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Nitrogen Sources and Rates for Direct-seeded and Transplanted Head Lettuce

J.L. Walworth[1], D.E. Carling[2], and G.J. Michaelson
Department of Plant and Animal Sciences, University of Alaska Fairbanks, Palmer Research Center, Palmer, AK 99645

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Abstract. **Head lettuce *(Lactuca sativa* L.) cv. Salinas was produced in field trials in southcentral Alaska with varying planting dates, planting methods, N sources, and N application rates. Variables measured included head weight and diameter and harvest date. Nitrogen source had little effect on head weight. Direct-seeded lettuce produced heaviest beads from early plantings; transplants produced heaviest heads when planted in mid- to late season. Transplanting generally produced heavier heads than direct-seeding. Head weight of transplanted and direct-seeded lettuce was maximized with ≈112 kg N/ha. The data suggest that 112 kg N/ha may be suitable for lettuce direct-seeded or transplanted throughout the growing season.**

Commercially grown head lettuce is planted sequentially over time to extend the length of the harvest season. Varying environmental conditions during growth of early, mid-, and late-season plantings may affect the response to N fertilizers (Richard et al., 1985). Direct-seeded lettuce and lettuce seedlings may respond differently to fertilizer because of environment or stage of maturity.

Nitrogen fertilizer form (Pew et al., 1983, 1984) and rate (Hemphill and Jackson, 1982; Richard et al., 1985; Van der Boon et al., 1986) influence head lettuce development. Environmental conditions may affect uptake of various forms of N. For example, Frota and Tucker (1972) reported nitrate uptake was affected more by temperature than was ammonium uptake. Influences of soil temperature and moisture on N transformations are well recognized (Firestone, 1982; Schmidt, 1982). Environmental conditions such as soil moisture and temperature (as related to planting date) may therefore affect the response of head lettuce to different N fertilizer forms.

In southcentral Alaska, lettuce is direct-seeded or transplanted in the field from late April until early July. The harvest season may run from mid-July through mid-September. The recommended N application rate is 112 $kg \cdot ha^{-1}$; however, this level frequently is exceeded in commercial production, particularly in later plantings. Ammonium nitrate is the primary N fertilizer used in Matanuska Valley head lettuce production, although the cost is about twice that of urea. The studies described herein were designed to encompass the conditions under which commercial head lettuce is produced in this area.

The objectives of the current studies were 3-fold: 1) to determine appropriate rates and sources of N for direct-seeded head lettuce, 2) to ascertain whether optimum rates differ between direct-seeded and transplanted lettuce, and 3) to determine the effect of planting date on head lettuce yield and quality at the various N rates.

Field trials were conducted from 1984-87 on Knik silt loam (Typic Cryorthent) near Palmer, Alaska. In 1984 and 1985, pelleted seed of head lettuce 'Salinas' was direct-seeded on 25 Apr., 25 May, and 25 June 1984 and 24 Apr., 29 May, and 26 June 1985. Nitrogen was applied as ammonium nitrate, calcium nitrate, or urea 1 to 2 days before planting and immediately incorporated to a depth of 10 to 15 cm. Each N source was applied at 56, 112, and 168 kg N/ha. In addition to the N fertilizer, 158 kg P/ha and 149 kg K/ha were broadcast uniformly across all plots and incorporated. Lettuce was planted in rows 46 cm apart and thinned to 28 cm in the row when the plants were ≈2.5 cm tall. Each plot was four rows wide and 7.6 m long. Treatments were arranged in a randomized complete block design and replicated four times. Plots were irrigated as necessary with overhead sprinklers, generally two or three 25-mm applications per growing season. At maturity, heads were harvested out of the center two rows of each plot, and the fresh weight of each head was determined. Maturity was determined by head firmness; harvests were conducted each day until 20 heads had been removed from each plot.

In 1986 and 1987 the number of N rates

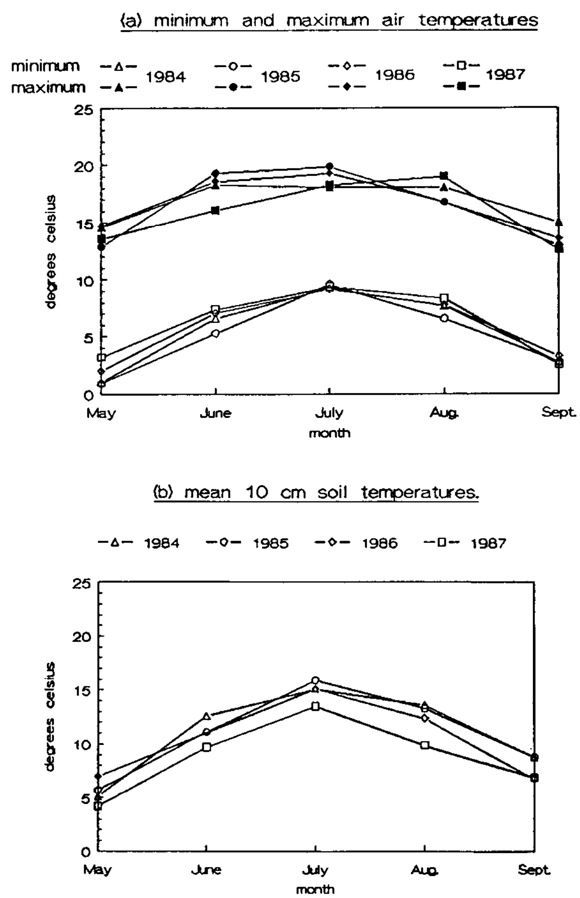

Fig. 1. Mean daily minimum and maximum air temperatures (a) and mean 10-cm soil temperatures (b) at test location.

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[1]Assistant Professor of Soil Fertility/Horticulture.
[2]Professor of Horticulture.
[3]Research Associate.

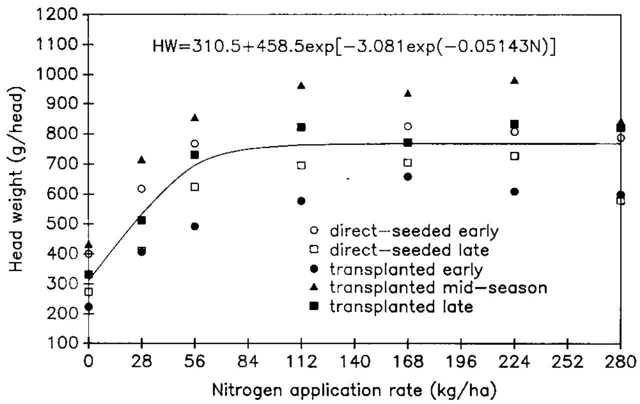

Fig. 2. Effect of rate of N fertilizer application on direct-seeded and transplanted head lettuce, 1986. Regression on pooled data with Gompertz equation.

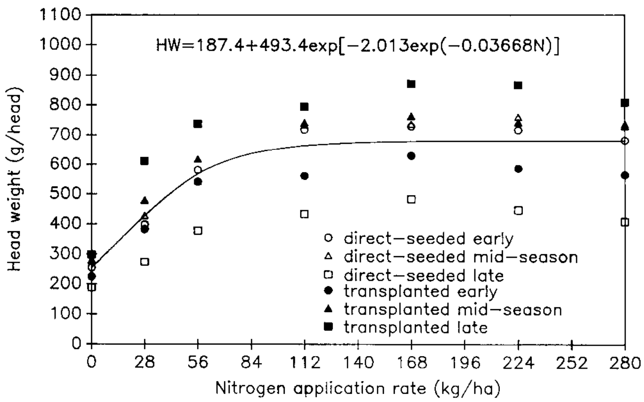

Fig. 3. Effect of rate of N fertilizer application on direct-seeded and transplanted head lettuce, 1987. Regression on pooled data with Gompertz equation.

Table 1. ANOVA table for the effects of N source, N rate, and planting date on lettuce head weight.

	1984		1985	
Source	df	Mean squares	df	Mean squares
N source	2	41,800	2	2,794
N rate	2	52,540*	2	7,430
Linear	1	103,520**	1	14,700
Residual	1	1,559	1	161
Date	2	872,115**	1	325,719**
Linear	1	1,740,294**	na	na
Residual	1	3,936	na	na
Experimental error	101	15,302	66	5,842

*,**F test significant at $P \leq 0.05$ or 0.01, respectively.

Table 2. ANOVA table for the effects of N rate, planting date, and method (transplant or direct-seed) on lettuce head weight and days from planting to harvest (DAP).

	1986		1987		
Source	df	MS (head wt)	df	MS (head wt)	MS (DAP)
Method (M)	1	61,383**	1	355,718**	27,900**
Date (D)	2	427,813**	2	91,284**	3,110**
Linear	1	8,540	1	133	3,333**
Quadratic	na	na	1	182,434**	2,888**
D × M	1	736,777**	2	682,125**	538**
N rate	6	480,222**	6	667,834**	31**
Linear	1	1,384,778**	1	2,494,081**	21**
Quadratic	1	1,280,893**	1	1,352,702**	129**
Cubic	1	149,762**	1	144,772**	16*
Residual	3	21,966*	3	5,150	7*
M × N rate	6	4,761	6	7,316	10**
D × N rate	12	7,736	12	5,257	10**
Experimental error	111	5,524	138	3,886	1.7

*,**F test significant at $P \leq 0.05$, 0.01, respectively.

was increased from three to six. Due to increased use of transplants in commercial production, a new variable was added; plants were established either by direct-seeding or by transplanting B-day-old greenhouse-grown plugs. The N source variable was eliminated. Field planting dates were 8 May, 5 June, and 25 June 1986, and 4 May, 2 June, and 25 June 1987. Ammonium nitrate was applied at rates of 0, 28, 56, 112, 224, or 280 kg N/ha; all plots also received 190 kg P/ha and 178 kg K/ha. In 1986, the in-row spacing was 28 cm, in 1987 it was 30 cm. Other cultural aspects were identical to those described for previous years. In 1987, lateral head diameter and number of days from planting to harvest were recorded in addition to head weight. Results were statistically analyzed using the PROC ANOVA, PROC GLM, and PROC NLIN (Gompertz and logistic models) routines of SAS (SAS Institute, Inc., Cary, N.C.). Means of individual head measurements in each plot were used as plot parameters.

In the study that included N source, N rate, and planting date (1984 and 1985), interactions among variables were not statistically significant, and, therefore, were pooled in the experimental error term for analysis of variance (Table 1). Differences in head weight of lettuce fertilized with ammonium nitrate, urea, or calcium nitrate were small; all three provided adequate N for the production levels achieved in this study. Nitrogen rate and planting date affected head weight in 1984, although only planting date affected head weight in 1985. The response to N rates was inconsistent. Higher N rates resulted in decreases in head weight in 1984; in 1985 head weight was not significantly affected by N rate. The variable that most consistently influenced head weight was planting date. In both years head weight decreased in later plantings. The poor growth of the late-season lettuce can be explained largely by the declining temperatures typically occurring in August and September (Fig. 1).

In the second study, the interaction between planting date and planting method was significant at $P = 0.01$ (Table 2). In general, good yields were obtained with midseason plantings both from direct-seeded and transplanted lettuce (Figs. 2 and 3). In 1986, the head weight of lettuce transplanted in midseason was higher than that of lettuce transplanted either early or late in the season, whereas in 1987 the later transplanted lettuce produced the heaviest heads. Conversely, the lettuce direct-seeded in late season yielded heads lighter than lettuce direct-seeded either in early or midseason. Low temperatures probably limited yields of plants from the late season direct-seeded plots (Fig. 1).

In both years of the study, the main effect of N rate was significant at $P = 0.01$ (Table 2). Regression equations relating head weights to N rates were determined with both Gompertz and logistic models. The Gompertz model resulted in the greatest reduction of sums of squares due to model. Although the head weights in 1986 (Fig. 2) exceeded those in 1987 (Fig. 3), regression equations from

Table 3. Effect of planting date, planting method, and N rate on number of days between planting and harvest (DAP) of head lettuce in 1987.

Seeding method and season	Nitrogen rate (kg·ha⁻¹) 0	28	56	112	168	224	280	Avg
Direct-seeded				*DAP*				
Early	102	99	100	102	104	105	106	103
Mid	91	89	89	87	88	88	89	89
Late	95	95	93	92	90	91	93	93
Transplanted								
Early	84	80	79	78	80	78	80	80
Mid	70	68	67	66	66	66	67	67
Late	63	60	60	59	59	59	59	60

the 2 years of data are similar. In each year, the head weight reached a plateau when ≈ 112 kg N/ha was added. Yields were depressed when the next lower N increment (56 kg N/ ha) was applied.

In 1987, the number of days from planting to harvest was recorded. Lettuce that received no N took longer to mature than lettuce that was fertilized with N, particularly in the early plantings (Table 3). In general, maturity was not delayed even when lettuce was fertilized with more than twice the level of N required to produce maximum head weight. However, some delay was noted in early direct-seeded lettuce that received a high rate of N. As expected, direct-seeded lettuce took longer to mature than transplanted lettuce and early planted lettuce matured more slowly than that planted in warmer weather.

Optimum head weight and diameter were achieved with 112 kg N/ha; this rate can be recommended for direct-seeded and transplanted lettuce. The slight differences in N response between various planting dates suggest that a single level of N application may be suitable for plantings made throughout the growing season as well. The small differences observed in head lettuce performance with various N sources indicate that all the materials tested provide an acceptable supply of N for field production of this crop.

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