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Field Scale Demonstration/Evaluation of the Point Injection Fertilizer Applicator System

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Background

From 2011-2013, trials were conducted comparing point injection fertilizer applicator systems with conventional knife blade applicators in iceberg lettuce. Results of the studies showed that when deficient rates nitrogen were applied, nutrient uptake was 17% higher when fertilizer was delivered using the point injection system as compared to with the knife blade applicator. Improved nutrient uptake translated into head weights, total yield and marketable yield increases of more than 10%. The studies also showed that through use of the system, applied nitrogen rates may be able to be reduced by 25% without negatively affecting crop yield. Further study was deemed warranted to determine if similar results can be found on commercial farms at the large plot and field scale levels.

Objectives

The project objectives were to:

1. Confirm previous study results which show that use of the point injection fertilizer applicator system improves nitrogen uptake efficiency in lettuce plants as compared to conventional knife-blade applicator methods.

2. Confirm previous study results which show that nitrogen rates can be reduced through use of the point injection fertilizer applicator system at the large plot size scale level.

3. Determine if lettuce yield is improved through use of the point injection system at the field scale level.

4. Educate growers and industry about the potential benefits of point injection systems through on farm field demonstrations and presentations at grower/industry meetings.

Methods

A four bed, two rank frame equipped with point injection type fertilizer applicators was fabricated for conducting the experiments (Fig. 1). The point injection systems were oriented so that their wheels operated on the sides of the bed walls. In this configuration, the units injected fertilizer below the plants and into the root zone. Trials were conducted at 3 commercial field sites in the fall of 2013 in the Yuma, AZ area. Treatments included the growers' standard practice of using a knife blade applicator to sidedress approximately 100 lb/ac of N in the form of liquid fertilizer (control), and using the point injection system to deliver that same amount of

material (100% of standard). Additional treatments included using the point injection system to apply deficient rates of nitrogen which included 50 lb/ac of N (50% of standard) and 75 lb/ac of N (75% of standard) at Site 1, and 75 lb/ac of N (75% of standard) at Sites 2 and 3. At Sites 1 and 3, experimental design was a randomized complete block design with 3 and 4 replications respectively. Experimental unit plot size was 4 beds wide by the length of the field. At Site 2, the experiment was conducted on a 40 acre field divided into three sections. The point injection system was used to apply the full rate of N (100% of standard) to a 10 acre portion of the field and a deficient rate of N (75% of standard) to a 1 acre section. The remaining 29 acres was conventionally sidedressed at the full rate by the grower. Additional nitrogen was applied through irrigation water at each site as needed. Fertilizer uptake in lettuce plants was assessed by measuring leaf midrib nitrate levels (NO_3-N) at three times during the growing period – prior to the first sidedress (~ eight leaf stage of growth), two weeks after sidedressing and at maturity. Whole plant samples were taken at maturity and analyzed for total nitrogen content. Crop yield was determined by harvesting, trimming and weighing individual heads from 15 ft of row from the middle two beds of each 4 bed plot at Sites 1 and 3. At Site 2, crop yield was determined by harvesting, trimming and weighing individual heads from 10 ft of row at 3 random locations within each of the 3 field sections (treatments). A marketable head was considered to be a head that weighed 1.3 lbs or more. Data were analyzed using SAS to determine if there were statistically significant differences between treatments.

Results

In total, approximately 15 acres of lettuce were sidedressed using the point injection system. In general, the system performed well. The injection points didn't or rarely plugged during operation and there were no mechanical failures. Midrib nitrate N levels prior to the first sidedress at Sites 1, 2 and 3 were roughly 7,500, 8,200 and 4,700 ppm, respectively and uniform across all treatments (data not shown). In general, there were very few differences in nutrient uptake levels or yield parameters between treatments at any of the sites (Figs 2-4). At Site 1, midrib nitrate-N levels, head weights and yield values were very similar for all treatments which included the point injection system reduced rates of applied N (50% of standard, and 75% of standard), the point injection full rate (100% of standard) and the grower standard (Fig. 2). When the point injection system was used to apply deficient or full rates of N, total N uptake values were numerically higher, but not significantly different than the grower standard. At Site 2, head weights and crop yield were again similar for the point injection system deficient rate (75% of standard), point injection system full rate (100% of standard) and conventional knife blade applicator treatment (Fig. 3). Nitrogen uptake levels varied, but due to experimental protocol, it was not possible to determine whether these differences were statistically significant. At Site 3, although midrib nitrate-N levels were similar, plant N content at maturity was significantly higher for the point injection full rate treatment (100% of standard) (Fig. 4). An unexpected result was that head weights and crop yields were significantly lower for this treatment as compared to the other treatments. A plausible explanation for this could not be formulated as one would presume that increased nitrogen uptake would result in equivalent or increased head size and crop yield. Head weights and yields of the point injection system at the reduced rate of N (75% of standard rate) were virtually identical to those of the grower standard.

Conclusions

The results of this study showed that when deficient rates of N are applied using the point injection system, lettuce midrib nitrate and N content are equivalent to or higher than applying the full rate of N with conventional applicators. These results help confirm previous studies that showed that as compared to conventional knife blade applicators, applied nitrogen rates can be reduced by at least 25% by using the point injection system without affecting nitrogen uptake levels. Although use of the applicator did not improve crop yield, equivalent yields were obtained when deficient rates of N were applied with the unit. These results also support previous research that showed that applied nitrogen rates may be able to be reduced by 25% through use of point injection system fertilizer applicators without negatively affecting crop yield. The terms "help confirm" and "support" are used here since these conclusions cannot be immediately drawn from these experiments as treatments where the knife blade applicator was used with deficient rates of nitrogen were not included in the study for direct comparison.

Outreach

Knowledge gained from this research was disseminated by giving a field day demonstration at the 2014 Southwest Ag Summit and by making oral presentations at the 2013 Pre-Season Vegetable Workshop, 2014 Southwest Ag Summit and at the 2014 Early Summer La Paz County Agronomic Workshop. Approximately 350 individuals were reached. As a result of this project, at least one grower has expressed serious interest in purchasing a point injection system for use on their farm.

Lessons Learned

During the experiments, it was noted that better results may have been obtained if beds had not been cultivated and shaved prior to sidedressing (Fig.5). This was the case at Sites 1 and 2. Shaving beds sidewalls induces relatively high soil disturbance and prunes feeder roots. Using the point injection system in these conditions eliminates or at least greatly reduces the purported advantages of the system – ability to apply liquid materials directly into the root zone with minimal root pruning and soil/plant disturbance. Also, shaving beds leaves plants close to the edge of the bed top. Because of this, inserting the injector tips fully into the bed sidewall tended to cause more soil and plant disturbance than desired. A more favorable environment for the point injection system is to operate in fields where beds have been left intact (Fig. 6). This was the case at Site 3 where the point injection system was observed to operate much more smoothly and disturb plants less. Although nutrient uptake and yield results were not significantly improved at this site, further study of point injection systems in fields where beds are left intact and sidewalls are cultivated using Lilliston cultivators is recommended to determine the merits of the device in this type of reduced tillage production system.

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Fig. 1. Four bed point injection system applicator.

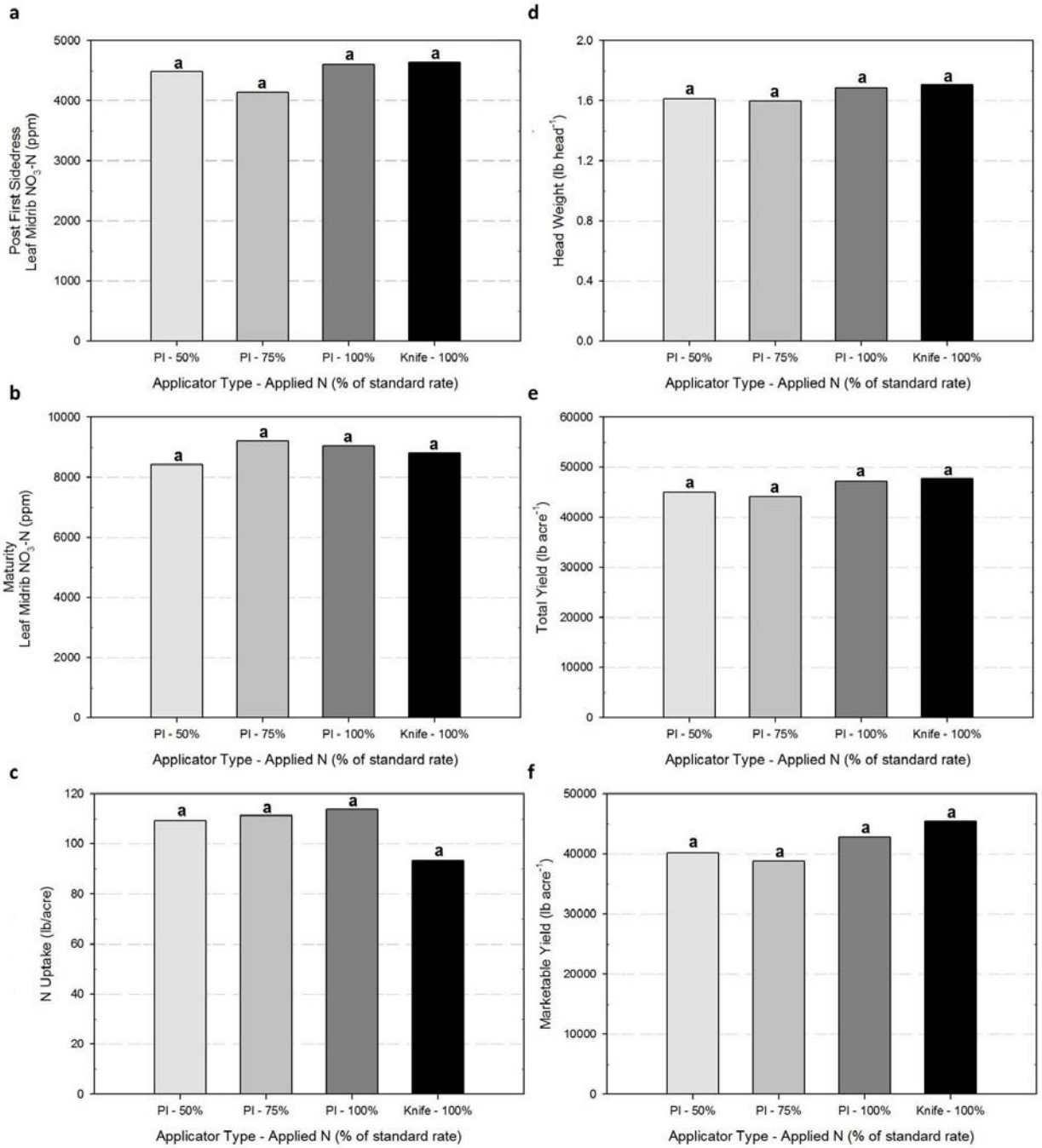

Fig. 2. Effect of fertilizer applicator type at various application rates of N on lettuce (a) midrib nitrate-N content after first side-dress, (b) midrib nitrate-N content at maturity, (c) total plant N at maturity, (d) head weight, (e) total yield and marketable yield (f) at Site 1 in trials conducted in Yuma AZ in 2013. Applicator types were a point injection system (PI), and a conventional knife blade applicator (Knife). Standard rate of N was 100 lb/ac, applied during first side-dress.

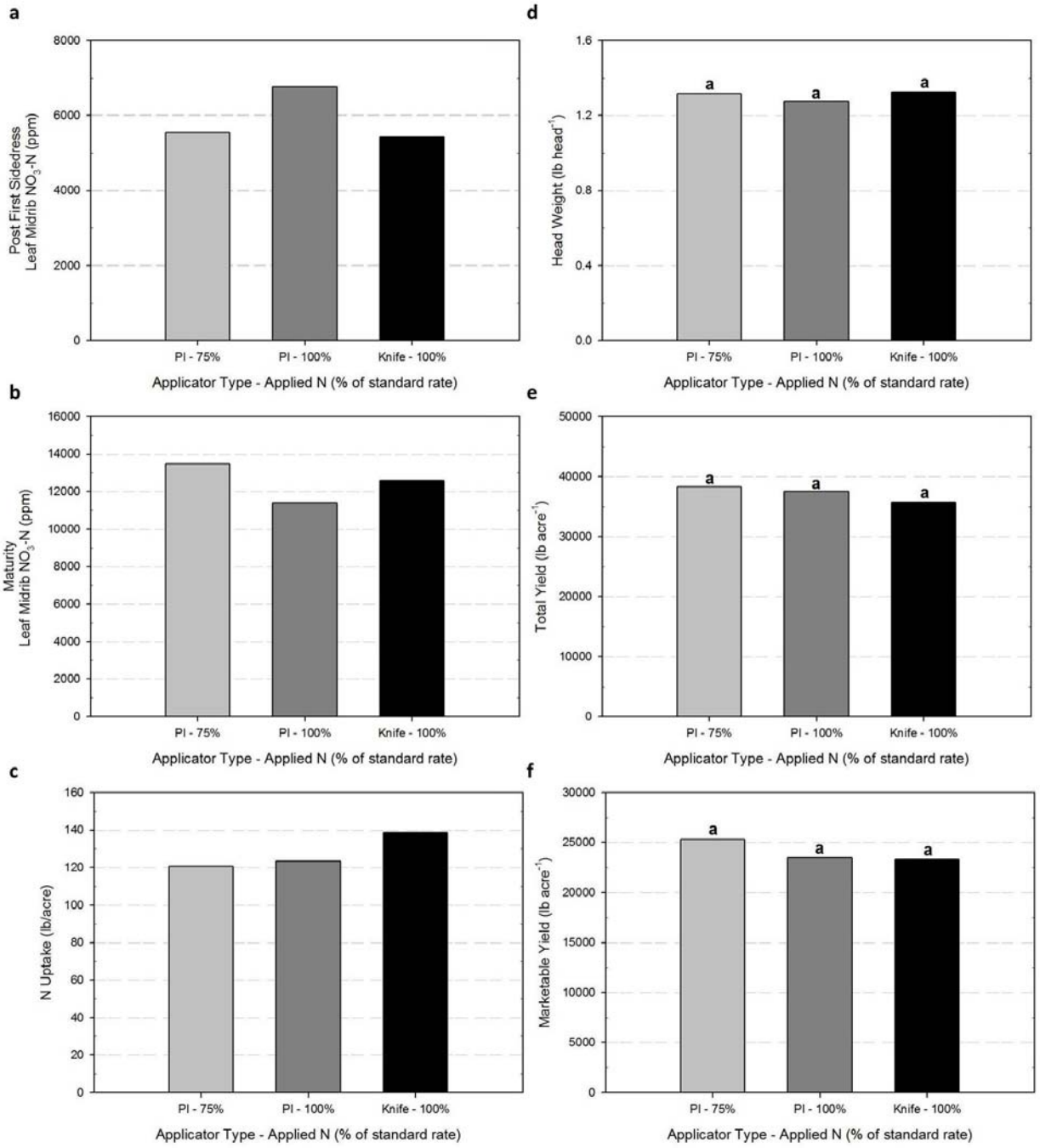

Fig. 3. Effect of fertilizer applicator type at various application rates of N on lettuce (a) midrib nitrate-N content after first side-dress, (b) midrib nitrate-N content at maturity, (c) total plant N at maturity, (d) head weight, (e) total yield and marketable yield (f) at Site 2 in trials conducted in Yuma AZ in 2013. Applicator types were a point injection system (PI), and a conventional knife blade applicator (Knife). Standard rate of N was 100 lb/ac, applied during first side-dress.

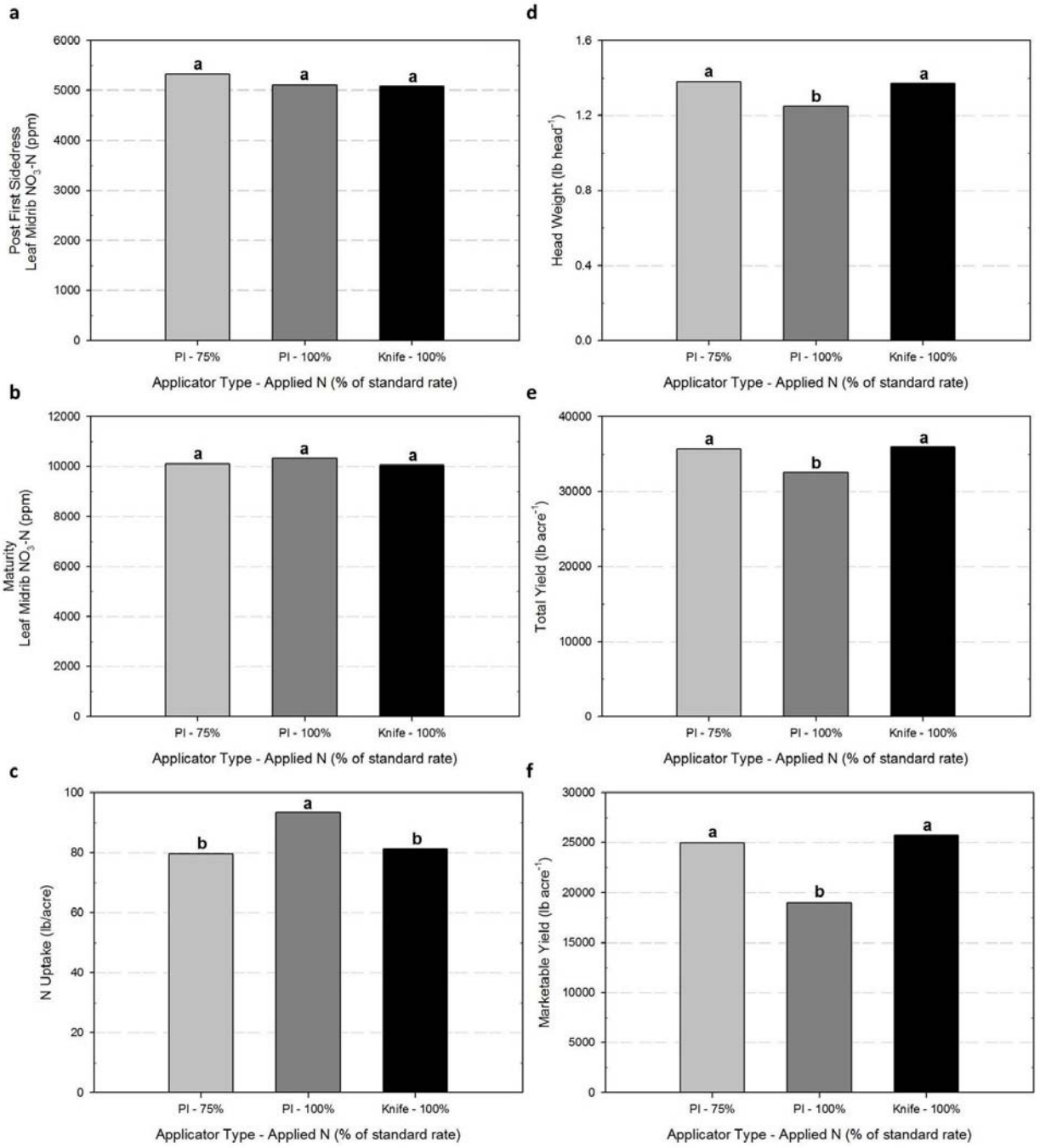

Fig. 4. Effect of fertilizer applicator type at various application rates of N on lettuce (a) midrib nitrate-N content after first side-dress, (b) midrib nitrate-N content at maturity, (c) total plant N at maturity, (d) head weight, (e) total yield and marketable yield (f) at Site 3 in trials conducted in Yuma AZ in 2013. Applicator types were a point injection system (PI), and a conventional knife blade applicator (Knife). Standard rate of N was 100 lb/ac, applied during first side-dress.

Fig. 5. Shaved and cultivated lettuce bed.

Fig. 6. Unshaved and uncultivated lettuce beds.