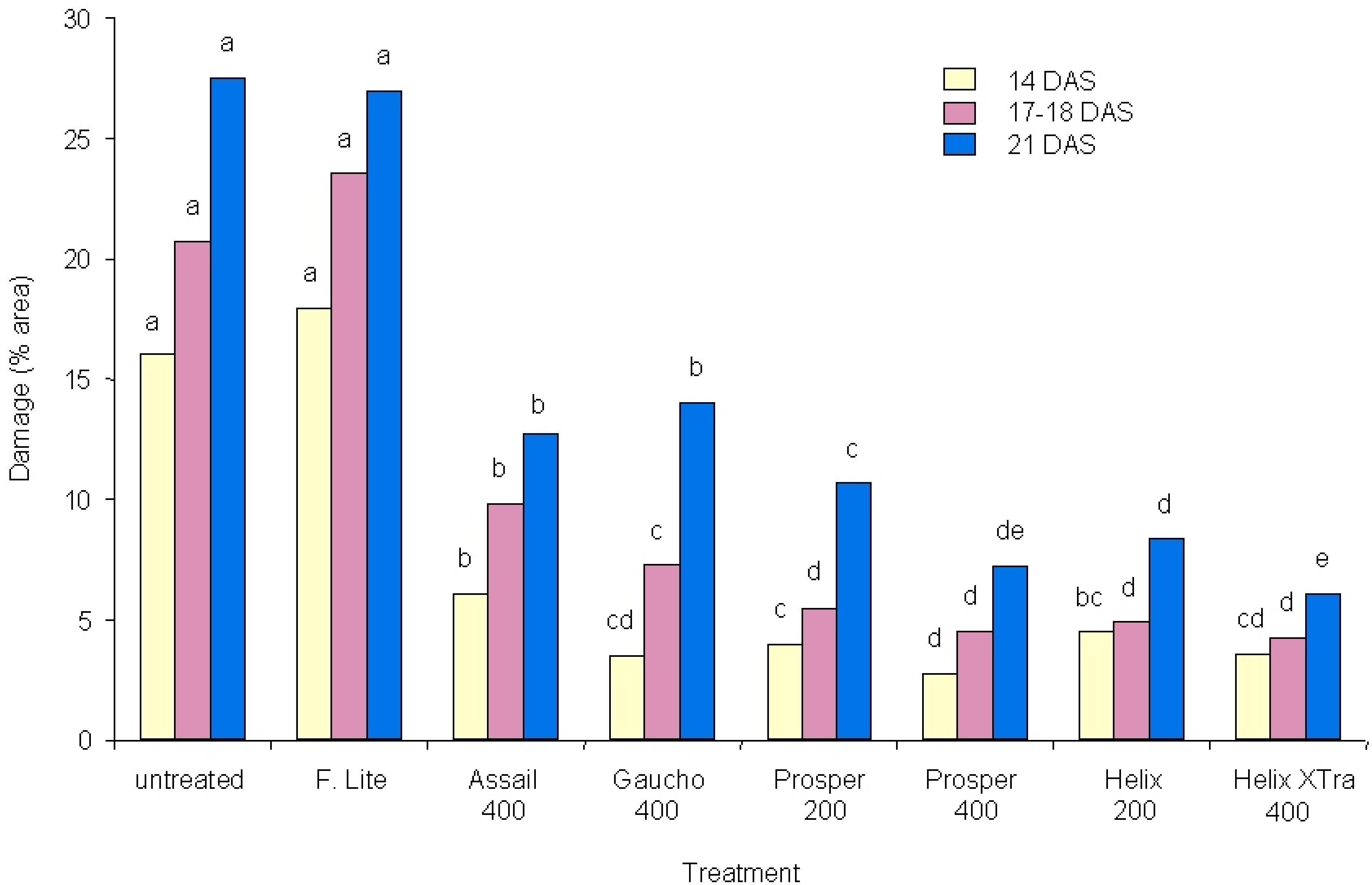

Fig. 11. Flea beetle damage to cotyledons of untreated and treated open-pollinated Argentine canola 14, 17-18 and 21 days after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05).

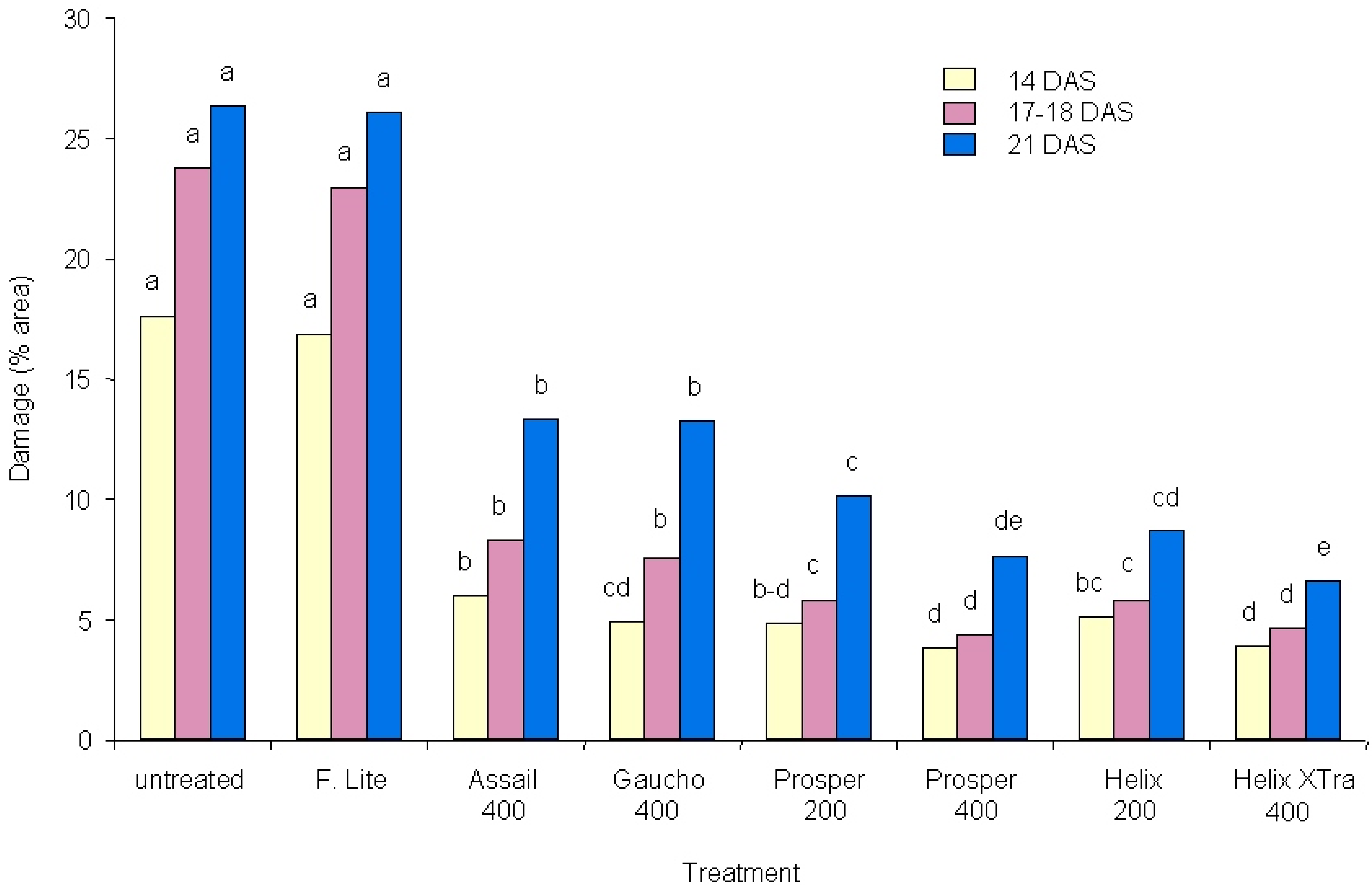

Fig. 12. Flea beetle damage to cotyledons of untreated and treated hybrid Argentine canola 14, 17-18 and 21 days after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P $\geq$ 0.05).

Table 22. Effect of seed treatments on numbers of seedlings/row of open-pollinated and hybrid Argentine canola 14 days after seeding in late May in 2003-2006. [1]

Treatment	Rate	Seedlings/row - op					Seedlings/row - hybrid				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	143.0a	162.0ab	172.0a-c	153.5a	157.6a	151.5a	158.0a	159.5a	164.0a	158.3a
Foundation Lite®	-	151.5ab	146.8a	171.8ab	164.0a-c	158.5a	156.3a	152.3a	162.0a	164.8a	158.8a
Assail 50 SF®	400	161.5bc	170.0bc	166.0a	156.8ab	163.6a	171.0b	163.5ab	167.8ab	166.8a	167.3b
Gaucho CS FL®	400	166.5c	177.0bc	172.5a-c	172.0c	172.0b	169.3b	176.8c	171.3ab	183.0b	175.1c
Prosper®	200	167.8c	174.0bc	192.8d	167.8a-c	175.6b	177.5b	175.5c	170.3ab	182.5b	176.4c
Prosper®	400	170.5c	181.0c	183.3cd	169.3bc	176.0b	175.5b	174.3bc	169.3ab	179.8b	174.7c
Helix®	200	170.5c	177.8c	177.8bc	168.3a-c	173.6b	172.3b	173.8bc	176.8b	169.0a	172.9c
Helix XTra®	400	171.5c	180.0c	172.5a-c	174.8c	174.7b	176.0b	158.8a	178.3b	182.0b	173.8c
	SE	5.4	7.4	5.4	7.1	3.2	4.6	5.4	6.3	4.9	2.7

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

Table 23. Effect of seed treatments on numbers of seedlings/row of open-pollinated and hybrid Argentine canola 21 days after seeding in late May in 2003-2006. [1]

Treatment	Rate	Seedlings/row - op					Seedlings/row - hybrid				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	130.3a	165.0a	174.0a-c	159.0a	157.1a	142.8a	166.3ab	168.0ab	164.5a	160.4a
Foundation Lite®	-	148.5b	164.8a	165.5a	162.5ab	160.3a	152.8a	160.5a	161.5a	165.5a	160.1a
Assail 50 SF®	400	165.8cd	180.8b	168.3ab	160.5ab	168.8b	172.8b	168.0a-c	172.5bc	168.0a	170.3b
Gaucho CS FL®	400	163.0c	181.8b	176.5bc	174.5c	173.9c	172.5b	177.8cd	169.3ab	180.8b	175.1bc
Prosper®	200	171.0cd	180.3b	188.5e	174.5c	178.6c	180.5b	176.8cd	174.5bc	183.5b	178.8c
Prosper®	400	173.5d	180.0b	186.3de	171.8bc	177.9c	179.8b	180.3d	175.3bc	179.5b	178.7c
Helix®	200	172.5cd	182.0b	176.0bc	170.0a-c	175.1c	172.3a	175.8b-d	180.0c	170.0a	174.5bc
Helix XTra®	400	175.3d	183.3b	178.3cd	178.0c	178.7c	179.0b	179.8d	171.8a-c	181.0b	177.9c
	SE	4.9	4.9	4.3	5.7	2.5	5.3	4.9	5.0	4.2	2.4

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Rate expressed as g AI/100 kg seed.

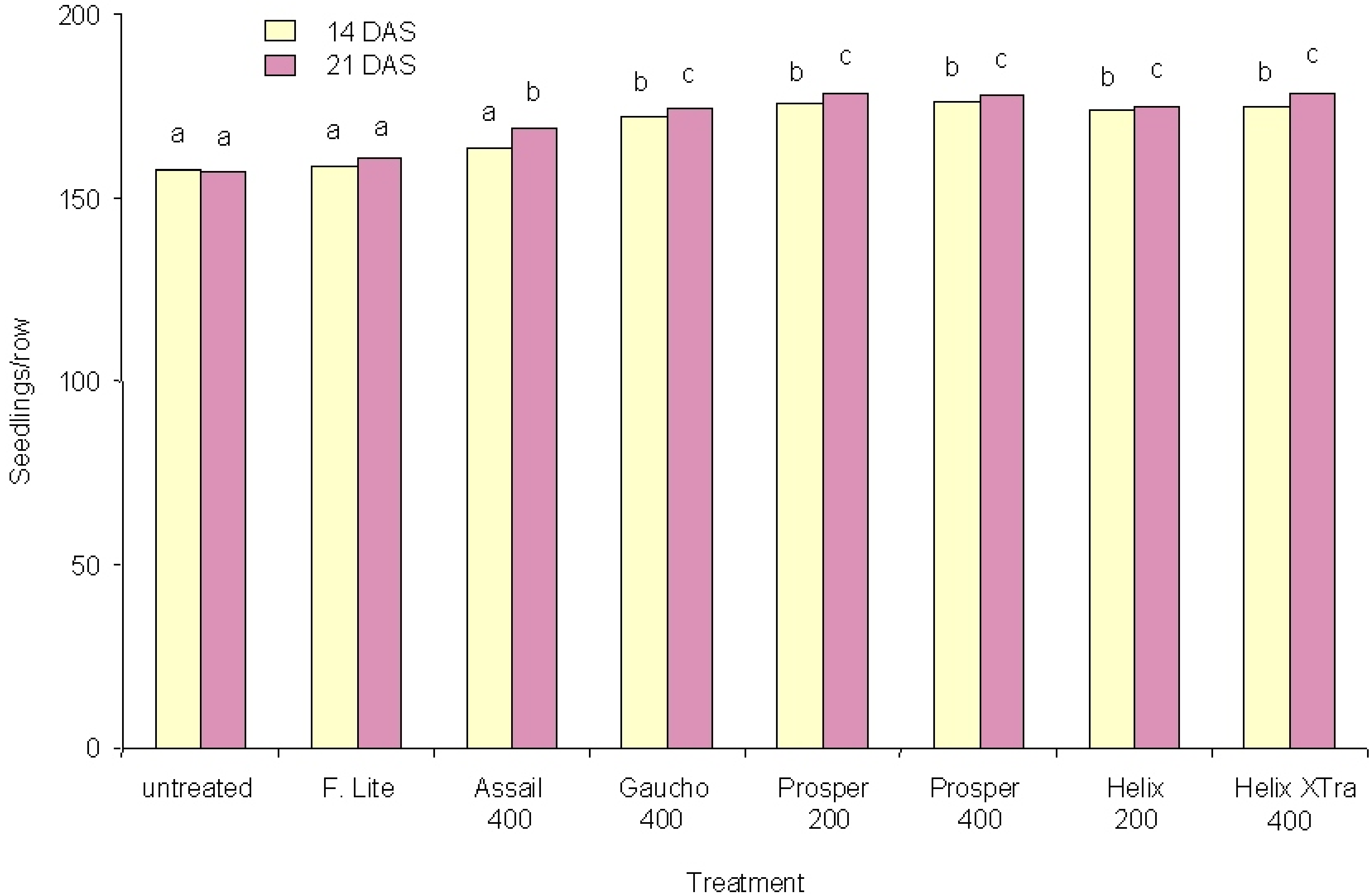

Fig. 13. Number of seedlings/row of untreated and treated open-pollinated Argentine canola 14 and 21 days after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Entries were seeded at 200 seeds per 6.1 m row.

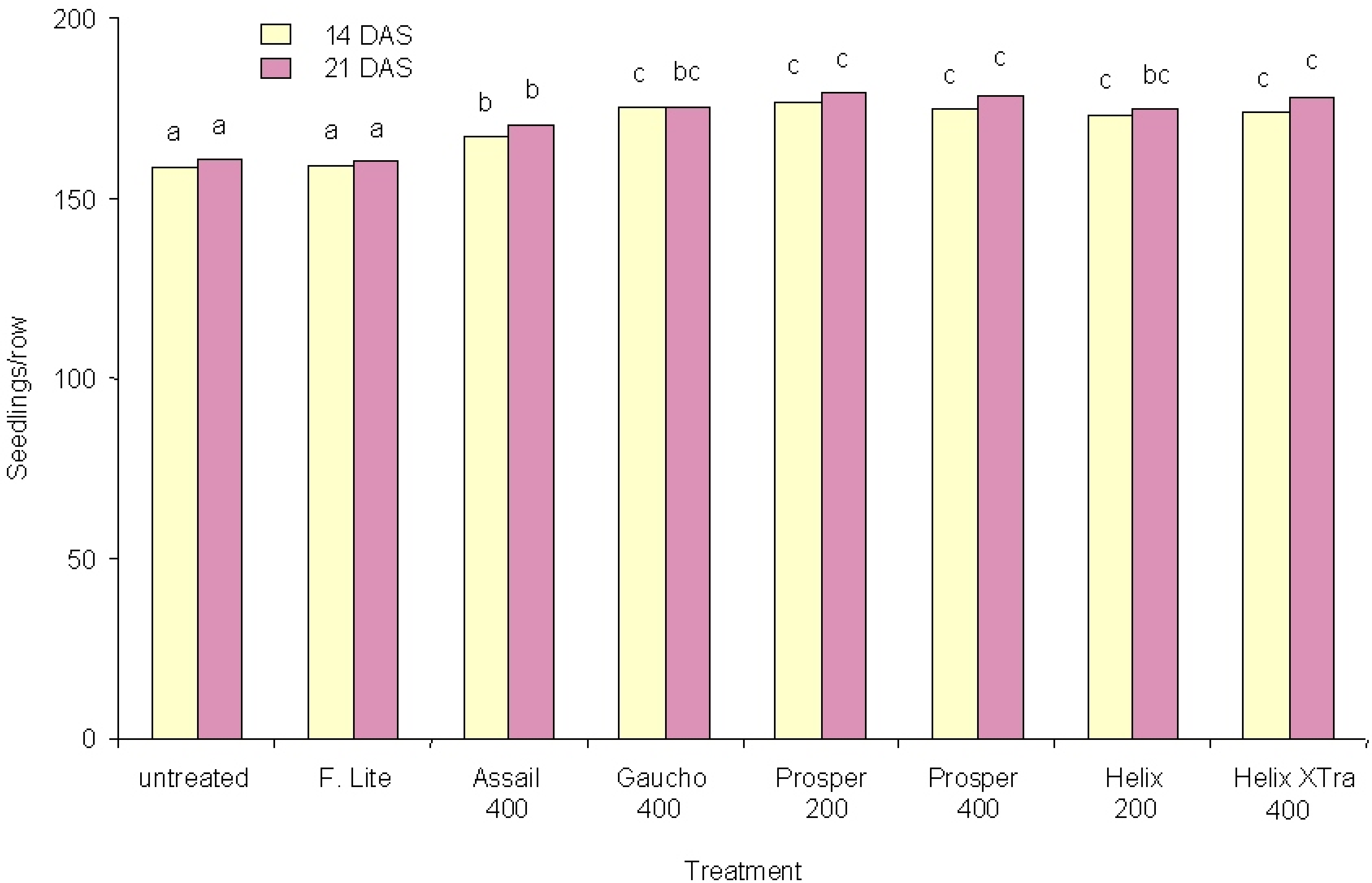

Fig. 14. Number of seedlings/row of untreated and treated hybrid Argentine canola 14 and 21 days after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P $\geq$ 0.05). Entries were seeded at 200 seeds per 6.1 m row.

Table 24. Effect of seed treatments on shoot dry weight of open-pollinated and hybrid Argentine canola 14 days after seeding in late May in 2003-2006. [1]

Treatment	Rate	Shoot dry wt. - op (mg/plant)					Shoot dry wt. - hybrid (mg/plant)				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	10.8ab	6.5b	9.3ab	13.3a	10.0a-c	11.2ab	7.9a	13.5a	18.9a	12.9a
Foundation Lite®	-	10.4ab	4.2a	8.5ab	13.5a	9.1a	12.6ab	8.4a	14.5a	19.1a	13.7ab
Assail 50 SF®	400	8.7ab	6.5b	8.6ab	12.5a	9.1a	11.4ab	13.0b	13.1a	18.5a	14.0ab
Gaucho CS FL®	400	8.6ab	6.5b	8.7ab	14.5a	9.6a-c	11.3ab	11.9b	14.4a	19.6a	14.3ab
Prosper®	200	9.1ab	7.7bc	7.9a	12.9a	9.4ab	9.2a	14.2b	13.4a	17.2a	13.5ab
Prosper®	400	7.5a	8.5c	8.1ab	14.8a	9.7a-c	12.7ab	11.5b	13.8a	18.0a	14.0ab
Helix®	200	11.8b	8.2c	9.4a	13.8a	10.8c	13.5b	12.1b	14.1a	20.5a	15.1b
Helix XTra®	400	10.3ab	8.9c	9.5b	14.0a	10.7bc	13.3b	11.6b	12.6a	20.3a	14.4ab
	SE	2.0	0.7	0.8	1.4	0.7	1.8	1.3	1.2	2.1	0.8

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 25. Effect of seed treatments on shoot dry weight of open-pollinated and hybrid Argentine canola 21 days after seeding in late May in 2003-2006. [1]

Treatment	Rate	Shoot dry wt. - op (mg/plant)					Shoot dry wt. - hybrid (mg/plant)				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	45.9ab	8.4a	59.1ab	41.2a	38.7ab	39.2a	16.1a	97.8a	55.4a	52.1a
Foundation Lite®	-	26.7a	9.2a	62.4ab	44.1ab	35.6a	39.3a	11.8a	113.9a	78.6bc	60.9ab
Assail 50 SF®	400	37.8a	16.6b	54.8a	39.0a	37.0a	70.0bc	32.9b	104.6a	65.9ab	68.4b-d
Gaucho CS FL®	400	37.6ab	19.3b	66.6ab	54.1bc	44.4bc	60.0ab	29.2b	95.6a	73.5bc	64.6bc
Prosper®	200	37.9a	19.5b	67.6ab	54.2bc	44.8bc	56.6ab	35.4b	106.3a	89.0c	71.8cd
Prosper®	400	42.9ab	20.7b	65.5ab	61.5c	47.6cd	64.1ab	33.1b	113.0a	86.4c	74.2cd
Helix®	200	61.4bc	22.6b	69.3ab	61.5c	53.7de	67.8ab	34.8b	121.8a	85.7c	77.5de
Helix XTra®	400	77.7c	22.3b	72.8b	54.9bc	56.9e	98.5c	34.6b	123.1a	85.8c	85.5e
	SE	10.6	3.0	7.6	5.6	3.6	14.2	4.1	13.6	8.2	5.4

1 Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 26. Effect of seed treatments on shoot dry weight of open-pollinated and hybrid Argentine canola 28 days after seeding in late May in 2003-2006. [1]

Treatment	Rate	Shoot dry wt. - op (mg/plant)					Shoot dry wt. - hybrid (mg/plant)				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	82.0a	20.1a	773.0ab	334.8a	302.5a	146.5ab	36.3a	1607.0a-c	562.5a	588.1ab
Foundation Lite®	-	116.5ab	17.9a	698.3a	344.5ab	294.3a	127.5a	31.7a	1297.8a	573.0a	507.5a
Assail 50 SF®	400	150.5a-c	52.4b	782.5a-c	338.0a	330.8ab	244.0a-c	92.6b	1524.8ab	660.0ab	630.3bc
Gaucho CS FL®	400	103.0a	72.2b-d	924.3b-d	423.3a-c	380.7bc	261.5a-c	102.3bc	1503.0ab	645.5ab	628.1bc
Prosper®	200	178.8bc	74.0cd	961.5cd	448.3c	415.6cd	201.3ab	114.2b-d	1657.5bc	724.5b	674.4b-d
Prosper®	400	177.8bc	61.5bc	990.8d	437.8c	416.9cd	295.0bc	137.0d	1633.8bc	668.8ab	683.6c-e
Helix®	200	194.0c	68.0b-d	1048.5d	373.5a-c	421.0cd	393.5c	128.4cd	1653.5bc	730.8b	726.5de
Helix XTra®	400	323.3d	84.9d	992.8d	436.0bc	459.2d	405.5c	122.8b-d	1876.8c	677.5ab	770.6e
	SE	35.9	10.3	88.4	44.6	26.4	80.4	16.6	158.7	63.2	47.4

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

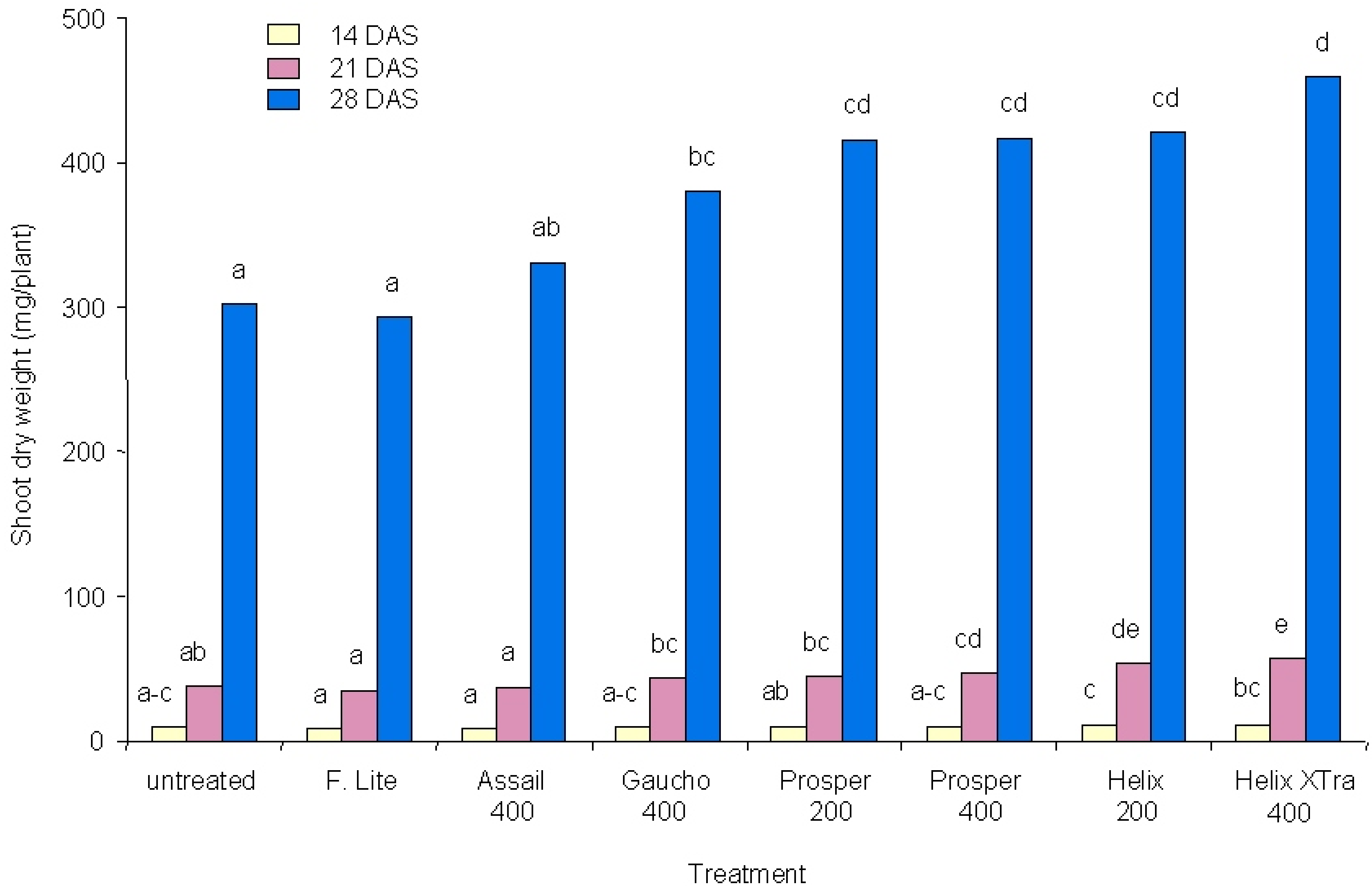

Fig. 15. Shoot dry weight of untreated and treated open-pollinated Argentine canola 14, 21 and 28 after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means are based on 160 plants.

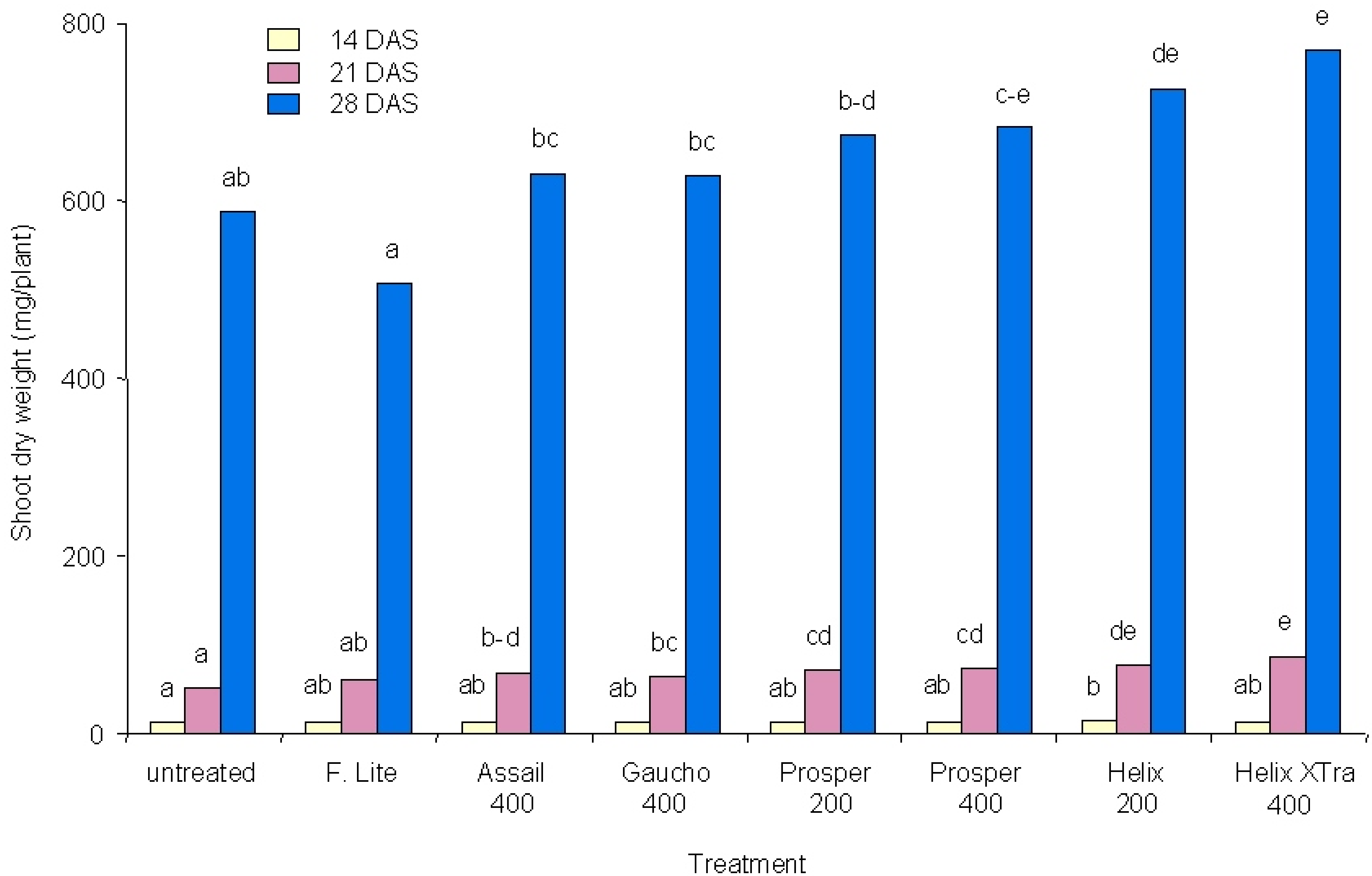

Fig. 16. Shoot dry weight of untreated and treated hybrid Argentine canola 14, 21 and 28 after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, P > 0.05). Means are based on 160 plants.

Table 27. Effect of seed treatments on shoot biomass of open-pollinated and hybrid Argentine canola 14 days after seeding in late May in 2003-2006. [1]

Treatment	Rate	Shoot biomass - op (g/m-row)					Shoot biomass - hybrid (g/m-row)				
		2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	2.1ab	1.3b	3.5a	3.4a	2.6a	2.5a	1.4a	4.9a	5.5a	3.6a
Foundation Lite®	-	2.3ab	0.6a	3.3a	3.8ab	2.5a	2.9a-c	1.6a	5.5a	5.8a	4.0ab
Assail 50 SF®	400	2.2ab	1.6bc	3.2a	3.4a	2.6a	3.3a-c	3.2bc	5.2a	5.7a	4.3bc
Gaucho CS FL®	400	2.2ab	1.7bc	3.2a	4.4b	2.9ab	3.0a-c	3.0bc	5.7a	6.5a	4.6c
Prosper®	200	2.4ab	2.0cd	3.4a	3.7ab	2.9ab	2.7ab	3.7c	5.2a	5.7a	4.3bc
Prosper®	400	2.0a	2.4d	3.2a	4.4b	3.0bc	3.7bc	3.0bc	5.4a	5.9a	4.5c
Helix®	200	3.2b	2.2d	3.7a	4.1ab	3.3c	3.9c	3.0bc	5.8a	6.4a	4.8c
Helix XTra®	400	2.9ab	2.4d	3.5a	4.3ab	3.2bc	3.9c	2.7b	5.1a	6.8a	4.6c
	SE	0.5	0.2	0.3	0.5	0.2	0.5	0.3	0.4	0.7	0.3

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 28. Effect of seed treatments on shoot biomass of open-pollinated and hybrid Argentine canola 21 days after seeding in late May in 2003-2006. [1]

		Shoot biomass - op (g/m-row)					Shoot biomass - hybrid (g/m-row)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	7.9a	2.1a	18.7ab	9.7a	9.6a	7.9a	4.0a	30.8ab	13.7a	14.1a
Foundation Lite®	-	5.1a	2.3a	18.9a-c	10.7ab	9.2a	8.5a	2.6a	34.4a-c	19.2b-d	16.2ab
Assail 50 SF®	400	9.0a	5.3b	16.4a	9.0a	9.9ab	18.1b	9.5b	33.3a-c	16.0ab	19.2b-d
Gaucho CS FL®	400	7.7a	5.9b	20.6a-c	13.3bc	11.9bc	14.4ab	8.6b	30.1a	18.9bc	18.0bc
Prosper®	200	9.2a	6.1b	23.0bc	13.1bc	12.9cd	14.9ab	10.8b	34.4a-c	22.9d	20.8c-e
Prosper®	400	10.2ab	6.5b	21.9bc	14.7c	13.3cd	17.2b	10.3b	37.4a-c	21.6cd	21.6d-f
Helix®	200	15.5bc	7.0b	21.8bc	15.1c	14.8de	18.0b	10.4b	41.3c	20.5cd	22.5ef
Helix XTra®	400	19.6c	7.2b	24.2c	14.0c	16.3e	26.5c	10.7b	40.5bc	22.2cd	25.0f
	SE	2.6	1.0	2.6	1.4	1.0	3.8	1.4	5.0	1.9	1.7

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

Table 29. Effect of seed treatments on shoot biomass of open-pollinated and hybrid Argentine canola 28 days after seeding in late May in 2003-2006. [1]

		Shoot biomass - op (g/m-row)					Shoot biomass - hybrid (g/m-row)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	13.6a	4.1a	227.6ab	70.1a	78.8a	28.9a	7.2a	492.1ab	120.2a	162.1ab
Foundation Lite®	-	17.2ab	3.5a	196.1a	74.2a	72.7a	25.6a	6.1a	387.3a	124.5ab	135.9a
Assail 50 SF®	400	32.4bc	12.8b	217.1a	71.4a	83.4a	60.5a-c	20.6b	474.6ab	146.1a-c	175.4bc
Gaucho CS FL®	400	30.1bc	17.0bc	276.8bc	100.0b	106.0b	61.8a-c	23.3bc	484.3ab	151.8a-c	180.3b-d
Prosper®	200	40.5cd	17.4bc	306.5c	104.5b	117.2bc	50.1ab	26.1bc	533.0bc	173.9c	195.8c-e
Prosper®	400	42.6cd	14.5b	320.4c	101.1b	119.6bc	70.0bc	31.5c	522.9bc	159.0bc	195.9c-e
Helix®	200	48.1d	16.2bc	313.3c	85.6ab	115.8bc	93.2c	29.6c	551.8bc	163.5c	209.5de
Helix XTra®	400	73.4e	20.9c	312.2c	103.3b	127.4c	87.8bc	28.9bc	619.2c	162.6c	224.6e
	SE	7.6	2.5	28.6	11.2	7.9	19.2	4.1	56.1	17.0	15.5

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P $\geq$ 0.05). Means in 2003, 2004, 2005 and 2006 based on 40 plants.

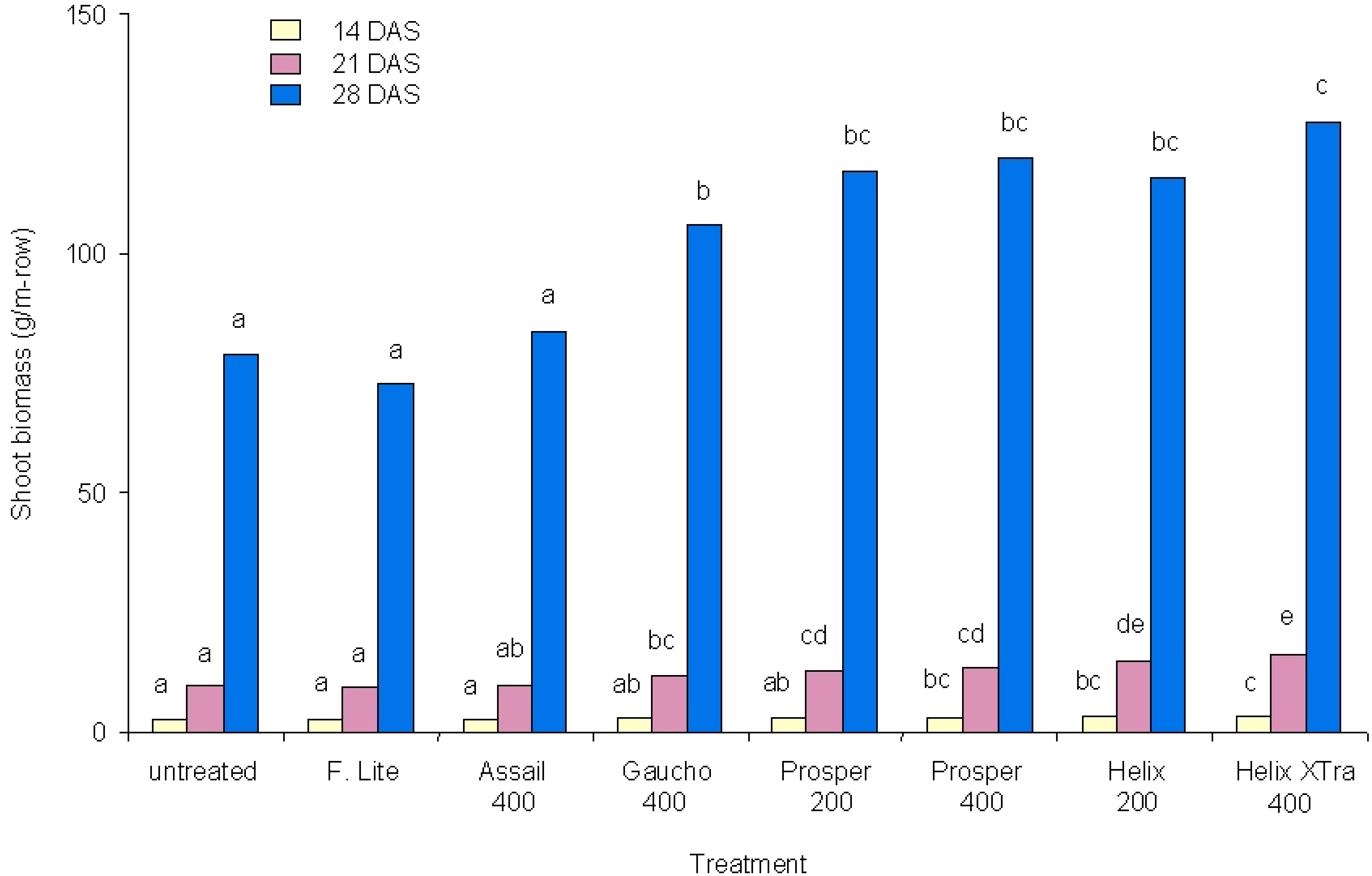

Fig. 17. Shoot biomass of untreated and treated open-pollinated Argentine canola 14, 21 and 28 days after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means are based on 160 plants.

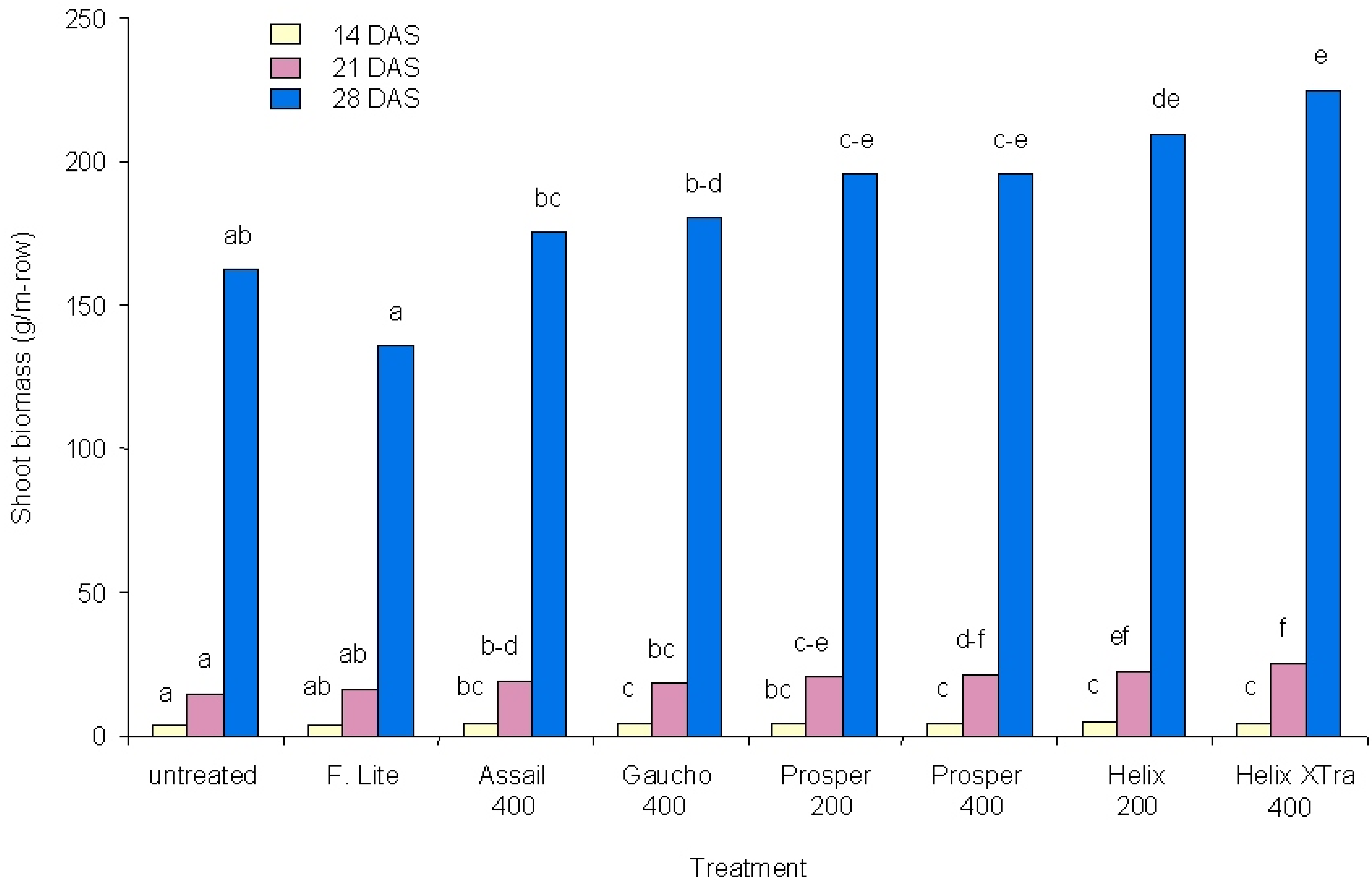

Fig. 18. Shoot biomass of untreated and treated hybrid Argentine canola 14, 21 and 28 days after seeding in late May in 2003-2006. For each sampling time, vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P \geq 0.05$). Means are based on 160 plants.

Table 30. Effect of seed treatments on seed yield of open-pollinated and hybrid Argentine canola seeded in late May in 2003-2006. [1]

		Yield - op (g/m^2)					Yield - hybrid (g/m^2)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	70.6a	188.6a	269.9ab	189.6a	179.7a	139.7ab	215.9a	322.1ab	236.6a	228.6a
Foundation Lite®	-	82.9ab	195.9ab	284.0bc	197.0ab	189.9ab	134.3a	222.4a	316.9a	243.0a	229.1a
Assail 50 SF®	400	94.5bc	258.1bc	261.8a	196.7ab	202.7bc	160.5cd	259.0bc	328.4a-c	245.7a	248.4b-d
Gaucho CS FL®	400	87.1ab	299.6c	291.7c	209.9bc	222.1d	147.9a-c	245.6ab	328.4a-c	243.7a	241.4b
Prosper®	200	89.2b	257.6bc	301.5c	201.3a-c	212.4cd	155.7b-d	264.8bc	329.8a-c	242.3a	248.1bc
Prosper®	400	107.3cd	260.9c	300.3c	210.1bc	219.7cd	164.2cd	256.8bc	335.1bc	240.1a	249.0b-d
Helix®	200	112.9d	266.7c	284.7bc	216.2c	220.1d	163.7cd	268.3bc	345.3c	250.1a	256.8cd
Helix XTra®	400	119.5d	267.1c	299.8c	206.1a-c	223.1d	167.6d	279.7c	331.4a-c	256.4a	258.8d
	SE	8.5	30.7	10.3	8.3	8.6	8.3	14.3	8.2	10.4	5.3

[1] Means within columns followed by the same letter are not significantly different (Fisher's protected LSD test, P ≥ 0.05).

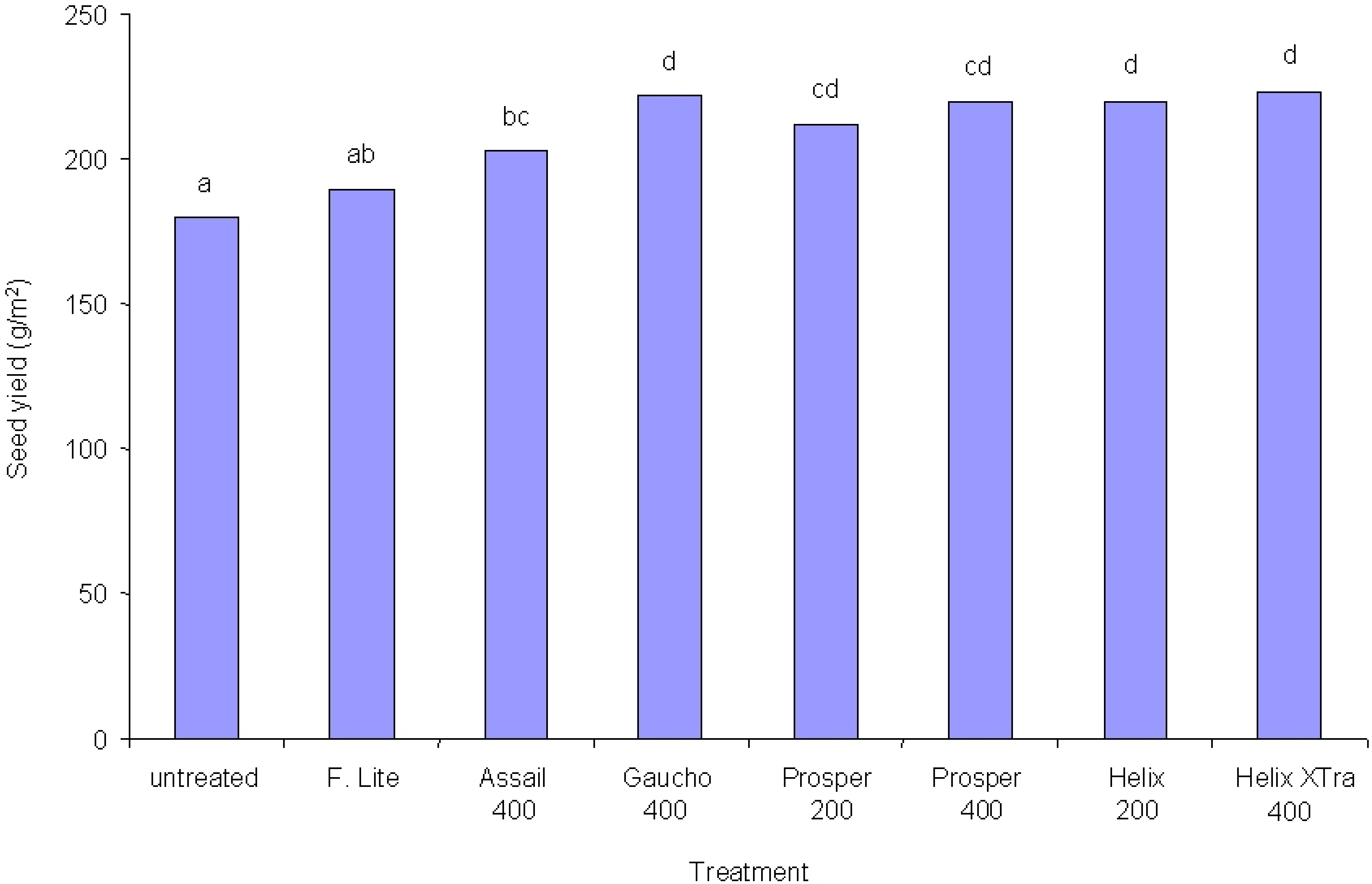

Fig. 19. Seed yield of untreated and treated open-pollinated Argentine canola seeded in late May in 2003-2006. Vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P > 0.05$).

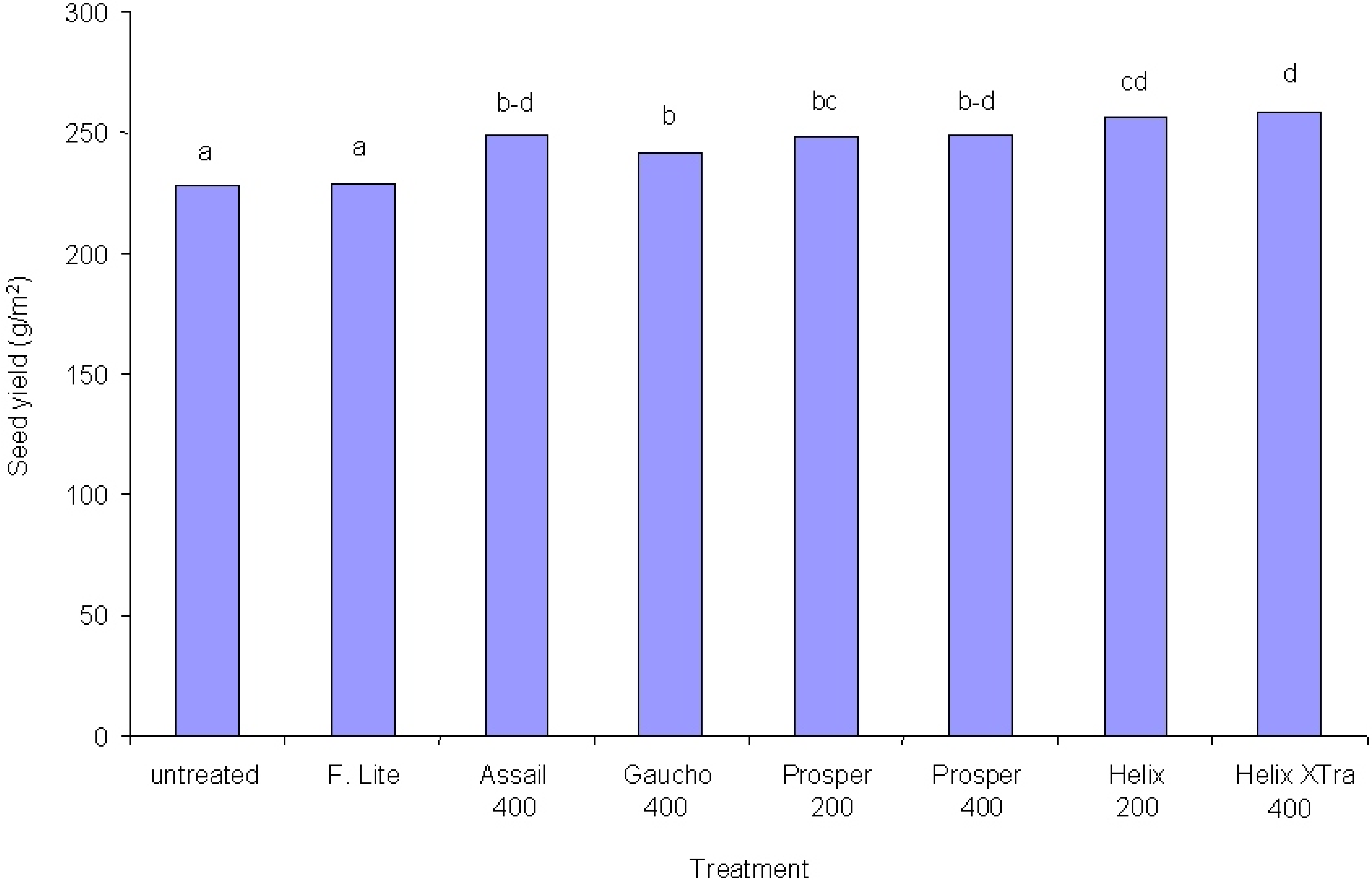

Fig. 20. Seed yield of untreated and treated hybrid Argentine canola seeded in late May in 2003-2006. Vertical bars with the same letter are not significantly different (Fisher's protected LSD test, $P > 0.05$).

Table 31. Effect of seed treatments on seed yield and economic returns of an open-pollinated Argentine cultivar seeded in late May in 2003-2006[1].

		Yield (bu/acre)					Economic return ($/acre)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	12.6	33.6	48.0	33.7	32.0	-	-	-	-	-
Foundation Lite®	-	14.8	34.9	50.6	35.1	33.8	-	-	-	-	-
Assail 50 SF®	400	**16.8**	**45.9**	46.6	35.0	**36.1**	$29.40	$86.10	-	$9.10	$28.70
Gaucho CS FL®	400	**15.5**	**53.3**	**51.9**	**37.4**	**39.5**	$20.30	$137.90	$27.30	$25.90	$52.50
Prosper®	200	**15.8**	**45.9**	**53.7**	35.8	**37.8**	$22.40	$86.10	$39.90	$14.70	$40.60
Prosper®	400	**19.1**	**46.4**	**53.5**	**37.4**	**39.1**	$45.50	$89.60	$38.50	$29.90	$49.70
Helix®	200	**20.1**	**47.5**	50.7	**38.5**	**39.2**	$52.50	$97.30	$18.90	$33.60	$50.40
Helix XTra®	400	**21.3**	**47.5**	**53.4**	36.7	**39.7**	$60.90	$97.30	$37.80	$21.00	$53.90
	LSD	3.1	11.4	3.8	3.1	3.0					

[1] Yields in bold print are significantly higher than untreated seed (Fisher's protected LSD test, $P \leq 0.05$). Economic return relative to untreated seed based on $7.00/bu canola.

Table 32. Effect of seed treatments on seed yield and economic returns of a hybrid Argentine cultivar seeded in late May in 2003-2006.[1]

		Yield (bu/acre)					Economic return ($/acre)				
Treatment	Rate	2003	2004	2005	2006	mean	2003	2004	2005	2006	mean
untreated	-	24.9	38.4	57.3	42.1	40.7	-	-	-	-	-
Foundation Lite®	-	23.9	39.6	56.4	43.3	40.8	-	-	-	-	-
Assail 50 SF®	400	**28.6**	**46.1**	58.5	43.7	**44.2**	$29.95	$53.90	$8.40	$11.20	$24.50
Gaucho CS FL®	400	26.3	43.7	58.5	43.4	**43.0**	$9.80	$37.10	$8.40	$9.10	$16.10
Prosper®	200	27.7	**47.1**	58.7	43.1	**44.2**	$19.60	$60.90	$9.80	$7.10	$24.50
Prosper®	400	**29.2**	**45.7**	59.6	42.7	**44.3**	$30.10	$51.10	$16.10	$4.20	$25.20
Helix®	200	**29.1**	**47.8**	**61.5**	44.5	**45.7**	$29.40	$65.80	$29.40	$16.80	$35.00
Helix XTra®	400	**29.8**	**49.8**	59.0	45.6	**46.1**	$34.30	$79.80	$11.90	$24.50	$37.80
	LSD	3.1	5.3	3.0	3.9	1.9					

[1] Yields in bold print are significantly higher than untreated seed (Fisher's protected LSD test, $P \leq 0.05$). Economic return relative to untreated seed based on $7.00/bu canola.

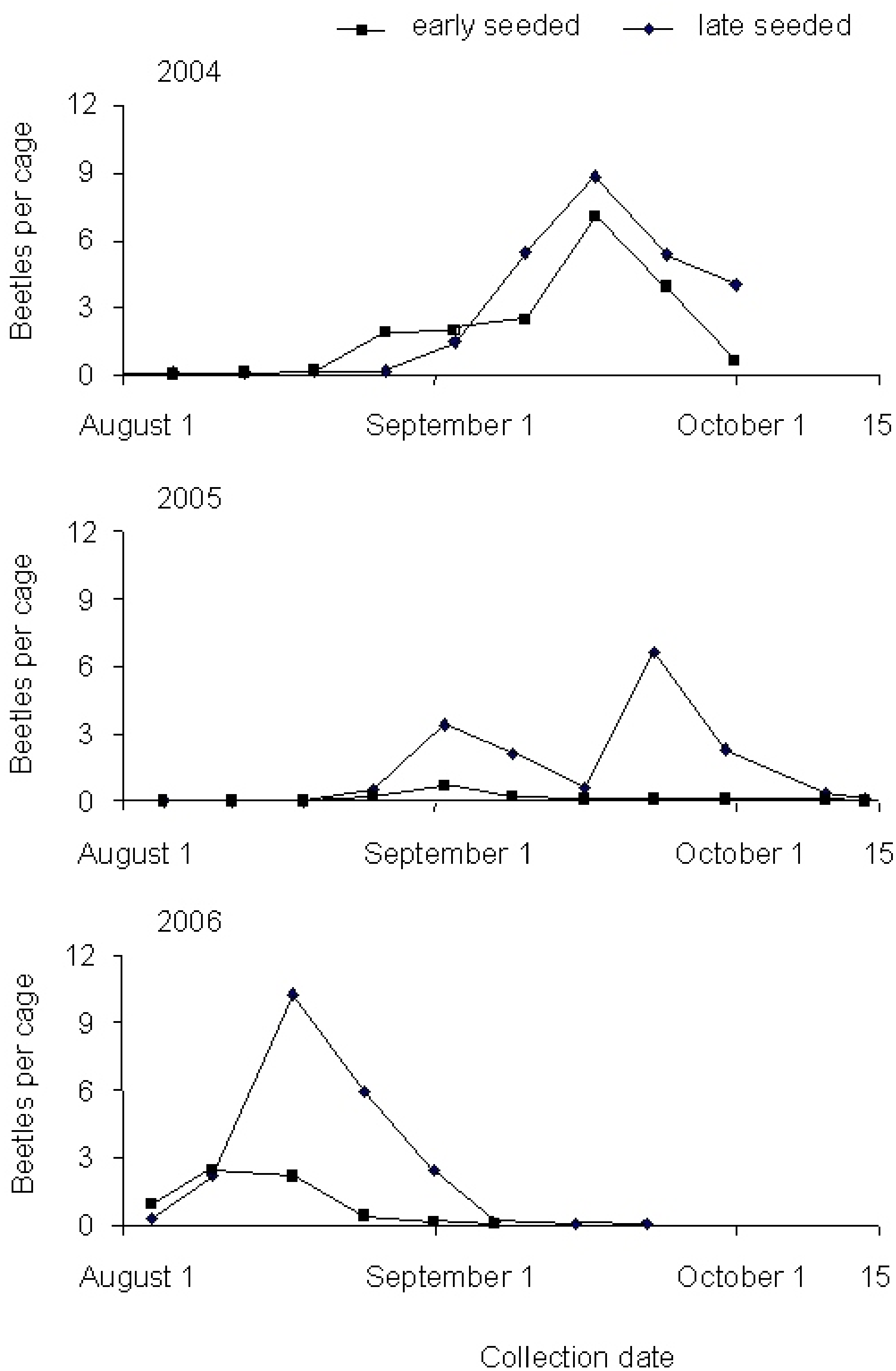

Fig. 21. Comparison of flea beetle emergence from plots seeded in early or late May 2004, 2005 and 2006.

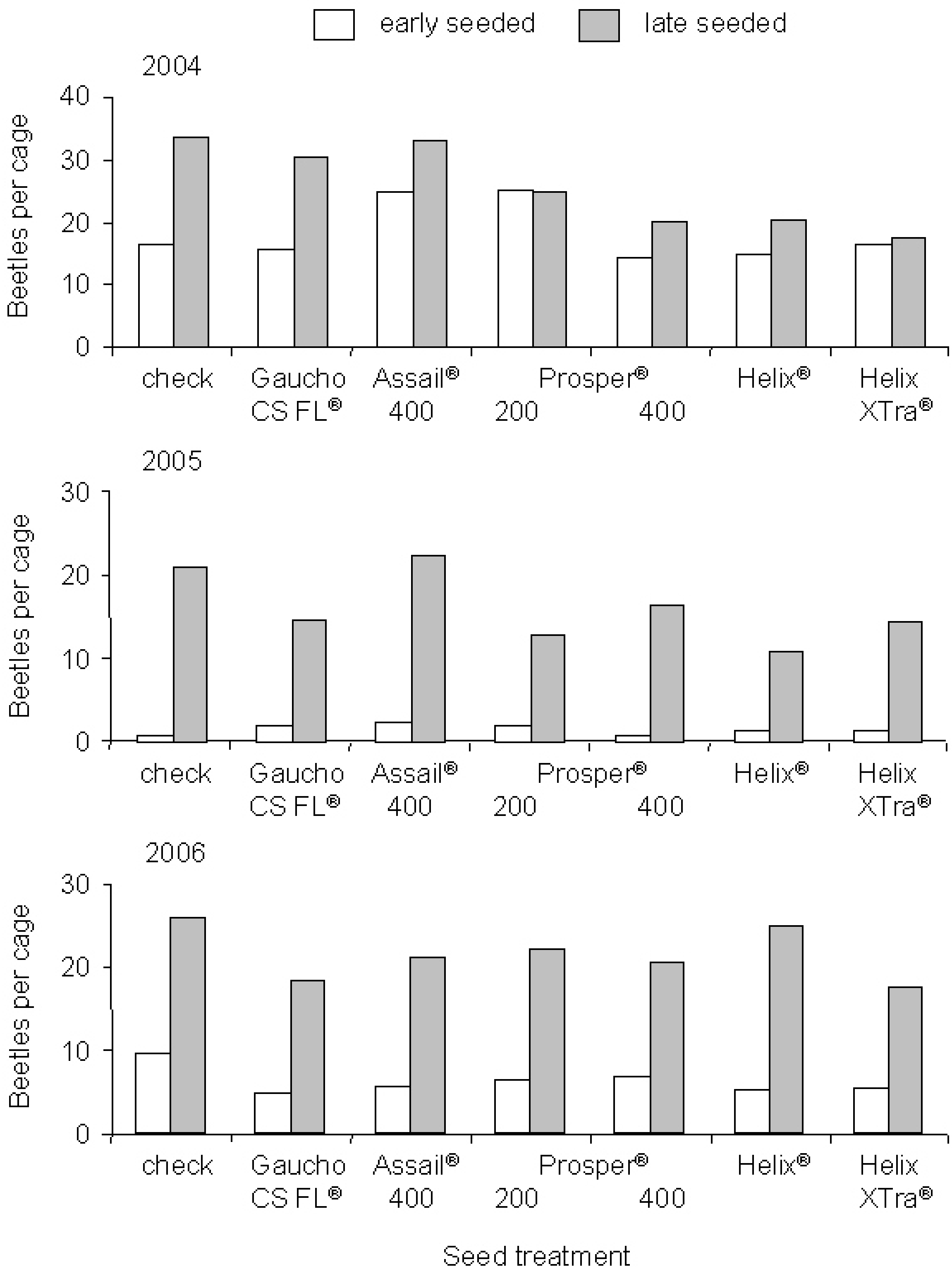

Fig. 22. Flea beetle emergence from untreated and treated Argentine canola seeded in early or late May 2004, 2005 and 2006.