Lettuce varieties propagated in engineered foam substrates achieve up to 200% higher fresh weights when initial nutrient application occurs from seeding onward versus plants that receive initial nutrient application after germination (day 3), even when receiving the same optimal nutrient concentration.

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Introduction

When growing hydroponic lettuce, making the right choices at the earliest developmental stage has a tremendous impact on the level of success later in the growing process. These choices include optimal timing of the initial nutrient application as well as nutrient concentration. While the role of substrates in hydroponic lettuce production is somewhat limited, substrate choice and initial preparation are crucial to grower success.

Hydroponic substrates serve to start seeds, grow young plants and stabilize plants after transplant into production systems. OASIS® engineered foam substrates are inert and free of nutrients, allowing precision growers maximum flexibility in nutrient dosing. By virtue of the unique properties of these engineered substrates, growers are advised to saturate the substrate with a complete nutrient solution such as OASIS® Hydroponic Fertilizer 16-4-17 at initial saturation/seeding.

Historically, many growers have delayed nutrient application until after seed germination (2 to 3 days after seeding), because food reserves in the seed fuel germination and nutrient uptake starts only after the root emerges. In addition, nutrient concentration typically used for young plant production has been 0.5 to 0.75 mS/cm (approximately 75 ppm N) — half the strength typically used after transplant into hydroponic production systems.

When engineered foam substrates are saturated with clear water at seeding, with initial nutrient application delayed until after germination, nutrients are not readily available for uptake in the root zone at the applied concentration. This delayed initial nutrient application in turn delays initial seedling growth. In addition, optimal nutrient concentration for young plant production is much higher than levels traditionally used.

Objective

The primary objective of this research was to gain understanding regarding the effect of timing and concentration of initial nutrient applications on young plant growth. A secondary objective was to screen the effect of nutrient application timing on young plant growth for six lettuce varieties propagated in OASIS® engineered hydroponic substrate.

Materials & Methods

Lettuce plants in the study were propagated in OASIS® engineered hydroponic substrate and always watered with OASIS® Hydroponic Fertilizer 16-4-17 unless specified otherwise. Designed for hydroponic young plant production, this one-bag, water-soluble nutrient blend incorporates advanced chelating agents, keeping Fe available up to a pH of 8. It also carries a low salt index, virtually eliminating concerns about salt burn (and costly mixing errors) even on young plants.

Nutrient solution was made with Kent, Ohio municipal water (EC 0.31 mS/cm, pH 7.46 and Alkalinity 49.56 mg/L). The pH was adjusted to 5.8 using sulfuric acid. Note: The various fertilizer concentration treatments in this study were referenced with nitrogen level and EC of complete nutrient solution. The EC indicated is only for the nutrients in the solution and does not include the EC of the target municipal water.

To study the effect of nutrient application timing and concentrations on young plant growth, one lettuce variety was used: Butterhead 'Rex'.

For screening the effect of nutrient timing in conjunction with optimal nutrient concentration on different lettuce varieties, six varieties were used: Butterhead 'Rex', Butterhead 'Skyphos', Butterhead 'Flandria', Batavia 'Impulsion', Lolla Rosa 'Red Curly' and Romaine 'Counter'.

Experiment Details

With the exception of nutrient timing and concentration treatments under study, the lettuce varieties in this study were propagated in accordance with standard recommended practices for hydroponic lettuce, including keeping irrigation solution in the pH range of 5.5 to 6.2.

After initial watering and seeding of the propagation substrate, recommended propagation practices prescribe moving trays into darkness under high humidity with temperatures between 65°F to 68°F (18°C and 20°C) for uniform germination and initial start. Germination occurs during the first 24 to 48 hours. No additional water is required during that period. After 48 hours, seedlings should be moved to full light to avoid stretching, then misted twice. From day 4 onward, growers should irrigate as required once a day or every alternate day.

Following germination, best practices for young plant production of lettuce include greenhouse day temperatures between 65°F and 75°F (18°C to 21°C), with night temperatures between 55°F and 60°F (12°C to 15°C). Relative humidity should be between 60% and 70%. Lettuce seedlings, which are very receptive to Daily Light Integrals (DLI) and light intensity, can handle DLI of more than 20 mol/day. Light intensity can be maintained between 500 to 600 µmol/m2/s. Consider shading when levels get higher than 600 µmol/m2/s.

To accomplish the above objectives of understanding the optimal nutrient application timing and concentration on young lettuce growth, Butterhead 'Rex' plants were subjected to six treatments:

+ Treatment 1 received plain municipal water at seeding, then received 150 ppm N (complete EC 1.18 mS/cm) beginning after germination (2-3 days after seeding) through harvest.
+ Treatment 2 received 50 ppm N (complete EC 0.39 mS/cm) from initial seeding to harvest.
+ Treatment 3 received 75 ppm N (complete EC 0.59 mS/cm) from initial seeding to harvest.
+ Treatment 4 received 100 ppm N (complete EC 0.78 mS/cm) from initial seeding to harvest.
+ Treatment 5 received 125 ppm N (complete EC 0.98 mS/cm) from initial seeding to harvest.
+ Treatment 6 received 150 ppm N (complete EC 1.18 mS/cm) from initial seeding to harvest.

To first determine the effect of nutrient application timing, Butterhead 'Rex' lettuce plants that received initial nutrient at 150 ppm N after germination (Treatment 1) were compared to plants that received initial nutrient at 150 ppm N from seeding through harvest (Treatment 6). For determining optimal nutrient concentration, a gradual increase of nutrient concentrations from 50 ppm N to 150 ppm N was also considered (Treatments 2-6).

Once optimal nutrient concentration was determined, the six lettuce varieties, including Butterhead 'Rex', were screened for the effect of initial nutrient application timing at the optimal concentration.

All varieties in the study were harvested 14 days after seeding, approximately the time that young lettuce plants would typically undergo transplant into hydroponic production systems. The effect of nutrient application timing and concentrations were then compared based on fresh weight in grams at harvest.

Results

Nutrient Application Timing and Concentration:

Figure 1 shows the effect of nutrient application timing and concentration on Butterhead 'Rex' seedlings propagated in OASIS® engineered foam substrates. The six treatments range from Treatment 1 (municipal water at seeding and 150 ppm N from germination through harvest) to Treatment 6 (150 ppm N from initial seeding through harvest).

Despite receiving the same treatment from germination (day 3) on, Treatment 1 and Treatment 6 demonstrated very different results. Treatment 6, which received nutrient applications beginning at seeding, had significantly higher fresh weight than Treatment 1, which had initial nutrient application delayed until after germination (2-3 days).

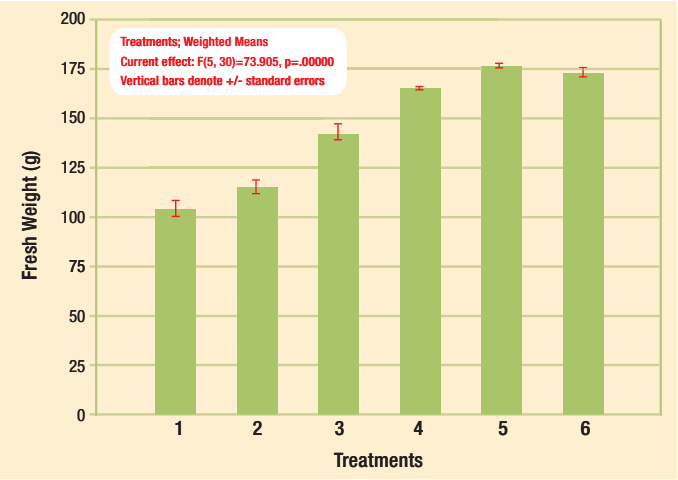

Fig. 1. The effect of initial nutrient timing and concentration on Lettuce Butterhead 'Rex' under six treatments: Treatment 1 started with municipal water, receiving 150 ppm N from germination through harvest. Treatments 2-6 started at seeding with 50 ppm N, 75 ppm N, 100 ppm N, 125 ppm N and 150 ppm N, respectively, and continued at their respective nutrient concentrations from seeding to harvest at day 14.

Results (cont.)

In addition, although using nutrient application concentrations of 75 ppm N for young plant production is common practice, we found that lettuce seedling growth increased significantly as fertilizer application concentration increased up to 125 ppm N. After reaching optimal concentrations of 125 ppm N, as demonstrated in Treatment 5, no additional improvement in fresh weight yields was observed.

Lettuce Variety Screening:

Once the optimal timing for initial nutrient application was determined to be at seeding/initial saturation and the optimal nutrient concentration of 125 ppm N was established, the six lettuce varieties were screened to confirm and compare the effect of initial nutrient timing across varieties with nutrient concentrations at optimal levels. This focused specifically on the effect of nutrient application from seeding through harvest compared to post-germination nutrient application, when both occur at optimal nutrient concentration levels.

Figure 2A shows the effect of nutrient application timing on lettuce seedlings propagated in OASIS® engineered substrate with OASIS® Hydroponic Fertilizer 16-4-17 applied at the optimal concentration of 125 ppm N, comparing results of initial nutrient application after germination to nutrient application applied with initial substrate saturation/seeding.

When the fertilizer was applied at seeding, fresh weights for seedlings harvested at 14 days were significantly higher for all six lettuce varieties tested. Across the varieties in this study, growth as measured by fresh weights at harvest was nearly doubled, with some varieties achieving even greater increases.

The gains associated with nutrient application at seeding are further demonstrated by two trays of Butterhead 'Skyphos' shown at day 14 in Figure 2B below. The tray at the far right received OASIS® Hydroponic Fertilizer 16-4-17 with initial watering. The tray at its left was started with water, receiving initial nutrient application after germination. Both trays received the same treatment from day 3 onward.

Fig. 2A-B. Timing initial nutrient application at seeding resulted in significantly higher fresh weights than post-germination nutrient application across six lettuce varieties studied (2A). Butterhead 'Skyphos' with initial nutrient application of 125 ppm N at seeding (2B, far right) compared to initial nutrient application delayed until germination (on its left). From day 3 on, both trays received the same optimal nutrient concentrations of 125 ppm N.

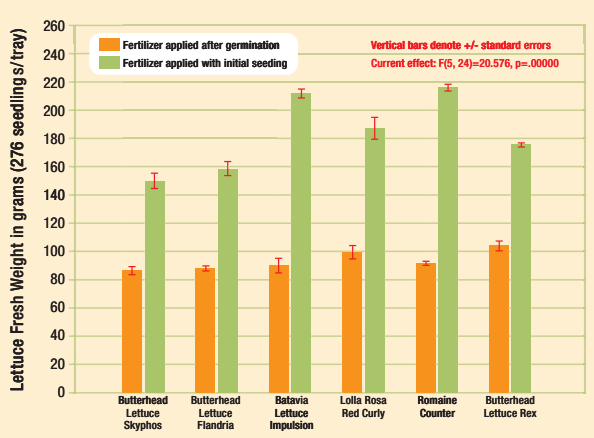

Fig. 2A

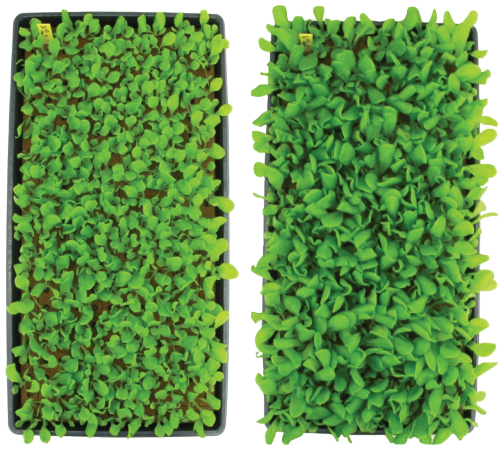

Fig. 2B

Conclusions

Both nutrient application timing and concentration have a dramatic impact on young plant growth with lettuce varieties grown in engineered foam substrates. Applying nutrient solution at the time of initial substrate saturation and seeding, compared to starting with water and then fertilizing after germination, can result in increased growth up to 200% or more by the time of transplant into hydroponic growing systems.

Similarly, lettuce seedling growth can be significantly enhanced with much higher concentrations than the 75 ppm N (approximately 0.5 to 0.75 mS/cm EC) commonly used by growers during propagation. Instead, optimal results can be achieved by fertilizing young plants during propagation at 125 ppm N (approximately 1.0 to 1.25 mS/cm EC). By optimizing both nutrient application timing and nutrient concentration during propagation, growers can expect increased growth during young plant production to positively impact performance during hydroponic production.