Evaluating the Effects of Nitrogen Fertilization on Hop Yield

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Introduction

Cultivation of hop plants in the United States dates back to 1633 when the first brewery was opened by Dutch immigrants near Fort Amsterdam on the southern tip of Manhattan Island, New York. Although the primary use for hop cones is flavoring and preservation of beer, research is ongoing for further uses of hop cones and resins as a sedative and antibacterial and antifungal properties.

Hop production is reemerging in areas previously decimated by hop diseases such as downy mildew. Downy mildew is a serious threat to the crop and one of the major reasons the industry moved production to the Pacific Northwest (Washington, Oregon, and Idaho). Hop downy mildew favors moist spring conditions with warm minimum nighttime temperatures. Although climate in the North Central region still poses challenges, new developments in pesticides and cultivar selections have mitigated some of these risks.

Hop production in Iowa has intrigued many Iowa landowners wishing to diversify from traditional crops (corn and soybeans). At the time of this report, approximately 20–30 growers are currently raising hop plants on more than 50 acres in Iowa. Due to limited research involving cultural management of hop plants in the North Central region, few resources are available outlining best management practices. It has been shown the crop has relatively high nitrogen (N) requirements, but the recommendations have a wide range. Brooks and Keller (1960) showed 100 lb available N/acre was the most efficient for Fuggle grown in Oregon. Darby (2011) suggests sampling organic matter content in the soil prior to scheduling N applications, as rates could vary between 80-200 N lb/acre. Single nitrogen fertilizer applications have been shown in two studies to be as effective as split applications, but they should be considered when leaching is an issue. In addition to high N needs, hop plants have high water requirements (up to 16 gallons/plant per week in sandy soils). Given the relatively high levels of irrigation needed to maintain quality hops, mobile forms of N can be lost via leaching. Over-application of N due to leaching has both economic and environmental impacts. Increased arthropod pest damage (two-spotted spider mite, hop aphid) has been observed with higher levels of N fertilization. Disease incidence (powdery mildew, verticillium wilt) also has been recognized as a potential effect of over-fertilization. Specific recommendations should reflect soil and climate conditions typical of the region. In response to these challenges, research investigating the response of the hop plant to varying levels and form of N fertilization are underway.

Materials and Methods

Seven levels of N fertilizer were applied in a split granular application to observe the response. Urea was selected as the N form and applied at 0, 50, 100, 150, 200, 250, and 300 lb/acre. First application was applied at bine training stage and the remaining half of each treatment was applied when the bines reached 9 ft (halfway up the trellis). Experiment was conducted using a randomized complete block design with five, nine-plant replications for each treatment.

Five combinations of three N forms were applied in split applications. Three forms of N were applied at 150 lb/acre: granular urea

(Urea); granular calcium nitrate (CN); and liquid urea ammonium nitrate (UAN). A nitrogen stabilizer (Instinct II) was applied to the entire plot in an attempt to prevent the ammonium forms of N from being transformed by nitrifying soil bacteria. Combinations included Urea/UAN, CN/UAN, Urea/Urea, CN/CN, UAN/UAN. Experiment was conducted using a completely randomized design with four, nine-plant replications for each treatment.

All plants were irrigated throughout the season as needed. Data collected included leaf greenness, photosynthetic rate, plant biomass, cone yield, soil moisture, and soil leachates. Hop cones were harvested by treatment using a mobile harvester. Only preliminary yield data is presented in this paper and should not be used without the author’s consent.

Results and Discussion

Every effort was made to collect all cones and each treatment was harvested the same in random order to minimize confounding variables. Cone dry weight is reported as an estimate [(cone dry weight/treatment ÷ 9 plants/treatment) × 1,000 plants]. Nitrogen applied at 250 and 300 lb/acre increased cone yield significantly compared with the 0 lb/acre N rate (Table 1). Subsequently, N applied at 50, 100, 150, and 200 lb/acre did not increase cone yields compared with the 0 lb/acre rate.

No significant differences were seen between the N forms (Table 2).

This first harvested crop of hop cones was successful. Hop plants take 3-4 years to fully mature to provide maximum yield. Harvest totals for 2016 were in line with a second year crop. Overall, the trend for increased yield with increasing N fertilizer can be detected. However, management challenges throughout the season could have blurred these effects, especially in the mid-level N rates. Interestingly, yields from the second study were unchanged by the form of N used as fertilizer. Further analysis of N found in both soil and soil water may provide evidence of the amount of N being utilized by the crop versus leached out of the system.

Table 1. Hop cone yield as influenced by level of N application.

Urea[z]	Dry weight (lb/acre)[y]
300	514a[x]
250	431a
200	334ab
150	380ab
100	338ab
50	364ab
0	204b

[z]Urea: lb/acre; N treatments were applied in split applications, with the first at bine training stage and the second application when bines reached halfway up the trellis (9 ft).
[y]Dry weight: estimated at 1,000 plants/acre.
[x]Means (within a column) with the same letters are not statistically different according to Tukey's HSD ($\alpha = 0.05$).

Table 2. Hop cone yield as influenced by N form.

N Form[z]	Dry weight (lb/ac)[y]
Urea/UAN	392a
CN/UAN	365a
Urea/Urea	318a
CN/CN	295a
UAN/UAN	290a

[z]N forms (150 lb/ac applied in split applications): Urea/UAN (75 urea/75 urea ammonium nitrate), CN/UAN (75 calcium nitrate/75 urea ammonium nitrate), Urea/Urea (75 urea/75 urea), CN/CN (75 calcium nitrate/75 calcium nitrate), UAN/UAN (75 urea ammonium nitrate/75 urea ammonium nitrate).
[y]Means (within a column) with the same letters are not statistically different according to Tukey's HSD ($\alpha = 0.05$).