Table 1. Effect of CO_2 enrichment, planting density, and postplanting fertilization on per-plant fresh weights of 'Parris Island Cos' and 'Great Lakes 659' lettuce.

CO_2 level	Fresh wt (g) ± SE							
	Parris Island Cos				Great Lakes 659			
	Low density		High density		Low density		High density	
	High fert.	Low fert.	High fert.	Low fert.	High fert.	Low fert.	High fert.	Low fert.
1000 ppm	202±11	195±27	122±30	99±19	298±25	279±9	212±21	177±25
Ambient	160±8	157±4	94±4	93±10	209±21	186±10	118±15	133±4

Table 2. Effect of CO_2 enrichment and planting density on leaf area in lettuce cultivars.

CO_2 level	Leaf area (cm^2) ± SE			
	Low density		High density	
	Great Lakes	Parris Island Cos	Great Lakes	Parris Island Cos
1000 ppm	6010±1097	3863±205	1229±177	1496±255
Ambient	3636±335	2567±156	1472±250	1331±189

closer together than the recommended spacing for those cultivars, and head shape would have been unacceptable in many of the high-density plants. This is similar to the finding of Chrimes (2) in spacing trials with lettuce in England.

The 2 cultivars were strikingly different in their response to CO_2 enrichment: 'Great Lakes 659' increased 50% with enrichment and 'Parris Island Cos' increased only 23%. This may reflect a higher growth potential in 'Great Lakes 659', as head weights were higher overall than in 'Parris Island'. This is in contrast to the results of Hand (3) with butterhead lettuce cultivars which did not differ greatly in response to CO_2 enrichment. Butterhead cultivars did, however, show a greater response to CO_2 during rapid postrosette growth periods. This supports the conclusion that CO_2 response is greatest under rapid growth conditions in lettuce.

The response to CO_2 was greater in the treatments given postplanting fertilization (44%) than in the treatments given only preplant fertilization (32%). This was seen even though fertilized treatments overall yielded only slightly (7%) heavier heads than nonfertilized treatments. This suggests that where CO_2 enrichment is used postplanting fertilization can be justified (11% increase in head weights), although it would not be necessary otherwise to add fertilizer after planting. In Michigan, higher nutrient levels are recommended for CO_2-enriched lettuce (8).

Although the leaf areas of enriched plants were 39% higher overall than nonenriched (Table 2), planting density greatly affected the response to CO_2 enrichment. Leaf areas did not differ significantly between enriched and nonenriched plants in the high-density treatments, but in the low planting density, leaf areas of enriched plants were 50% higher for 'Parris Island' and 65% higher for 'Great Lakes 659'. This differs from the results of Hand (3), who found no effect of CO_2 enrichment on leaf area of greenhouse lettuce in England. In his study, head weight increase with enrichment was solely a result of increase in weight per unit leaf area. Sionit et al. found that leaf areas increased with enrichment in wheat, however (6).

Fertilization treatments did not affect leaf areas. 'Great Lakes 659' had a greater leaf area than 'Parris Island' at low but not high densities.

Thus, in using CO_2 enrichment to increase head weights of winter-grown lettuce, densities and fertilization practices need not be altered, but greater response can be expected from some cultivars than others. Our data suggest rapidly growing cultivars are more responsive. CO_2 enrichment also can be used to increase leaf areas but here the effect was much greater at low density. Because of unusually cloudy conditions, high-density plants were probably light-, rather than CO_2-limited.

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Response of 'McFarlin' Cranberry to Nitrogen Sprays[1]

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Abstract. **Two nitrogen formulations, urea and ammonium sulfate, were applied as aqueous sprays to 'McFarlin' cranberry (*Vaccinium macrocarpon*, Ait.) vines at the rate of 0, 1.12, 2.24, 3.36, 4.48, and 5.60 kg N/ha at 5, 50, and 80% bloom. Urea applied 3 times during bloom at 4.48 kg N/ha increased yield. The nitrogen treatments had no significant effect on soluble solids, pH, or fruit breakdown.**

Yield in cranberries is the product of 5 morphological components that occur sequentially: 1) number of uprights per unit area; 2) proportion of fruiting uprights; 3) number of flowers per fruiting upright; 4) berries set per number of flowers; and 5) berry weight (5, 6, 7, 9). Nitrogen may be a limiting factor in cranberry growth and fruit development. The demand for this element is high especially during berry set and enlargement. To satisfy demand, frequent leaf feeding may be used. Foliar feeding is not a substitute for soil fertilizer treatment, but can provide an alternative method for getting nutrients into vines when demand exceeds absorption rates. Washington research has shown that nutritional foliar sprays containing 10% N, 5.3% P, and 2% Zn (10–12–0 + Zn 2%) can significantly increase size and weight of berries

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Table 1. Germination of 'McFarlin' cranberry pollen on nitrogen-treated, glucose-amended cornmeal agar and influence of nitrogen spray application at 5, 50, and 80% bloom on 'McFarlin' cranberry yield.

N source	Rate (kg/ha)	Pollen Germination[z] (% of control)	Yield (% of control)
Control	0	100	100
Urea	1.12	104	105
	2.24	107	103
	3.36	114	109
	4.48	109	132
	5.60	113	120
Ammonium sulfate	1.12	81	115
	2.24	78	95
	3.36	80	91
	4.48	39	91
	5.60	66	98
Significance			
Within urea (linear)		*	*
Within ammonium sulfate (linear)		NS	NS
Control vs. urea		NS	NS
Control vs. ammonium sulfate		*	NS
Urea vs. ammonium sulfate		*	*

[z]Pollen tetrad germination calculated on basis of control plots at 100%.
[NS,*]Nonsignificant (NS) or significant at 5% (*) level.

and can reduce berry breakdown and CO_2 production (8).

Cranberries in Washington have a rather extended blossoming period, lasting from 3 to 6 weeks (3). During this period fungicides are applied to control blossom blight (2). The fungicide and foliar nitrogen can be applied together. For commercial production, urea at the rate of 1 to 2 kg N/400 liters applied with a fungicide spray is recommended (4). Several fungicides registered for blossom blight control have been shown to be toxic to cranberry pollen *in vitro* and have reduced yield significantly, possibly by lowering fruit set (1, 10).

The work reported here was conducted to determine if nitrogen foliar spray also might be injurious to cranberry pollen and to evaluate its effect on cranberry production when applied during bloom.

In vitro tests. Pollen germination was evaluated *in vitro* on glucose-amended cornmeal agar [Difco 5% (w/v) cornmeal infusion, 1.5% (w/v) agar, and 0.2% (w/v) glucose] prepared in distilled water. The medium was autoclaved, cooled to about 45°C, and dispensed into 9-cm diam Petri plates at the rate of 18 ml/plate. One ml of the nitrogen aqueous sprays used in the field experiment was spread on the surface of the glucose-cornmeal agar, and the excess was decanted. The nitrogen forms tested were urea and ammonium sulfate at 1.12, 2.24, 3.36, 4.48, and 5.60 kg N/ha. Plates were used immediately after being prepared, and the surface of the medium was seeded with freshly collected 'McFarlin' cranberry pollen. Germination was recorded after 24 hr incubation at 20± 1°.

Cranberry pollen is shed as tetrads. The percentage of tetrads with at least 1 pollen tube and the percentage of germinating grains were determined for a minimum of 50 tetrads on each of 5 replicate plates.

Cranberry pollen seeded on glucose-amended cornmeal agar treated with distilled water gave 85% germination. Suspensions of urea *in vitro* were associated with increased pollen germination up to a maximum of 114% of control at 3.36 kg/ha, but this increase was not significant. Ammonium sulfate at 2.24, 4.48, and 5.60 kg N/ha reduced pollen germination (Table 1). Other soluble salts were not tested at parallel concentrations nor was the pH controlled.

Field trials. Foliar sprays of urea and ammonium sulfate at 1.12, 2.24, 3.36, 4.48, and 5.60 kg N/ha were applied 3 times during bloom to 'McFarlin' cranberry vines growing at the Coastal Washington Research and Extension Unit, Long Beach. Foliar sprays were applied in water at 2000 liters/ha using a Solo knapsack sprayer at 5, 50, and 80% bloom. A surfactant, X-77 at 0.1%, was used in all treatments including the control. Five replications of 9 m^2 plots were arranged in a randomized complete block design. Berries were harvested on Sept. 29, 1980, at physiological maturity (when daily respiration rates of the fruit reached a minimum level) (3). Berries were screened by hand to remove trash and soft fruit. The weight of marketable berries was determined. Berry volume was measured and recorded using a pycnometer.

Urea spray applications at the 3 periods increased yield with a maximum at 4.48 kg/ha. Results with ammonium sulfate were inconsistent. Berry volume, soluble solids, pH, and fruit breakdown showed no significant differences.

This data suggests that urea applied during bloom may increase yield. In this experiment, any yield increase was likely the result of percentage fruit set increase in marginally N-deficient vines and possibly from direct influence of urea on pollen germination.

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