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# Lettuce Seedling and Yield Response to Preplant and Foliar Fertilization during Transplant Production[1]

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*Abstract.* **'Great Lakes R-200' (*Lactuca sativa* L.). seedlings were fertilized with preplant-incorporated 8N-14P-7K at 0–32 g/liter of medium and combined with daily misting of 13N-11P-21K at 0–1800 ppm using 6 different media. The recommended foliar range is 200–600 ppm combined with preplant incorporation of 0–8 g/liter of medium. The 200 ppm foliar treatment required 4–8 g/liter of medium-incorporated fertilizer while the 600 ppm foliar treatment required 0–4 g/liter. The 0 foliar treatment decreased seedling weight, head firmness, and head weight. The 1800 ppm foliar rate is undesirable since it can decrease head size and percent salable heads, and cause soft seedlings. Large differences among treatments at the seedling stage moderated at hearvest time. The highest preplant rates (16–32 g 8N-14P-7K/liter of media) caused excess salinity and this resulted in delayed seed germination and reduced seedling fresh weight. Total salable weight and average head weight were not influenced by any of the 6 media tested. However, a lower seedling fresh weight occurred with 1 medium in the first experiment and 2 media in the second experiment.**

Development of vigorous seedlings is prerequisite to successful transplanting and optimal vegetable production. Optimization of fertilization contributes greatly to the production of vigorous seedlings.

Lettuce absorbed over 70% of its total nutrient uptake 3 weeks preceeding first harvest (10). Similarly, more than 70% of the fresh weight accumulated during this period. The variability of lettuce growth declines with age such that differences among plants are greatest at the seedling stage (4,6).

This study was undertaken to determine the effect of media, preplant, and foliar fertilizer on lettuce seedling growth and to determine if the growth rate differences at the seedling stage are expressed at the mature head stage.

## Materials and Methods

'Great Lakes R-200' lettuce was planted in styrofoam trays with a cell volume of 25 $cm^3$(shaped as inverted pyramids with 2.5 cm upper surface sides and a depth of 7.5 cm). The following media were used: Jiffy Mix (Jiffy Products of America, Chicago), Lite-Gro (J. M. McConkey & Co., Sumner, Wash., Mica-Peat (Langley Peat Ltd., Fort Langley, B.C.,Canada), Pro-Mix (Premier Peat Moss Corporation, N.Y.) and Terra-Lite (W. R. Grace & Co., Cambridge, Mass.). A 2:1 mixture of Kilohana loamy fine sand and peat was included in the second experiment (Table 1).

A commercially available preplant-incorporated N-P-K starter fertilizer (8-14-7) was applied to each medium at rates of 0, 4, 8, 16, and 32 g/liter of media. This fertilizer also contained 8% S and 0.5% Zn. In the seedling house all preplant fertilizer-media com-

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Table 1. Composition of 6 media.

| Variable | Media type | | | | | |
|---|---|---|---|---|---|---|
| | Jiffy-Mix | Lite-Gro | Mica-Peat[z] | Pro-Mix | Sand-Peat | Terra-Lite |
| Sphagnum peat (%) | 50 | 50[y] | 60 | 60 | 33 | 50 |
| Vermiculite (%) | 50 | 50 | | 20 | | 50 |
| Perlite (%) | | | 40 | 20 | | |
| Sand (%) | | | | | 67 | |
| Dolomitic lime (kg/m$^3$) | | 3.0 | 5.3 | 6.0 | | [x] |
| Ground limestone (kg/m$^3$) | 3.0 | | 5.3 | | | |
| Fritted trace elements (kg/m$^3$) | 0.07 | 0.07 | | 0.11 | | [x] |
| Calcium nitrate (kg/m$^3$) | 0.6 | 0.6 | | 0.9 | | [x] |
| Gypsum | | | | | | [x] |
| Potassium nitrate (kg/m$^3$) | | | 0.4 | | | |
| Ferrous sulfate (kg/m$^3$) | | 0.3 | 0.07 | | | [x] |
| Superphosphate (kg/m$^3$) | 0.6-1.2 | | | 0.9 | | |
| Treble superphosphate (kg/m$^3$) | 1.2 | | 0.4 | | | [x] |
| Wetting agent (kg/m$^3$) | 0.11 | | 0.25 | 0.9 | | [x] |

[z]Normally contains 40% vermiculite. [y]Peat was 70% water by weight. [x]Precise amounts are proprietary data.

binations were watered by misting with 0, 200, 600 and 1800 ppm of a water soluble N-P-K fertilizer (13-11-21). This fertilizer also contained 0.01% B, 0.013% Cu, 0.1% Fe, 0.02% Mo, 0.04% Mg, 0.012% Mn, 0.014% Zn and 0.0005% Vitamin B-1. The electrical conductivities of the foliar solutions were 0.1, 0.3, 0.8 and 2.0 mmho/cm, respectively.

Misting was performed twice daily with an application rate of 3.8 mm/day. Seedlings were raised in a fiberglass-covered greenhouse with open sides. Transparent interior partitions prevented drift of the irrigating mist.

Four-week-old seedlings were transplanted into the field in a Waimea silt loam soil. Subsequent cultural operations, including fertilizer application and sprinkler irrigation, were uniform for all the media preplant-foliar fertilizer treatments. Each plot contained 10 seedlings spaced 38 cm between plants and 60 cm between rows in a bed arrangement of 3 rows/bed. Beds were 90 cm apart. Two harvests of mature heads were taken at a 1-week interval.

Data collected include fresh weight of 4-week-old seedlings (10 seedlings/plot), percent harvestable heads, total salable weight (outer wrapper leaves removed), average weight per salable head, a qualitative head firmness rating, and salinity of the medium in each treatment at seeding and 4 weeks after seeding. Salinity was measured as the electrical conductivity (EC) of saturated medium paste in a conductivity cell. The experiment was arranged as a 3-way factorial with 6 media, 5 preplant and 4 foliar fertilizer treatments. The first trial was a randomized complete block with 3 replications. The second trial was a randomized complete block in time with a 2-week interval between each of 4 replications. Experiment I was conducted between November 1977 and February 1978. The 4 replicates of Experiment II were conducted from February–June, 1978. Mean daily low and high temperatures in the seedling house for November (1977), February, March and April (1978) were 12–25, 9–25, 13–24, and 13–25°C respectively. Field mean low and high temperatures from December (1977) through June (1978) were 12–21, 11–20, 9–21, 13–20, 13–21, 14–22 and 15–22°C, respectively.

## Results and Discussion

The main effect and interaction F-test values for seedling fresh weight, percent salable heads, average weight/head, head firmness, total salable weight and media EC are shown in Table 2.

*Seedling fresh weight.* Seedling fresh weight was influenced by preplant fertilizer, foliar fertilizer, and media type. In addition, significant 2-factor interactions occurred with preplant × foliar, preplant × media and foliar × media combinations (Table 2). The effects of preplant × foliar combinations summed over all media are shown in Fig. 1. The fresh weight generally increased in the 0 and 200 ppm foliar fertilizer treatments with increasing preplant fertilizer up to 8 or 16 g/liter of media. It decreased at 16 or 32 g/liter of media. The fresh weight of the seedlings treated with 600 ppm foliar fertilizer increased with 4 g preplant fertilizer/liter of media and then decreased with added preplant fertilizer. Dramatic fresh weight decreases occurred on seedlings treated with 1800 ppm foliar fertilizer when more than 4 g/liter of preplant fertilizer was incorporated in the media. Fresh weight data indicate that the

Table 2. Main effect and interaction F-test values for 7 yield parameters in 2 experiments.

| Yield parameter | Experiment | F values | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Preplant fertilizer | Foliar fertilizer | Media | Preplant x foliar | Preplant x media | Foliar x media | Preplant x foliar x media |
| Seedling fresh wt | I | 32.3** | 440.7** | 17.2** | 19.2** | 3.3** | 5.1** | 1.1 |
| | II | 48.9** | 340.9** | 6.7** | 18.2** | 2.1** | 1.9* | 0.9 |
| Media EC at seeding | I | 405.7** | | 6.1** | | 2.2* | | |
| | II | 887.5** | | 67.3** | | 14.7** | | |
| Media EC at 4 wks | I | 85.4** | 696.3** | 10.2** | 1.1 | 2.6** | 4.7** | 0.9 |
| | II | 33.1** | 160.4** | 2.3* | 2.4* | 0.1 | 1.8* | 0.5 |
| % Salable heads | I | 5.8** | 16.0** | 3.3** | 2.9* | 0.9 | 1.5 | 0.7 |
| | II | 0.8 | 2.1 | 2.2 | 0.8 | 1.1 | 1.1 | 0.8 |
| Avg wt/head | I | 0.9 | 16.6** | 1.0 | 1.3 | 0.5 | 1.3 | 0.6 |
| | II | 0.8 | 16.6** | 1.1 | 3.2** | 0.4 | 1.0 | 1.0 |
| Head firmness | I | 1.3 | 9.0** | 0.2 | 2.4** | 1.2 | 2.2** | 1.0 |
| | II | 2.2 | 13.8** | 1.7 | 2.3** | 0.8 | 1.2 | 0.7 |
| Total salable wt | I | 4.6** | 23.7** | 2.2 | 1.8* | 0.7 | 1.5 | 0.8 |
| | II | 0.7 | 3.3* | 1.5 | 2.1* | 0.8 | 1.0 | 1.0 |

*, **Significant F values at 5% (*), 1% (**)

treatment of 1800 ppm foliar + 0–4 g/liter preplant fertilizer resulted in the largest seedlings. However, all plants treated with 600 and 1800 ppm foliar fertilizer experienced abnormally rank and succulent growth. This was presumably caused by an overabundance of available N (2). Consequently, these plants required more careful handling when transplanted to prevent damage to the foliage. Furthermore, the November–December seedlings in Experiment I appeared to be weaker than the February–April ones raised in Experiment II. This is probably related to the shorter day length since the mean temperature difference between the two periods was less than 3°C.

Table 3. Fresh weight main effect means of lettuce seedlings 4 weeks after seeding when raised in 6 media.

| Media type | Fresh wt (g/head) | |
|---|---|---|
| | Experiment | |
| | I | II |
| Jiffy-Mix | 0.91 b[z] | 1.52 a |
| Lite-Gro | 1.35 a | 1.54 a |
| Mica-Peat | 1.26 a | 1.22 c |
| Pro-Mix | 1.40 a | 1.36 b |
| Sand-Peat | | 1.45 ab |
| Terra-lite | 1.28 a | 1.47 ab |

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 4. EC of 6 media at seeding time in Experiment II when 5 rates of 8N-14P-7K preplant fertilizer were incorporated with the media.

| Preplant (g 8-14-7/liter of media) | EC (mmho/cm)[z] | | | | | |
|---|---|---|---|---|---|---|
| | Jiffy-Mix | Lite-Gro | Mica-Peat | Pro-Mix | Sand-Peat | Terra-Lite |
| 0 | 1.1 abc | 1.3 bcd | 0.5 ab | 1.2 bc | 0.2 a | 1.1 aabc |
| 4 | 1.6 cde | 2.5 efg | 2.3 defg | 1.8 cdef | 1.4 bcd | 2.0 cdef |
| 8 | 2.6 fgh | 3.5 hi | 2.5 efg | 3.1 ghi | 2.3 defg | 3.1 ghi |
| 16 | 5.0 j | 5.6 j | 4.9 j | 4.9 j | 3.9 i | 5.2 j |
| 32 | 9.4 lm | 9.8 m | 8.6 l | 7.3 k | 7.1 k | 9.3 lm |

[z]Mean separation within columns and rows by Duncan's multiple range test, 5% level.

Seedling fresh weight was always increased by the addition of foliar fertilizer. This may be a positive response to the micronutrients contained in the foliar fertilizer, increased macronutrient uptake or uptake efficiency through the foliage (3, 9) or increased salt tolerance due to greater nutrient availability (1).

In Experiment I, seedlings growing in Jiffy-Mix were significantly smaller. Seedlings growing in Mica-Peat and Pro-Mix were significantly smaller in Experiment II (Table 3). However, these differences were less than those caused by the fertilizer treatments.

*Salinity*. Salinity in all media increased with increased preplant fertilization at seeding time (Table 4). However, salinity of the media had greatly decreased within 4 weeks after seeding due to

Table 5. EC of media 4 weeks after seeding in Experiment II when separated as the main effect means of media type, preplant fertilization and foliar fertilization.

| Main effect | Variable | EC (mmho/cm)[z] |
|---|---|---|
| Media type | | |
| | Jiffy-Mix | 0.59 ab |
| | Lite-Gro | 0.63 a |
| | Mica-Peat | 0.54 bc |
| | Pro-Mix | 0.57 ab |
| | Sand-Peat | 0.48 c |
| | Terra-Lite | 0.61 ab |
| Preplant rate (g 8N-14P-7K/liter of media) | | |
| | 0 | 0.43 d |
| | 4 | 0.48 cd |
| | 8 | 0.53 c |
| | 16 | 0.62 b |
| | 32 | 0.79 a |
| Foliar rate (ppm 13N-11P-21K) | | |
| | 0 | 0.34 c |
| | 200 | 0.32 c |
| | 600 | 0.54 b |
| | 1800 | 1.09 a |

[z]Mean separation within main effects by Duncan's multiple range test, 5% level.

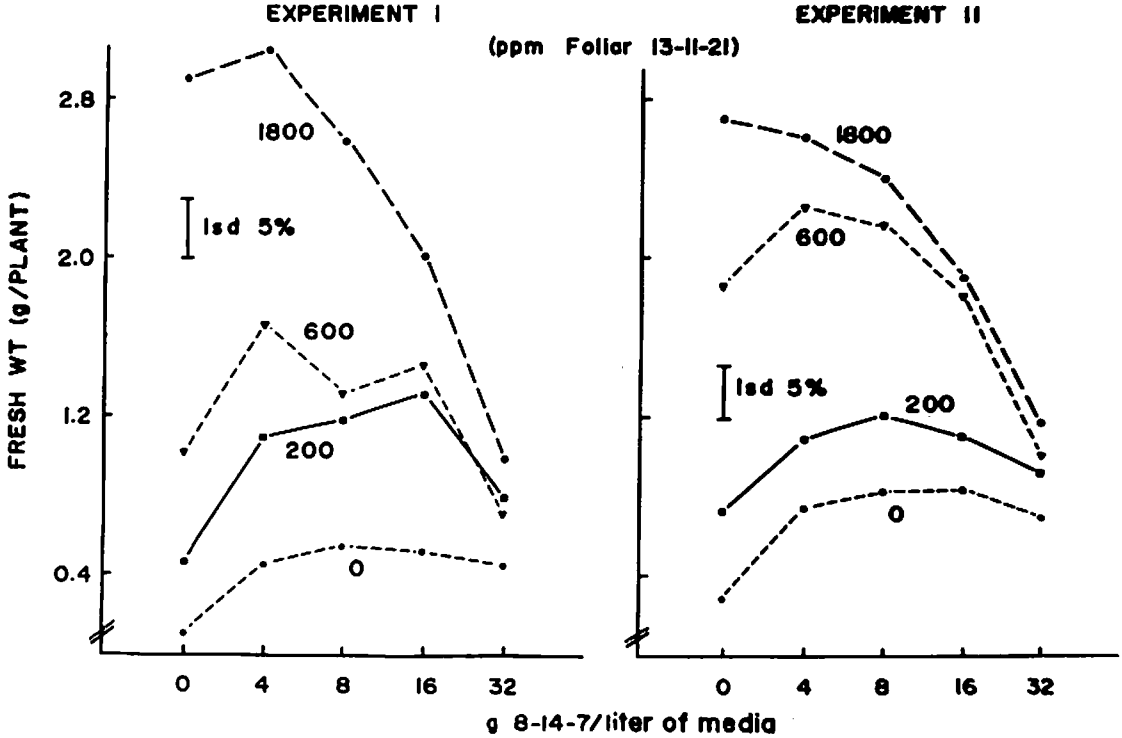


Fig. 1. The effects of 5 preplant (8N-14P-7K) and foliar (13-11-21) fertilizer rates on the fresh weight of 4-week-old lettuce seedlings in 2 experiments. (LSD 5% bar refers to all means.)

the leaching by the daily irrigations (Table 5). The sand-peat and Pro-Mix were slightly less saline at 4 weeks than the other media. Salinity increased with increasing preplant and foliar fertilization rates except for the 2 lowest foliar rates. The highest main-effect mean EC (1.09) mmho/cm) was caused by the 1800 ppm foliar rate. However, this level appears to be safe since lettuce yield has been reported to decrease 13% for each mmho/cm above 1.3 mmho/cm measured as electrical conductivity of the saturation extract (5). A germination delay of 2–4 days was observed in all the 32 g/liter preplant treatments. This is consistent with the literature (7, 8). The decreased seedling weight at 32 g/liter of preplant fertilizer can be attributed to both delayed germination and growth reduction due to excessive salinity.

*Percent salable heads.* The percent salable heads was influenced by preplant fertilizer, foliar fertilizer, media and the preplant × foliar interaction in the first experiment, and by none of the variables in the second experiment (Table 2). This difference between experiments probably occurred because the seedlings in Experiment I were not as hardy as those in Experiment II due to the shorter day length. Excepting the 200 ppm foliar treatment, the percent salable heads noticeably decreased at the 16 and 32 g/liter preplant fertilizer rates (Fig. 2). It was surprising that field losses did not exceed 25% for the largest seedlings of the 600 and 1800 ppm foliar treatments because there were often heavy winds in the field. Differences due to media types were small compared to the differences due to fertilizer.

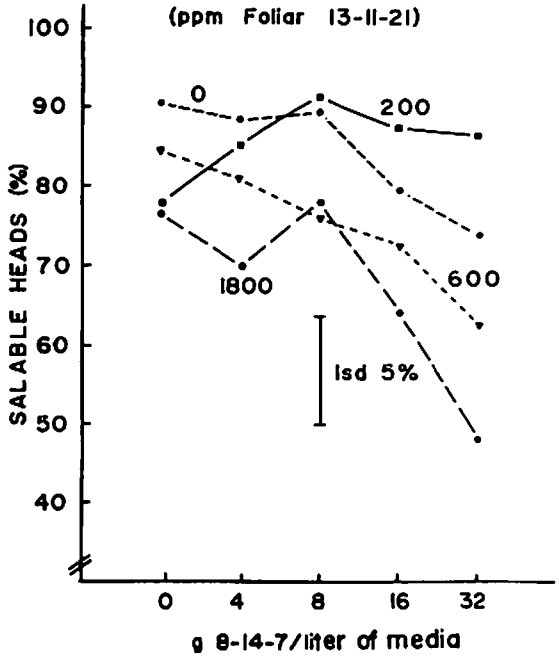


Fig. 2. The effect of 5 preplant (8N-14P-7K) and 4 foliar (13-11-21) fertilizer rates on the % salable heads at harvest time in Experiment I. (LSD 5% bar refers to all means.)

*Average head weight.* The average head weight was influenced only by foliar fertilization in the first experiment and additionally by the preplant × foliar fertilization interaction in the second experiment (Tables 2 and 6, Fig. 3). An average head weight decrease was caused by the 1800 ppm foliar rate in Experiment I. However, the highest head weight in Experiment II occurred at the 1800 ppm foliar rate but proceeded to decrease with added preplant fertilizer. Both experiments indicate that maximum head weight was developed at 200-600 ppm foliar fertilization combined with preplant fertilizer rates not exceeding 16 g 8-14-7/liter of media.

Table 6. Average head weight of lettuce caused by 4 foliar fertilization rates (main effect means) in Experiment I.

| Foliar fertilizer rate (ppm) | Avg head wt (g)[z] |
|---|---|
| 0 | 959 a |
| 200 | 987 a |
| 600 | 993 a |
| 1800 | 881 b |

[z]Mean separation by Duncan's multiple range test, 5% level.

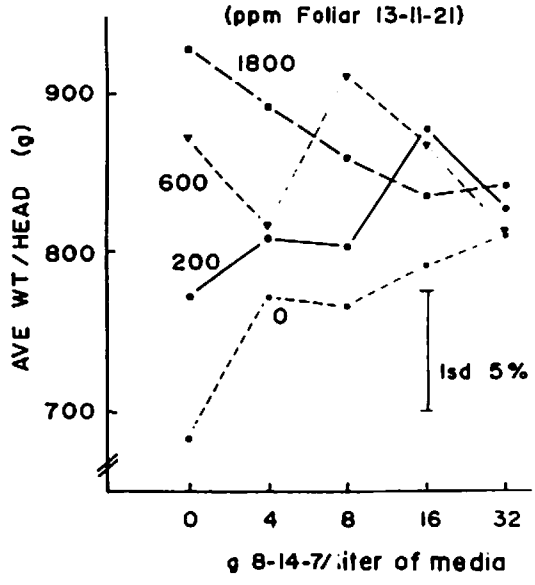


Fig. 3. The effects of 5 preplant (8N-14P-7K) and foliar (13-11-21) fertilizer rates on the average weight/salable head of lettuce at harvest time in Experiment II. (LSD 5% bar refers to all means.)

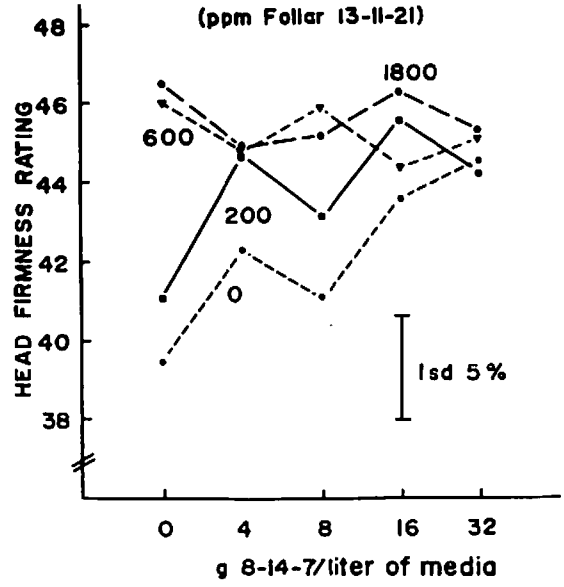


Fig. 4. The effects of 5 preplant (8N-14P-7K) and 4 foliar (13-11-21) fertilizer rates on lettuce head firmness at harvest time in Experiment II (10 loose and unmarketable, 30=spongy but marketable, 50=a solid premium head). (LSD 5% bar refers to all means.)

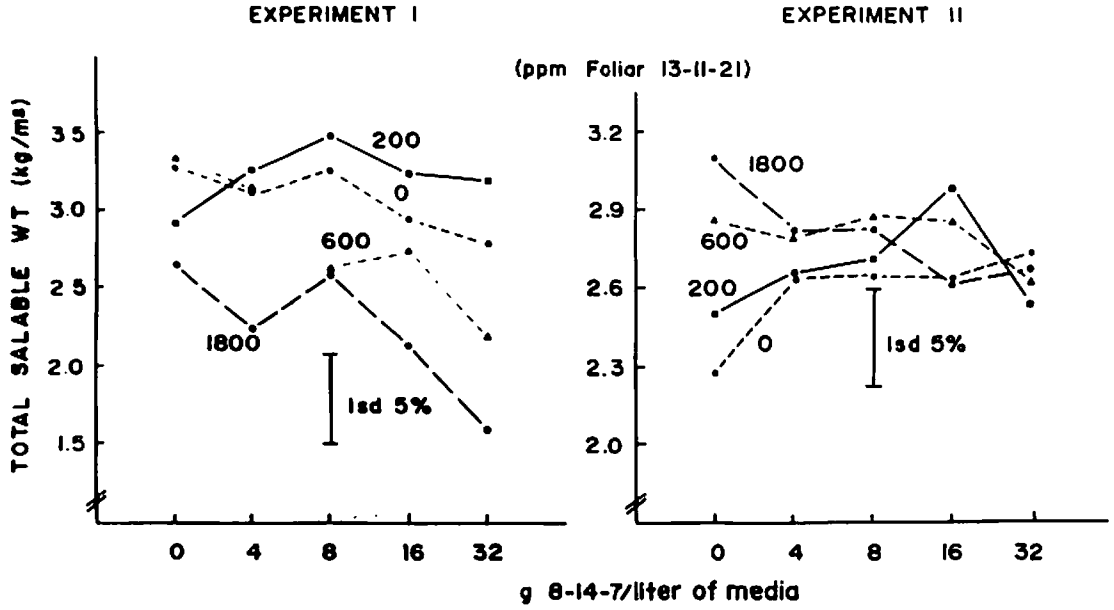


Fig. 5. The effects of 5 preplant (8N-14P-7K) and 4 foliar (13-11-21) fertilizer rates on the total salable weight of lettuce at harvest time in 2 experiments. (LSD 5% bar refers to all means.)

*Head firmness.* Head firmness was only slightly influenced by the foliar fertilization and the preplant × foliar fertilization interactions in both experiments and additionally by the foliar fertilization × media type interaction in the first experiment (Table 2 ). A firmness rating of 10 indicates a loose unmarketable head, 30 a spongy but marketable head, and 50 a solid head. The two factor-interaction rating means varied from 44–49 in the first experiment and 39–47 in the second experiment (Fig. 4). Favorable heading conditions existed during both experiments. Head firmness was decreased by 0–8 g/liter preplant fertilizer in the absence of foliar fertilizer and 200 ppm foliar fertilization in the absence of preplant fertilizer.

*Total salable weight.* Total salable weight was dependent upon the percent salable heads and the average head weight. In Experiment I, total salable weight decreased most drastically at the 600 and 1800 ppm foliar rates with 32 g/liter preplant fertilizer added (Fig. 5). This was largely due to a decrease in the percent salable heads (Fig. 2). The highest yield occurred with the 200 ppm foliar treatment plus 8 g preplant fertilizer/liter of media. However, in Experiment II the large head size of the 1800 ppm foliar treatment (Fig. 3) and the relatively small effect of the treatments on percent salable heads combined to produce the highest total salable yield at 1800 ppm without preplant fertilizer. A rather narrow range of yield differences occurred with the various fertilizer combinations except for the 0 and 200 ppm foliar rates without preplant fertilizer which produced lower yields. These 2 experiments demonstrated that yield reductions can occur with both the very high or very low fertilizer rates on lettuce seedlings and that plants performed equally well in all media.

## Conclusion

Differences larger than 15-fold among treatments at the seedling stage were moderated at harvest to less than 30% for average head weight. This is consistent with the literature (4, 6). The primary yield differences at harvest occurred when seedlings were produced under either too high or too low a fertility regime.

The recommended range of fertilizer application for the media tested is a foliar application of 200–600 ppm 13-11-21 plus 4–8 g of 8-14-7 fertilizer/liter of media for the 200 ppm foliar fertilizer and 0–4 g/liter for the 600 ppm rate. Although seedlings at the 600 ppm foliar rate performed better than those at 200 ppm in these tests, more mechanical injury due to handling might occur as a result of the softness in the former. The 1800 ppm foliar rate with added preplant fertilizer is undesirable since it can cause the production of soft seedlings, less salable heads, and a smaller head size. The 0 ppm foliar fertilization treatment is undesirable because seedling weight, head firmness, and head weight may be reduced.

Total salable weight, head firmness, and average head weight were not influenced by any of the 6 media tested. However, a lower seedling fresh weight occurred with Jiffy-Mix in the first experiment and with Mica-Peat and Pro-Mix in the second experiment.

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