CANOLA RESPONSE TO NITROGEN FERTILIZER TYPE AND PLACEMENT

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Abstract

The response of canola to granular nitrogen (N) fertilizers urea (46-O-O) and ammonium nitrate (34-O-O) placed with the seed, 0.5, 1 and 2" from the seed was examined in a field experiment at Scott, Saskatchewan in 1993 and 1994. The response of direct seeded canola to seed placed urea and ammonium nitrate was examined in a parallel experiment at Scott in 1994. Seed placed ammonium nitrate was as risky as similar rates of N as urea for canola emergence, seed yield and volume weight, whether seeding on fallow or direct seeding into stubble. If precipitation occurs shortly after seeding, then the severity of damage from seed placed N is reduced; however, the seed to fertilizer separation required to avoid damage is increased. Thus, although no crop damage occurred in 1993 when fertilizer was placed 0.5" from the seed (no precipitation during seed germination and seedling emergence), emergence was reduced in 1994 when seed and fertilizer were separated by this distance (precipitation soon after seeding). Therefore, 1" is an acceptable minimum distance between seed and fertilizer so as to avoid crop injury.

Introduction

Nitrogen (N) fertilizers can cause germination and seedling damage to cereal and oilseed crops when placed with the seed. Ammonium toxicity is the major mechanism of germination and seedling damage when urea (46-O-O) is the N source. In contrast, excess salinity is the major mechanism of damage with seed placed ammonium nitrate (34-O-O), because of its higher salt index. For cereal grains, suggested safe N rates of ammonium nitrate are about 25% higher than for urea (Farm Facts Bulletin 1994). Prior to 1993, it was assumed that oilseed crops also tolerated higher rates of seedplaced ammonium nitrate than urea.

However, research on the response of canola to seed placed urea and ammonium nitrate that was conducted in 1993 in Saskatchewan (Brandt 1993, unpublished data) and Alberta (Penny 1993), indicated that ammonium nitrate was just as damaging to seedlings as urea. This paper reports on the results of the Saskatchewan experiment that was conducted in 1993 and 1994, including information on how increasing seed/fertilizer separation influences canola tolerance to urea and ammonium nitrate. In addition, results are presented from a parallel experiment that examined the response of direct seeded canola to seed placed urea and ammonium nitrate at Scott in 1994.

Materials and Methods

The response of canola 'AC Parkland' to N fertilizer type and placement was examined in two field experiments conducted at the Agriculture and Agri-Food Canada Research Farm at Scott, Saskatchewan in 1993 and 1994. The soil at the site is an Elstow clay loam (Orthic Dark Brown Chemozem) with 4% organic matter content.

Experiment A (1993 and 1994). The land where the experiment was located was fallowed the previous year. The experiment was arranged in a split-plot design with four replicates per treatment. Main plot factor is fertilizer rate (0, 20, 40, 80 and 120 kg N ha^{-1}). The split-plot factor consisted of factorial combinations of fertilizer type (urea and ammonium nitrate) and distance between seed and fertilizer.

Seed and fertilizer were placed with separate double disc openers operating at the same depth (1 inch), with fertilizer placed in the same row as seed or at distances of 0.5, 1 or 2 inches to the side of the seedrow. Canola was seeded at 7 kg ha- 1 (9" row spacing) on May 27 in 1993 and May 16 in 1994. Seedling emergence (density) was measured 12 days after seeding. Seed yield (kg ha^{-1}), volume weight (kg hl^{-1}) and percentage green seed (1993 only) also were measured.

Experiment B (1994). The land where this experiment was located was sown to barley the previous year. The experiment was arranged in a split-block design with three replicates per treatment. Main plot factor is fertilizer type (urea and ammonium nitrate). The strip-plot factor is fertilizer rate (0, 5, 15, 25 and 50 kg N ha^{-1} seed placed). Canola was direct seeded at a rate of 7 kg ha^{-1} and at a depth of 1/2 to 3/4" (knife openers at 9" row spacing) on May 2 in 1994 using an air drill with side banding capability. Each strip-plot received a total of 80 kg N ha^{-1}. For example the plot that received 25 kg N ha^{-1} seed placed also received 55 kg N ha^{-1} side banded. Phosphorus was applied at a rate of 20 kg P_2O_5 ha^{-1} in all plots.

Data analyses. For consistency, all data were expressed as a percentage of the untreated controls. Rate-response curves (quadratic and exponential decay) were fitted to the data by non-linear regression procedures. Regression curves were statistically compared by using the parameter estimates as described by Ratkowksy (1983).

Results and Discussion

Experiment A. Daily precipitation during the growing season at Scott, Saskatchewan in 1993 and 1994 is shown in Figure 1. The response of canola to N fertilizer type and placement differed between 1993 (Figure 2 and Table 1) and 1994 (Figure 3 and Table 2). Less crop injury in 1994 was likely explained by precipitation soon after seeding, whereas in 1993, no precipitation occurred during the time of seed germination and seedling emergence. Seedling emergence in 1993 was similarly reduced by urea and ammonium nitrate placed in the seed row. A 0.5" separation between seed and fertilizer was sufficient to alleviate any seedling emergence damage. Canola yield illustrated a similar pattern, with yield reduced equally with increased rates of urea or ammonium nitrate placed in the seed row, but no yield loss when seed was separated from fertilizer. Seed volume weight was decreased equally by seed placed urea and ammonium nitrate. However, volume weight increased with increased rates of urea and ammonium nitrate placed 0.5 and 1" from the seed row, and was unaffected at a 2" seed:fertilizer separation. The reduced volume weight of canola seed in the seed placed treatment is reflected in the percentage of green seed, which is markedly and equally increased with increased rates of urea or ammonium nitrate.

In contrast to 1993, seedling emergence in 1994 was reduced when the seed and fertilizer rows were separated by 0.5". A possible explanation why the crop was injured in 1994 but not the previous year may be due to the significant amount of precipitation that occurred soon after seeding. This may have resulted in toxic levels of ammonia near the seed. Urea and ammonium nitrate similarly reduced emergence when placed in the seed row and at 0.5" separation. Seedling emergence was unaffected by either N fertilizer at 1" separation or greater. Canola yield was not affected by urea or ammonium nitrate at all placements. Markedly higher plant densities in 1994 than in 1993 (see footnote 'z' in Tables 1 and 2) may have masked any detrimental effect of seed placed N on yield, despite reduced emergence. Similar to yield, seed volume weight was not reduced by increased rates of the N fertilizers, but equally increased with increased rates of urea or ammonium nitrate placed 1" from the seed row.

Table 1. Parameter estimates of the equations for the regression curves for the response of canola to N fertilizer type and placement at Scott in 1993.

Treatment[z]		a[y]	b	c	R^{2x}
Emergence (m^{-1})					
U	0	101.9	-0.034		0.96**
AN	0	101.3	-0.038		0.86**
U	0.5	108.0	-0.341	0.0005	0.19
AN	0.5	102.0	0.238	-0.0018	0.03
U	1	102.5	-0.356	0.0015	0.17
AN	1	96.8	0.090	-0.0015	0.10
U	2	97.5	-0.048	-0.0010	0.18
AN	2	98.7	0.133	-0.0004	0.02
Yield (kg ha^{-1})					
U	0	110.3	-0.370	-0.0028	0.70**
AN	0	104.6	-0.132	-0.0032	0.72**
U	0.5	108.1	0.040	0.0001	0.01
AN	0.5	99.4	-0.188	0.0019	0.10
U	1	99.9	-0.010	0.0002	0.01
AN	1	97.4	-0.139	0.0022	0.19
U	2	97.7	-0.181	0.0018	0.10
AN	2	97.9	-0.033	0.0005	0.02
Volume Wt. (kg hl^{-1})					
U	0	101.0	-0.110	0.0002	0.64**
AN	0	100.4	-0.079	0.0003	0.51**
U	0.5	100.0	0.003	0.0001	0.34**
AN	0.5	100.0	0.014	-0.0001	0.34**
U	1	99.9	0.004	0.0001	0.22*
AN	1	100.0	0.007	0.0001	0.24*
U	2	99.9	0.021	-0.0002	0.13
AN	2	100.0	-0.023	0.0002	0.07
Green seed (%)					
U	0	106.3	5.556	0.0183	0.89**
AN	0	165.1	-0.101	0.0498	0.72**
U	0.5	99.7	0.661	-0.0016	0.16
AN	0.5	100.0	0.223	-0.0020	0.01
U	1	101.9	-0.304	0.0001	0.06
AN	1	97.1	-0.778	0.0053	0.04
U	2	96.8	0.573	-0.0020	0.08
AN	2	114.0	2.44	-0.0147	0.10

[z]Mean values in control (unfertilized) plots: *Emergence* (m^{-1}) - 0"=61, 0.5"=65, 1"=70, 2"=69; Yield (kg ha-l) - 0"=1563, 0.5"=1613, 1"=1648, 2"=1706; ***Volume*** *wt* (kg hl^{-1}) - 0"=67.7, 0.5"=67.5, 1"=67.6, 2"=67.7; Green ***seed*** (%) - 0"=3.5, 0.5"=4.6, 1"=4.6, 2"=3.8.

[y]Exponential function equation: $y = a\, e^{bx}$ where a = intercept (% of control) and ab = initial slope; quadratic function equation: $y = a + bx + cx^2$ where a = intercept (% of control), ***b*** = linear coefficient, and c = curvilinear coefficient; y is the plant variable (% of control) and x is the fertilizer rate (kg N ha-l).

[x]Coefficient of determination: significant at the 5% level (*), 1% level (**).

Table 2. Parameter estimates of the equations for the regression curves for the response of canola to N fertilizer type and placement at Scott in 1994.

Treatment[z]		a[y]	b	c	R^{2x}
Emergence (m^{-1})					
U	0	101.6	-0.232	0.0005	0.31*
AN	0	101.2	-0.703	0.0043	0.53**
U	0.5	101.3	-0.225	0.0003	0.31*
AN	0.5	98.3	-0.535	0.0023	0.33**
U	1	100.7	0.211	-0.0010	0.19
AN	1	100.2	0.146	-0.0012	0.03
U	2	102.0	0.114	-0.0011	0.04
AN	2	100.7	-0.062	0.0006	0.01
Yield (kg ha^{-1})					
U	0	103.7	0.319	-0.0022	0.12
AN	0	106.6	-0.015	0.0006	0.02
U	0.5	102.1	0.203	-0.0018	0.03
AN	0.5	101.5	0.274	-0.0024	0.05
U	1	104.3	0.464	-0.0039	0.16
AN	1	102.1	0.058	-0.0006	0.01
U	2	103.0	0.156	-0.0018	0.06
AN	2	101.2	0.074	-0.0010	0.03
Volume Wt. (kg hl^{-1})					
U	0	100.0	-0.003	0.0001	0.10
AN	0	100.1	-0.004	0.0001	0.04
U	0.5	100.3	0.002	0.0001	0.11
AN	0.5	100.2	0.006	-0.0001	0.15
U	1	100.2	0.024	-0.0001	0.44**
AN	1	100.3	0.013	-0.0001	0.35**
U	2	100.0	-0.005	0.0001	0.10
AN	2	99.9	0.005	-0.0001	0.09

[z]Mean values in control (unfertilized) plots: *Emergence* (m-l) - 0"=102, 0.5"=115, 1"=116, 2"=116; Yield (kg ha-l) - 0"=1217, 0.5"=1362, 1"=1304, 2"=1316; *Volume wt* (kg hl^{-1}) - 0"=68.0, 0.5"=67.6, 1"=67.4, 2"=67.8.

[y]Quadratic function equation: $y = a + bx + cx^2$ where a = intercept (% of control), *b* = linear coefficient, and c = curvilinear coefficient; y is the plant variable (% of control) and x is the fertilizer rate (kg N ha-l).

[x]Coefficient of determination: significant at the 5% level (*), 1% level (* *).

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Figure 1. Seeding dates in relation to daily precipitation during the growing season at Scott, Saskatchewan in 1993 (top) and 1994 (bottom).

Figure 2. Emergence, yield, volume weight and percentage green seed of canola as affected by N fertilizer type and placement at Scott, Saskatchewan in 1993.

Figure 3. Emergence, yield and volume weight of canola as affected by N fertilizer type and placement at Scott, Saskatchewan in 1994.

Experiment B. Canola yield was significantly reduced by increased rates of seed placed urea and ammonium nitrate (Figure 4 and Table 3). There was no difference in canola yield response to these two N fertilizers. Although 2 mm of precipitation occurred soon after canola was direct seeded into barley stubble on May 2 in 1994 (Figure 1), it likely did not reach either the seed or fertilizer. Although yield was reduced, seed volume weight was not affected by urea or ammonium nitrate.

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Figure 4. Yield and volume weight of canola as affected by seed placed urea (dotted line) and ammonium nitrate fertilizer (solid line) at Scott, Saskatchewan in 1994 (Experiment B).

Table 3. Parameter estimates of the equations for the regression curves for the response of direct-seeded canola to N fertilizer type at Scott in 1994.

Treatment[z]	ay	b	c	R^{2x}
Yield (kg ha^{-1})				
U	**98.9**	**-0.773**	**0.0099**	**0.52”” **
AN	**100.5**	**-0.87 1**	**0.0102**	**0.33”” **
Volume Wt. (kg hl^{-1})				
U	‘100.1	-0.006	0.0003	0.04
AN	99.8	-0.034	0.0005	0.13

[z]Mean values in control plots: Yield (kg ha^{-1}) - U=1458, AN=1404; *Volume wt* (kg hl^{-1}) - U=67.5, AN=68.0.

[y]Quadratic function equation: $y = a + bx + cx^2$ where a = intercept (% of control), *b* = linear coefficient, and c = curvilinear coefficient; y is the plant variable (% of control) and x is the fertilizer rate (kg N ha^{-1}).

[x]Coefficient of determination: significant at the 5% level (*), 1% level (**).

Conclusion

Seed placed ammonium nitrate can be as risky as similar rates of N as urea for canola production, whether seeding into a prepared seedbed or direct seeding into stubble. Therefore, producers that are considering placing a portion of their N fertilizer requirements with the seed should use urea, which also is cheaper and more readily available than ammonium nitrate. If precipitation occurs shortly after seeding, then the severity of damage from seed placed N is reduced; however, the seed to fertilizer separation required to avoid damage is increased. Thus, although no crop damage occurred in 1993 when fertilizer was placed 0.5" from the seed (no precipitation during seed germination and seedling emergence), emergence was reduced in 1994 when seed and fertilizer were separated by this distance (precipitation soon after seeding). Therefore, 1" is an acceptable minimum distance between seed and granular N fertilizer so as to avoid crop injury.

Acknowledgments

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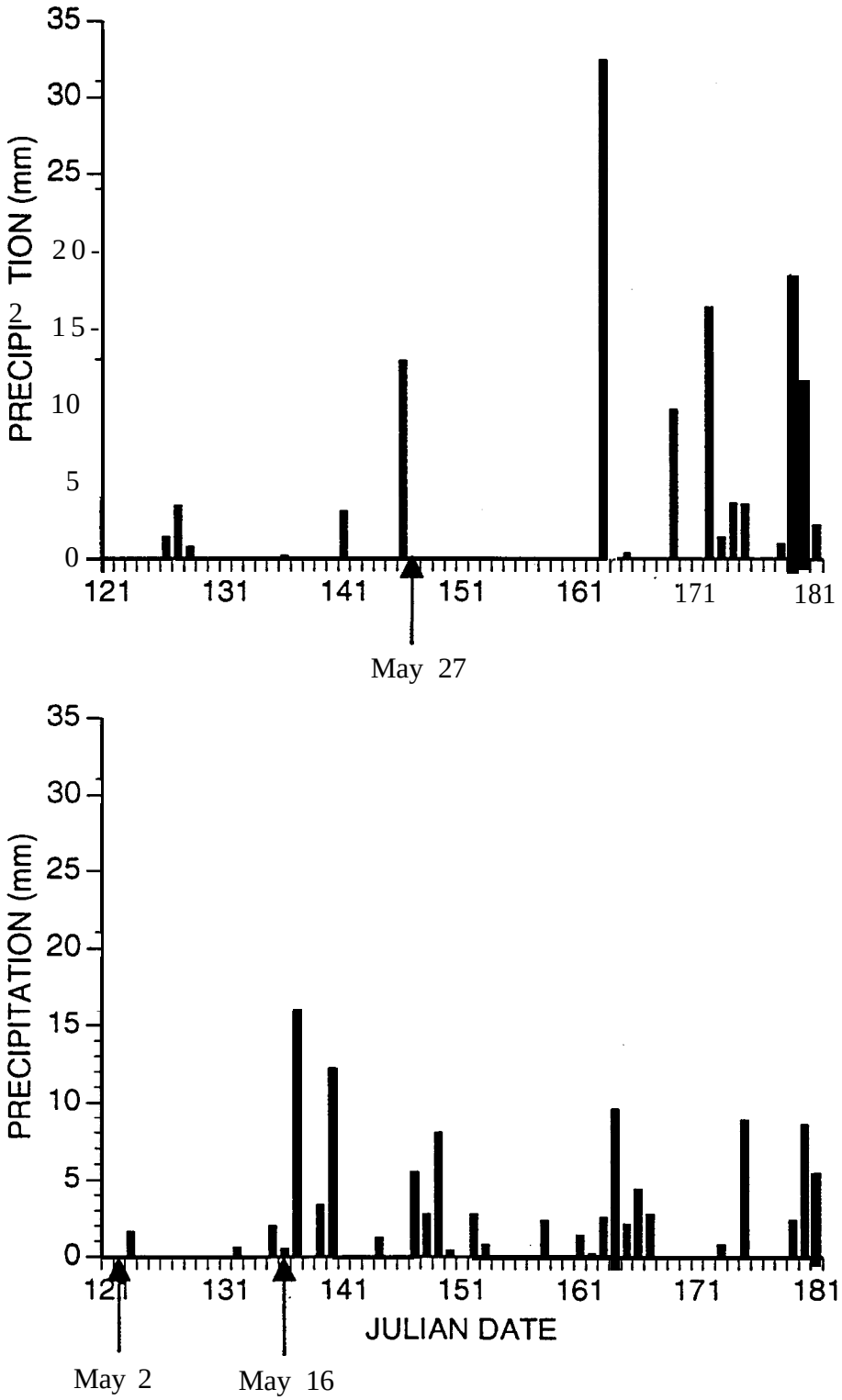

(Experiment B) (Experiment A)

Figure I. Seeding dates in relation to daily precipitation during the growing season at Scott, Saskatchewan in 1993 (top) and 1994 (bottom).

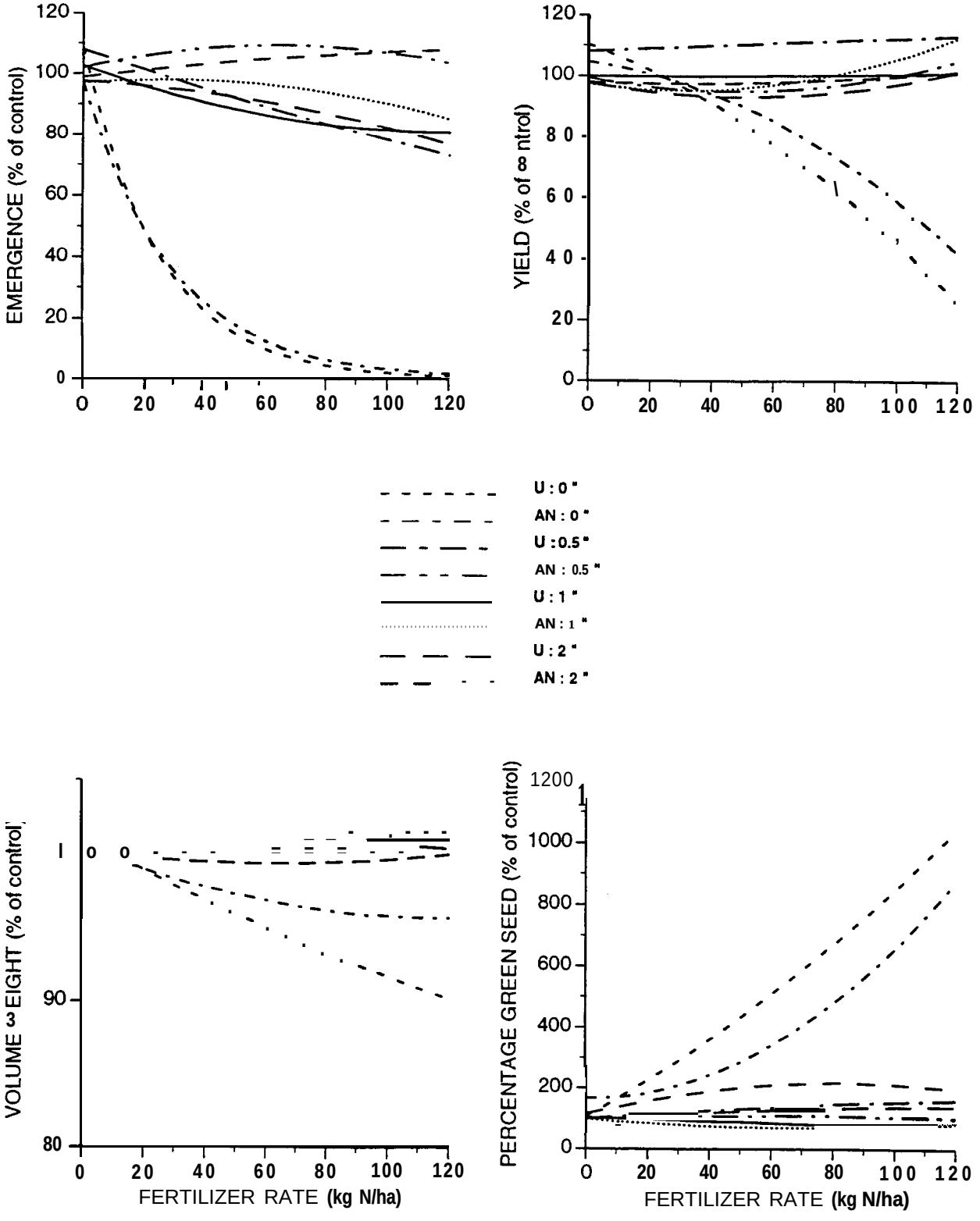

Figure 2. Emergence, yield, volume weight and percentage green seed of canola as affected by ***N*** fertilizer type and placement at Scott, Saskatchewan in 1993.

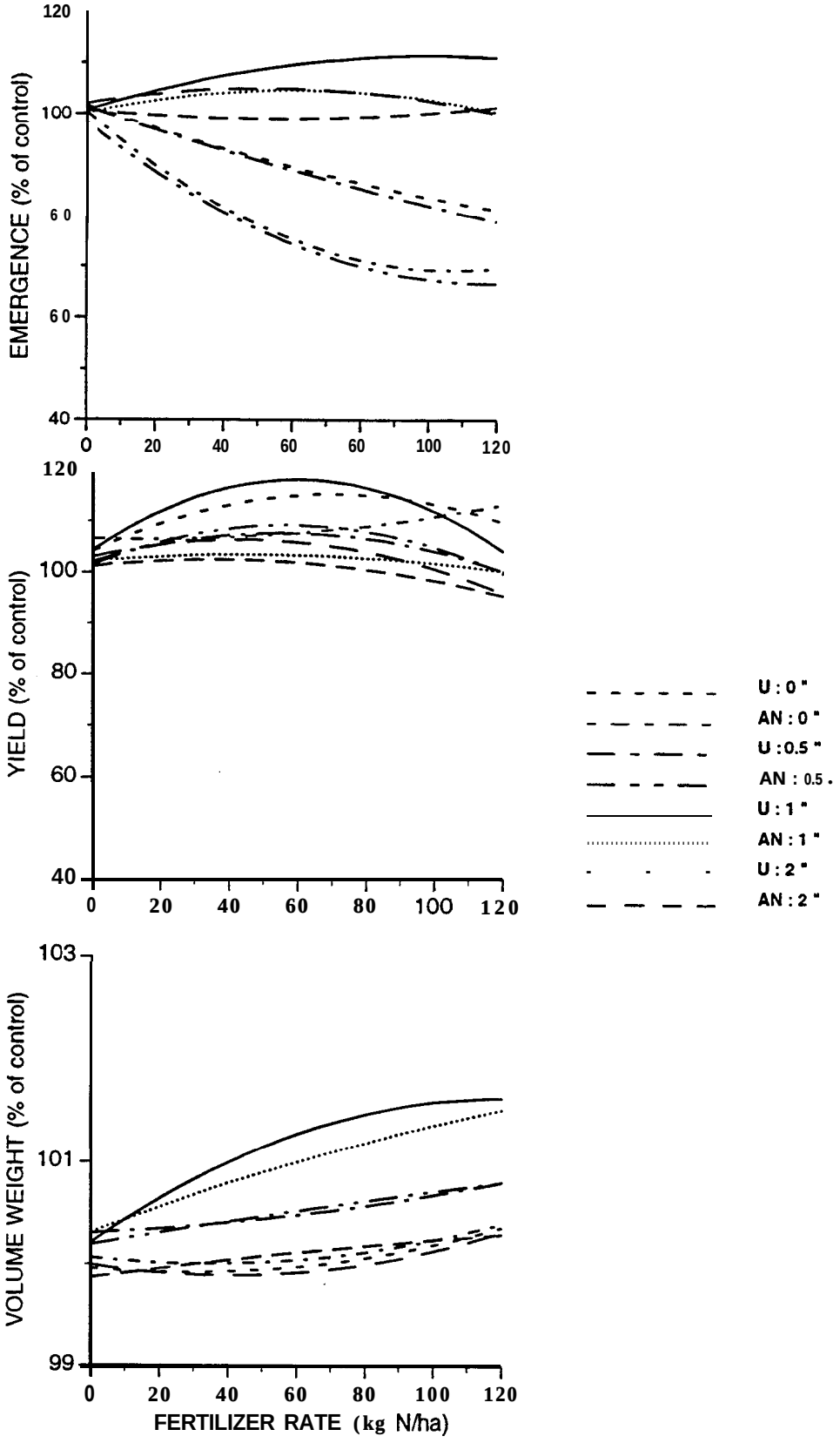

Figure 3. Emergence, yield and volume weight of canola as affected by N fertilizer type and placement at Scott, Saskatchewan in 1994.

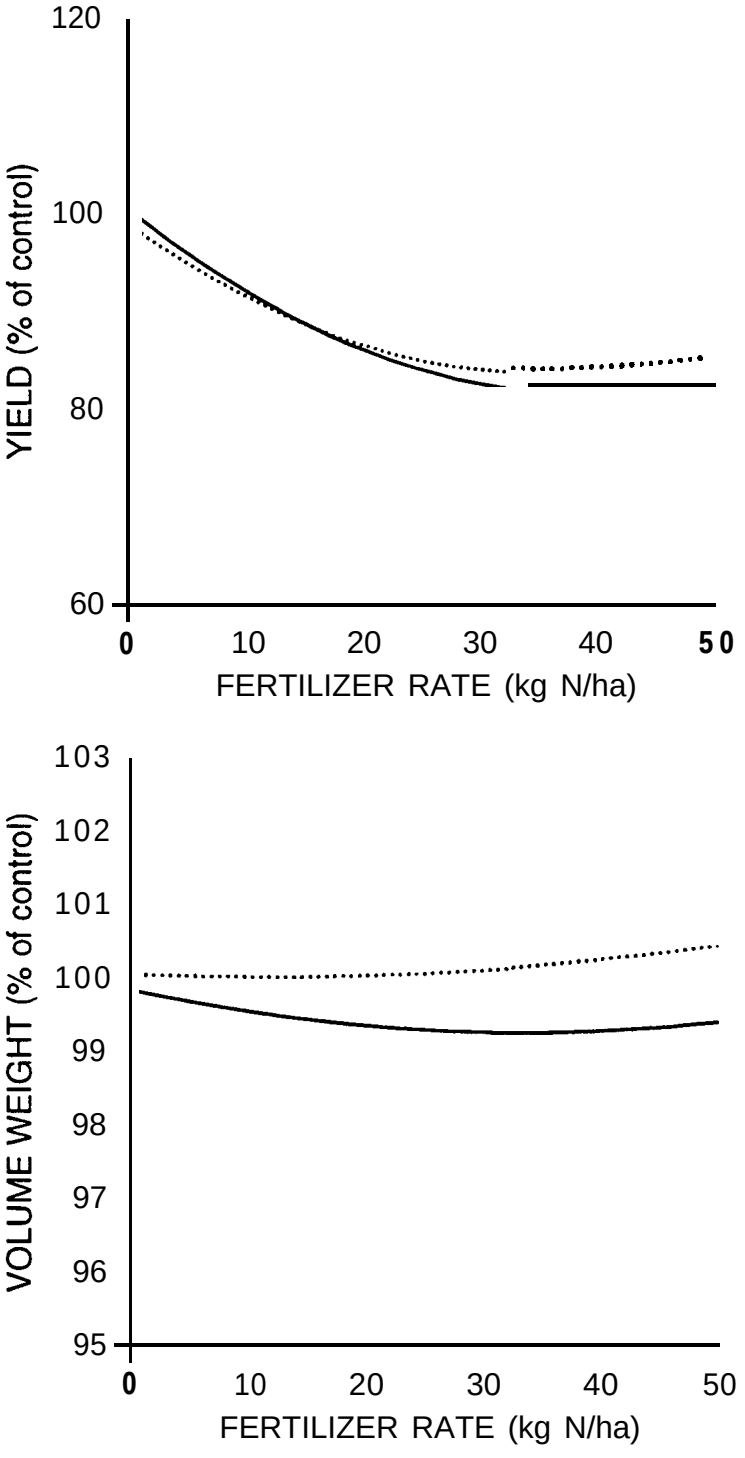

Figure 4. Yield and volume weight of canola as affected by seed placed urea (dotted line) and ammonium nitrate fertilizer (solid line) at Scott, Saskatchewan in 1994 (Experiment B).