OPTIMAL N FERTILIZER RATES FOR MAXIMUM ECONOMIC YIELD OF SUNOLA

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Abstract. A 3-year study was established at Melfort in the Black soil zone and at Scott in the Dark Brown soil zone in 1993 to determine optimal rates of N fertilizer for maximum economic yield (M.E.Y.) of sunola under different tillage systems. Likely because of good soil moisture conditions during the growing season, there was no difference between conventional tillage and direct seeded plots in sunola yield response to N fertilization at either location. As expected, a higher rate of N fertilizer was required to attain M.E.Y. at Melfort than at Scott because of the greater yield potential in the Black soil zone.

INTRODUCTION

Sunola is a miniature sunflower (*Helianthus annuus* L.), 0.6- to 0.9-m tall, which was registered in 1992 by Agriculture Canada. It was grown on approximately 19,000 ha in Saskatchewan in 1993. Time from seeding to crop maturity is similar to spring wheat (99 to 103 days). The recommended seeding rate is 10 kg ha^{-1}, with a 15- to 30-cm row spacing, and a seeding depth of 4 to 5 cm (Sask. Agric. & Food 1993).

Sunola compares favorably with canola. It has outyielded canola by an average of 15% and has a more stable yield than canola over a wide range of environments. The seed oil content is 4 to 5% higher than canola and the oil is relatively high in polyunsaturates. As well, there is no chlorophyll in the seed to cause downgrading. Sunola is immune to blackleg but susceptible to sclerotinia. It is not attacked by flea beetles or most other canola pests.

Sunola is an alternative cash crop that can enhance diversification in Saskatchewan and improve net economic returns for farmers. This is particularly important in the drier regions of the province where fewer crops can be grown sucessfully compared with the Parkland region. Drought, heat, and frost tolerance of sunola are higher than for canola, flax, or mustard, which makes it a good stubble crop in the Dark Brown and Black soil zones.

There is a lack of information on the response of sunola to N fertilization. Current fertilizer recommendations are vague. Information is required on optimal rates of N fertilizer with respect to maximum economic yield (M.E.Y.) of sunola in different agroecological zones. Because the microclimate and soil physical and biochemical properties may differ between conventional tillage (C.T.) and direct seeding (D.S.) cropping systems, the response of sunola to N fertilization may be affected by preseeding tillage. Therefore, a 3-year study was established at Melfort in the Black soil zone and at Scott in the Dark Brown soil zone in 1993 to determine optimal rates of N fertilizer for M.E.Y. of sunola under different tillage systems.

MATERIALS AND METHODS

This study was established in 1993 at the Agriculture Canada Research Station at Melfort and Experimental Farm at Scott, Saskatchewan. The experiments were arranged in a Randomized Complete Block (split-plot) design with four replicates per treatment. Main plots consisted of 2 tillage treatments: 1) conventional tillage (C.T) with one preseeding tillage operation using a field cultivator with mounted harrows; and 2) direct seeding (D.S) into barley (*Hordeum vulgare* L.) stubble. Split-plots (2 by 6 m) comprised 6 N fertilizer (urea) rates (0, 25, 50, 75, 100, and 150 kg N ha^{-1}) banded at 7.5 to 10-cm depth prior to seeding. Fertilizer P (triple superphosphate) was side-banded at a rate of 25 kg P_2O_5 ha^{-1} based on soil tests. Fertilizer S was not applied at Melfort and Scott because available soil levels were high. Sunola was seeded at a rate of 15 kg viable seed ha^{-1} on May 13 at Melfort using a disc drill with 18-cm row spacings, and on May 18 at Scott using a hoe drill with 20-cm row spacings. Sunola was harvested at Melfort on September 17 and at Scott on October 4.

The data was analyzed using nonlinear regression procedures. A quadratic model was used to describe sunola yield response to N fertilizer. Economic evaluation of N fertilizer rates for M.E.Y. was conducted using Net Present Value (NPV) criterion (Malhi et al. 1993). The NPV was calculated as follows:

$$NPV = -P_f F + P_y(Y-Y_o)\ (1 + r)^{-t}$$

where:

NPV = net present value ($/ha)
P_f = price of N fertilizer ($/kg N)
F = rate of N fertilizer (kg N/ha)
P_y = price of sunola ($/kg seed)
Y = sunola yield with N fertilizer (kg/ha)
Y_o = sunola yield without N fertilizer (kg/ha)
r = interest rate available on off-farm investments of comparative risk (%)
t = time interval between fertilizer purchase and sunola harvest (yr)

Values assigned to the parameters were: P_f = $0.55/kg N for urea fertilizer; P_y = $0.33/kg seed; r = 15%; and t = 0.5 yr. Values for Y and Y_o were determined from the regression equations for the yield response curves.

As an alternative to the NPV criterion, a second economic analysis to determine N fertilizer recommendations for M.E.Y. was based on a minimum acceptable marginal rate of return (i.e. return on the last portion of the fertilizer applied) of 1.5 times the cost of the fertilizer. This type of analysis has traditionally been used by Plains Innovative Laboratory Services (formerly Saskatchewan Soil Testing Lab) This takes into account the cost associated with handling the additional yield, interest costs associated with the fertilizer investment between the time of purchase and sale of the crop, and risk involved due to the unpredictability of fertilizer responses in any given year.

RESULTS AND DISCUSSION

The 1993 growing season was wetter and cooler than normal (Table 1). Physical and chemical properties of soils at the two sites illustrate the contrasting inherent fertility of the two soils (Table 2).

Table 1. Growing season weather at Melfort and Scott, Saskatchewan in 1993.

	Precipitation		Temperature	
	Amount	% of 30-yr mean	Av. daily	% of 30-yr mean
Melfort	mm	%	C	%
May	13	34	11.0	107
June	119	167	13.2	86
July	158	245	15.2	87
August	46	84	15.4	96
Scott				
May	24	72	11.2	109
June	102	153	12.7	88
July	86	143	14.3	83
August	37	80	14.9	93

Because soil moisture conditions were good to excellent during sunola growth and development, the crop responded well to N fertilizer (Figure 1). The marked yield response also was due to low preseeding soil residual nitrate-N (NO_3-N) levels at Melfort and Scott (25 and 15 kg ha^{-1}, respectively). Sunola yields were not

Table 2. Description of soil profiles at Melfort and Scott, Saskatchewan.

Melfort silty clay (Orthic Black Chernozem) at Melfort					
Soil horizon	Ah	Ah	Bm	Ck	Ck
Lower boundary (m)	0.15	0.30	0.60	0.90	1.5
Organic carbon (mg g^{-1})	55	35	13	5	5
Sand (mg g^{-1})	160	160	130	80	80
Clay (mg g^{-1})	440	440	590	750	740
F. C. [0.033 MPa] (m m^{-1})	0.48	0.48	0.50	0.54	0.59
P. W. P. [1.5 MPa] (m m^{-1})	0.27	0.27	0.30	0.35	0.37
pH	6.0	6.5	7.0	8.0	8.0
Bulk density (Mg m^{-3})	1.2	1.2	1.4	1.4	1.4
Elstow clay loam (Orthic Dark Brown Chernozem) at Scott					
Soil horizon	Ah	Bm	Bm	Ck	Ck
Lower boundary (m)	0.15	0.30	0.60	0.90	1.5
Organic carbon (mg g^{-1})	25	12	8	5	5
Sand (mg g^{-1})	270	270	220	230	350
Clay (mg g^{-1})	310	310	350	430	390
F. C. [0.033 MPa] (m m^{-1})	0.38	0.38	0.36	0.45	0.39
P. W. P. [1.5 MPa] (m m^{-1})	0.19	0.19	0.18	0.20	0.20
pH	7.4	7.6	7.8	8.0	8.0
Bulk density (Mg m^{-3})	1.3	1.3	1.3	1.3	1.6

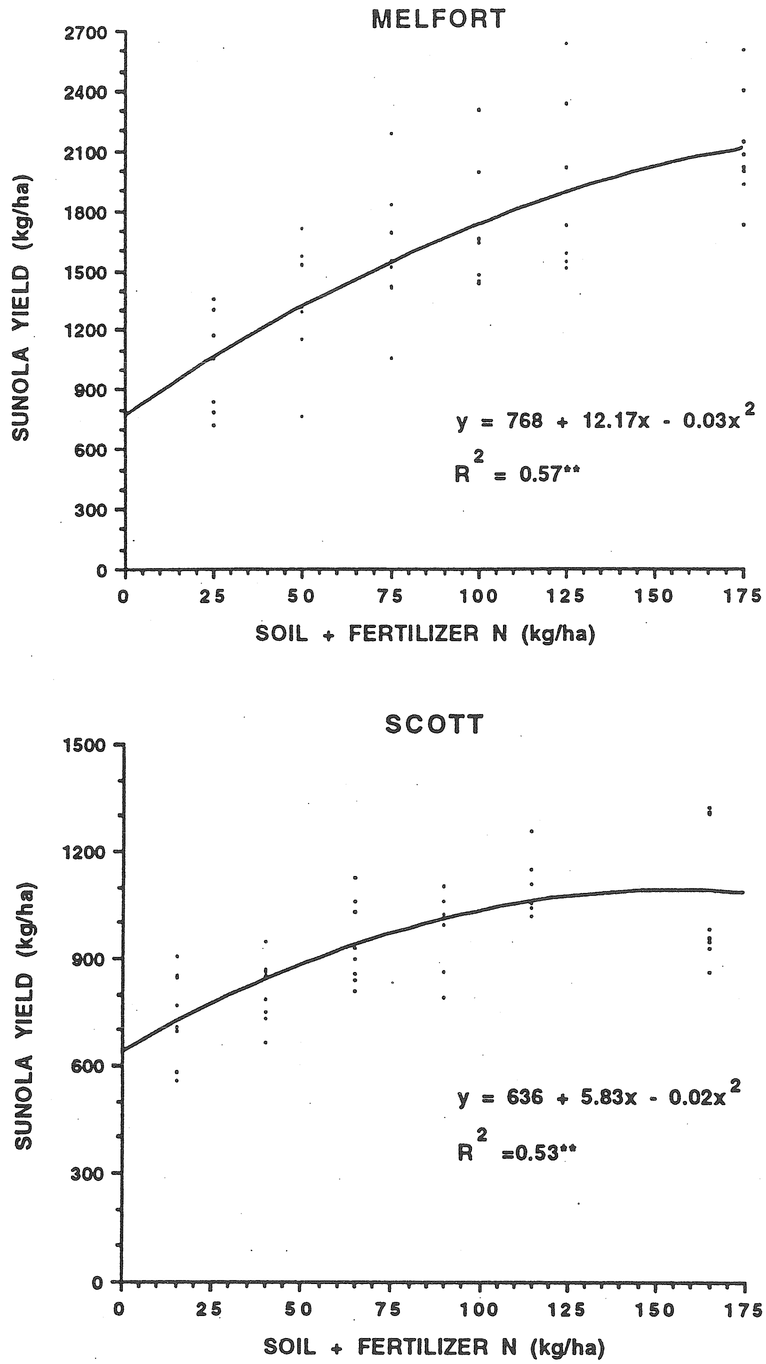

Figure 1. Response of sunola yield to N fertilizer at Melfort and Scott, Saskatchewan in 1993 (** - significant at $P = 0.01$).

significantly different between C.T. and D.S. tillage treatments at Melfort and Scott, probably because of favorable moisture conditions. Four weeks after emergence, crop densities in C.T. and D.S. plots at Melfort also were similar (26 and 28 plants m^{-2}, respectively, averaged across fertilizer treatments). At Scott, sunola plant densities in D.S. plots were significantly less than in C.T. plots (12 versus 18 plants m^{-2}). However, this did not translate into yield differences between tillage treatments at maturity.

Yield responses to N fertilizer were best described by a quadratic (second-order polynomial) model. Although yield plateaued at the highest fertilizer rate (150 kg N ha^{-1}) at Scott, higher rates would have been necessary at Melfort for the yield response to significantly decline. Unfertilized yields at Melfort and Scott were 1035 and 740 kg ha^{-1}, respectively. Yields at the highest rate of N fertilizer applied at Melfort were 2110 kg ha^{-1} at 1080 kg ha^{-1} at Scott.

The M.E.Y., according to NPV analysis, was attained at fertilizer rates of 150 and 95 kg N ha^{-1} at Melfort and Scott, respectively (or 175 and 110 kg soil + fertilizer N ha^{-1}). Using the ratio of marginal return to marginal cost of 1.5, the same N fertilizer rate was calculated for Melfort. However, a fertilizer rate of only 75 kg N ha^{-1} (90 kg soil + fertilizer N ha^{-1}) was required at Scott for M.E.Y. The fertilizer recommendations will be less if the farmer's yield goal is lower than the M.E.Y. These recommendations are only preliminary and should be placed in the context of favorable soil moisture conditions during much of the growing season in 1993. Results from future years with more normal weather conditions during the growing season will provide a firmer foundation for N fertilizer recommendations for sunola in the Dark Brown and Black soil zones.

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