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Getting the Most From Your Lettuce Seedlings: International Nutrition Research©

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INTRODUCTION

Lettuce (*Lactuca sativa*) transplants grown with a floatation irrigation system often show limited root growth, which results in root systems not pulling out completely from the transplant flat and poor establishment in the field. In the present investigation, 'South Bay' lettuce transplants were grown in a peat and vermiculite medium in the greenhouse. They were fertilized with varying concentrations of N, P, and K via floatation irrigation at selected fertigation frequencies to determine optimum nutrient and water management requirements for production of high quality lettuce transplants, with sufficient roots to fill a 10.9 cm^3 tray cell and that ultimately establish in the field rapidly. To avoid inconsistency in the duration of the light period, natural photoperiod was extended to 16 h in all experiments.

FERTILIZER MANAGEMENT

To determine the optimum P concentration necessary for production of high quality transplants, plants were propagated by floating flats in nutrient solution containing either 0, 15, 30, 45, or 60 $mg{\cdot}L^{-1}$ P in summer and autumn experiments, and either 0, 15, 30, 60, or 90 $mg{\cdot}L^{-1}$ P in factorial combination with 60 or 100 $mg{\cdot}L^{-1}$ N in a winter experiment. When the concentration of P in the medium (saturated paste extract) was more than 12 $mg{\cdot}L^{-1}$ (summer experiment), P at 0, 15, 30, 45, or 60 $mg{\cdot}L^{-1}$ subirrigated every 2 to 4 days, did not influence fresh or dry root mass. However, when the concentration of P in the medium was about 0.5 $mg{\cdot}L^{-1}$ (autumn experiment), fresh and dry root mass increased with each level of P fertigated every 2 to 4 days. When the fertigation frequency was every 2 days (winter), fresh and dry root mass increased in response to 15 $mg{\cdot}L^{-1}$ P, with no further increases in root mass at higher P concentrations up to 90 $mg{\cdot}L^{-1}$ even though the medium P concentration was only 0.4 $mg{\cdot}kg^{-1}$.

The major transplant growth responses to applied P occurred between 0 and 15 $mg{\cdot}L^{-1}$ P, regardless of fertigation frequency and medium P concentration. Added P increased fresh and dry shoot mass, root length and area, leaf area, pulling success, leaf tissue P, relative growth rate (RGR), specific leaf area (SLA), leaf area ratio (LAR), leaf mass ratio (LMR), but reduced root : shoot ratio (RSR), net assimilation rate (NAR), and root mass ratio (RMR). Only about 30% of plants grown with 0 P could be pulled from the transplant flat, compared to approximately 90% pulling success with any level of applied P. Quality transplants had dry shoot mass of not more than 115 mg, dry root mass of at least 21 mg. Root : shoot ratio of 0.25 and leaf tissue P of 4 $g \cdot kg^{-1}$ can be considered optimum for production of high quality transplants.

All pretransplant P concentrations had similar effects of increasing head mass at harvest time, and reducing time to maturity regardless of season. At transplanting, plants grown with pretransplant P were larger than those grown with no P. Therefore, larger plants at transplanting led to earlier harvests, and larger head size at harvest.

This work demonstrated that at least 15 $mg \cdot L^{-1}$ P, supplied every 2 days via floatation irrigation, was required for production of high quality lettuce transplants in a peat + vermiculite medium that contained less than 0.5 $mg \cdot L^{-1}$ P (saturated paste extract).

Floatation fertigation with K at 0, 15, 30, 45, or 60 $mg \cdot L^{-1}$ K applied every 2 to 4 days, increased fresh and dry root mass when the concentration of K in the medium (saturated paste extract) was less than 15 $mg \cdot kg^{-1}$, but with higher medium K (24 $mg \cdot kg^{-1}$), root mass was unaffected. Fresh and dry shoot mass, leaf area, RSR, RGR, LMR, and RMR were unaffected by applied K, regardless of the initial K concentration in the medium. Plant available K in the medium (11 to 24 $mg \cdot kg^{-1}$ K in the saturated paste extract) may have supplied the K needs during lettuce transplant growth and development. In an experiment comparing 60 with 100 $mg \cdot L^{-1}$ N at various levels of K, applied K did not influence SLA at 60 $mg \cdot L^{-1}$ N, while at 100 $mg \cdot L^{-1}$ N, SLA increased at each level of applied K. Lettuce growth and yield in the field was not affected by pretransplant K fertilization.

Nitrogen was the nutrient with the greatest impact on lettuce transplant growth. Nitrogen at 0, 15, 30, 45, or 60 $mg \cdot L^{-1}$ subirrigated every 2 to 4 days, increased fresh and dry shoot and root mass, leaf area, transplant height, stem diameter, RGR, SLA, LAR, and LMR, but reduced RSR, NAR, and RMR. Transplants grown with 60 $mg \cdot L^{-1}$ N were about 80 mm tall, had dry shoot mass ranging from 55 to 73 mg, dry root mass ranging from 15 to 22 mg, and RSR ranging from 0.23 to 0.32, and leaf tissue N ranging from 15 to 17 $g \cdot kg^{-1}$. It was observed that transplants could not be easily pulled from the transplant flat at all levels of applied N in these experiments. When the mean dry root mass was less than 20 mg, pulling success was observed to be even more reduced. Nitrogen at 60 $mg \cdot L^{-1}$ was perhaps not adequate with the irrigation programs used. Therefore, additional experiments were designed to investigate the effect of N fertilization to 120 $mg \cdot L^{-1}$ and fertigation frequency on lettuce transplant growth and development.

In the field, lettuce head mass was improved at harvest by pretransplant N. The heaviest heads were obtained from plants grown with 60 $mg \cdot L^{-1}$ pretransplant N. In the greenhouse, transplants grown with 60 $mg \cdot L^{-1}$ N also had the greatest shoot and root mass.

Nitrogen fertilizer programs revealed that at least 60 $mg \cdot L^{-1}$ N supplied every 2 to 4 days via floatation irrigation, was required for improved transplant shoot and root growth in a peat and vermiculite mix low in NO_3-N. Transplants grown with 60 compared to 15 $mg \cdot L^{-1}$ N were larger at transplanting, resulting in improved head mass at harvest.

IRRIGATION AND NITROGEN MANAGEMENT

To determine the optimum N concentration and fertigation frequency, transplants were fertigated every day or every 2nd, 3rd, or 4th day with N at 0, 30, 60, 90, or 120 $mg \cdot L^{-1}$.

In order to determine the seasonal effect of N fertilization practices on lettuce transplant growth, the N by fertigation frequency experiments were conducted in spring, summer, and autumn. Regardless of fertigation frequency, N from 30 to 120 $mg \cdot L^{-1}$ increased dry shoot and root mass, leaf area, pulling success, leaf tissue N, RGR, SLA, LAR, and LMR, but reduced RSR, NAR, and RMR. The concentration of N necessary for obtaining high quality transplants, especially in terms of root growth, was seasonally related. High quality transplants were obtained with daily fertigation of 30 $mg \cdot L^{-1}$ N in summer, and with 60 $mg \cdot L^{-1}$ N in autumn or spring, supplied every other day via floatation irrigation. Therefore, N concentration and fertigation frequency must be considered together.

Pulling success was improved from less than 16% with 0 N to about 88% with the initial N application of 30 $mg \cdot L^{-1}$ in the spring and autumn experiments. In general, pulling success was reduced during summer compared to spring or autumn crops, indicating that very high temperatures (average daily maximum medium temperature of 38 °C) were detrimental to pulling success. Quality transplants had dry shoot mass of not more than 136 mg, dry root mass of at least 23 mg, RSRs ranging from 0.30 to 0.48, with leaf tissue N ranging from 16 to 23 $g \cdot kg^{-1}$.

Pretransplant N, but not fertigation frequency, improved head mass at harvest and reduced time to maturity. This is of particular significance in northern Florida where the growing period for lettuce is short. Earliness is extremely important to the grower and transplant nutrition can affect earliness.

CONCLUSIONS

In conclusion, a quality transplant can be produced with no supplemental K if medium K (saturated paste extract) is at least 15 $g \cdot kg^{-1}$. Phosphorus at 15 to 30 $mg \cdot L^{-1}$ P, applied every other day, is adequate for production of a quality transplant all year round if medium P (saturated paste extract) is less than 12 $g \cdot kg^{-1}$. Nitrogen at 30 $mg \cdot L^{-1}$ applied daily during the summer or 60 $mg \cdot L^{-1}$ N applied every other day during autumn or spring can be considered adequate for production of a quality transplant. Pretransplant N at 60 $mg \cdot L^{-1}$ in the spring or autumn led to more lettuce head mass and reduced time to maturity. A quality transplant should be about 80 mm tall, fill-up a 10.9 cm^3 tray cell with roots in 28 days to facilitate ease of removal from the transplant flat, have dry root mass of no less than 25 mg, and dry shoot mass of about 100 mg to achieve a RSR of approximately 0.25. Adequate tissue levels for N, P, and K are about 17, 4, and 40 $g \cdot kg^{-1}$, respectively.

Identifying and understanding the differential growth responses of roots and shoots of lettuce transplants to N, P, and K fertilization, has provided new guidelines for the production of quality transplants. Quality lettuce transplants can be produced with lower fertilizer inputs than growers are currently using, which could lead to lower transplant production costs, and reduce the risk of polluting the environment. The fertilizer and irrigation programs for lettuce could potentially be applied to other vegetable transplants.