# Impact of tank-mixing chlorothalonil with other fungicides on management of Ascochyta blight of chickpeas

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## THIS IS A RESEARCH UPDATE ON A CONTINUING PROJECT

- Funding is being sought from the Northern Pulse Growers Association to continue this research in 2020.

## OBJECTIVE & RATIONALE

- **Problem #1:** When Ascochyta disease pressure is very high, fungicides get overwhelmed by the disease, resulting in unsatisfactory disease control and poor chickpea yield and quality.
- **Problem #2:** Ascochyta management in chickpeas relies almost exclusively on two fungicide modes of action, FRAC 3 (triazole) and FRAC 7 (SDHI). New fungicides with recent or anticipated commercialization on chickpeas are premixes of fungicides with these modes of action. The widespread, recurrent use of just two modes of action is high-risk for the development of resistance.
- Preliminary testing showed that tank-mixing the triazole fungicide Proline (prothioconazole, FRAC 3) with the contact fungicide Bravo WeatherStik (chlorothalonil, FRAC M) conferred sharp gains in Ascochyta control and chickpea yield under Ascochyta pressure.
- This project seeks to evaluate the efficacy of tank-mixes of Proline and Bravo WS under diverse environments; evaluate the impact of tank-mixing Bravo WS with other fungicides, especially SDHI (FRAC 7) fungicides used in rotation with Proline; and to determine the optimal application rates of Bravo WS in tank-mixes..

## MAJOR FINDINGS

1. Across 11 studies conducted over 4 years, tank-mixing Bravo WeatherStik (1.38 pt/ac) and Proline (5.0 or 5.7 fl oz/ac) consistently improved Ascochyta management relative to Proline applied alone. Gains in disease control and yield were observed at low, moderate and high Ascochyta disease pressure (Figure 1).
2. Increasing the application rate of Bravo WeatherStik from 1.38 pt/ac to 2.0 pt/ac may increase the efficacy of tank-mixes with Proline (5.0 or 5.7 fl oz/ac; Figure 2).
3. Provysol, the new triazole fungicide from BASF, and associated premix fungicides showed strong increases in efficacy when tank-mixed with Bravo WeatherStik (Figure 2).
4. Tank-mixing Bravo WS with the SDHI fungicides Priaxor and Endura improved Ascochyta management under high disease pressure, but tank-mixing Bravo WS with Priaxor has not provided consistent improvements in Ascochyta management (Table 1 and Figure 3).
5. Tank-mixing Bravo WS with Miravis TOP (a premix of SDHI and triazole active ingredients) improved Ascochyta management under high disease pressure but has not provided consistent improvements in Ascochyta management across trials (Table 2 and Figure 4).

## METHODS

**Application methods**: Fungicides were applied with a 60-inch hand-held boom equipped with four nozzles, each 20 inches apart. Wilger or TeeJet flat-fan nozzles were utilized at pressures emitting fine or medium droplets.
**Row spacing:** 7.0 or 7.5 inches **Plot size:** 5 ft x 25 ft or 5 ft x 30 ft at planting.
**Experimental design:** randomized complete block design with four or five replicates.
**Disease establishment:** Infested crop residues were spread in non-harvested buffer and guard plots adjacent to the treatment plots during early to mid-vegetative growth. For lentils, no supplemental pathogen inoculation was conducted. **Disease assessment:** The percent of the canopy diseased was estimated twice after fungicides were applied, including once shortly before crop maturity. Disease progress over time was calculated on a 0 to 100 scale by calculating the area under the disease progress curve from the first fungicide application until the last disease assessment; a score of 50 translates into an average of 50 percent of the canopy diseased over this period.
**Yields** were calculated on the basis of the measured plot length and reported at a standard 13.5% moisture. Grain was cleaned prior to yield assessment.

**FIGURE 1. Impact of tank-mixing Proline and Bravo WeatherStik.**

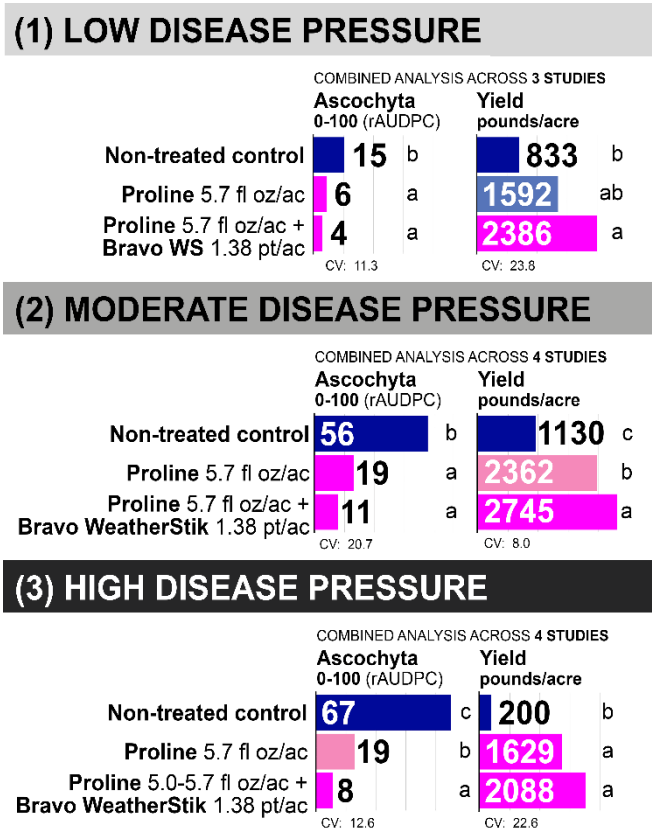
Testing was conducted across four locations, three locations, and four chickpea varieties.

Applications were made in 15 gal/ac at 30 or 40 psi using a hand-held boom equipped with flat-fan nozzles emitting fine or medium droplets at that pressure.

In each study, three to five fungicide applications were made 10-14 days apart, with the first application coinciding with the first appearance of disease symptoms and the number of applications dependent on the weather.

Average values followed by different letters represent statistically significant differences ($P < 0.05$; Tukey multiple comparison procedure).

**Combined analysis across multiple studies** (right):




**Results from individual studies** (below):

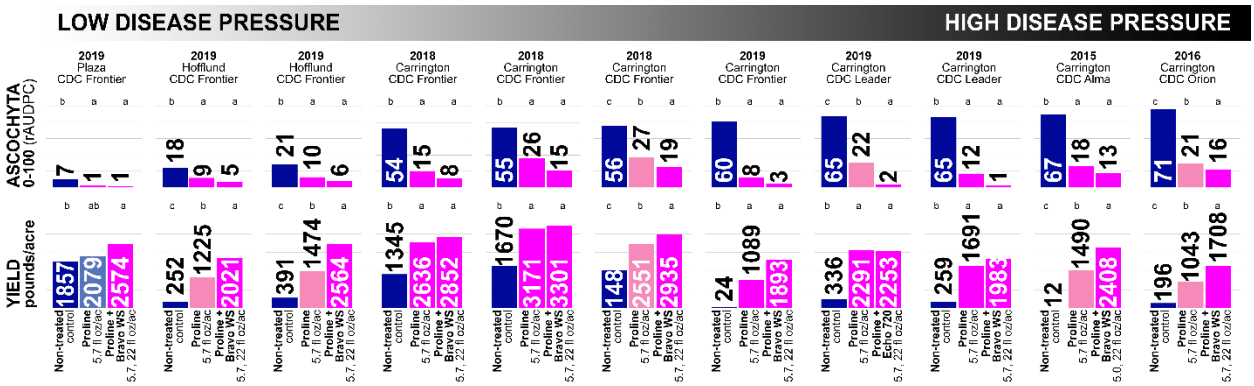
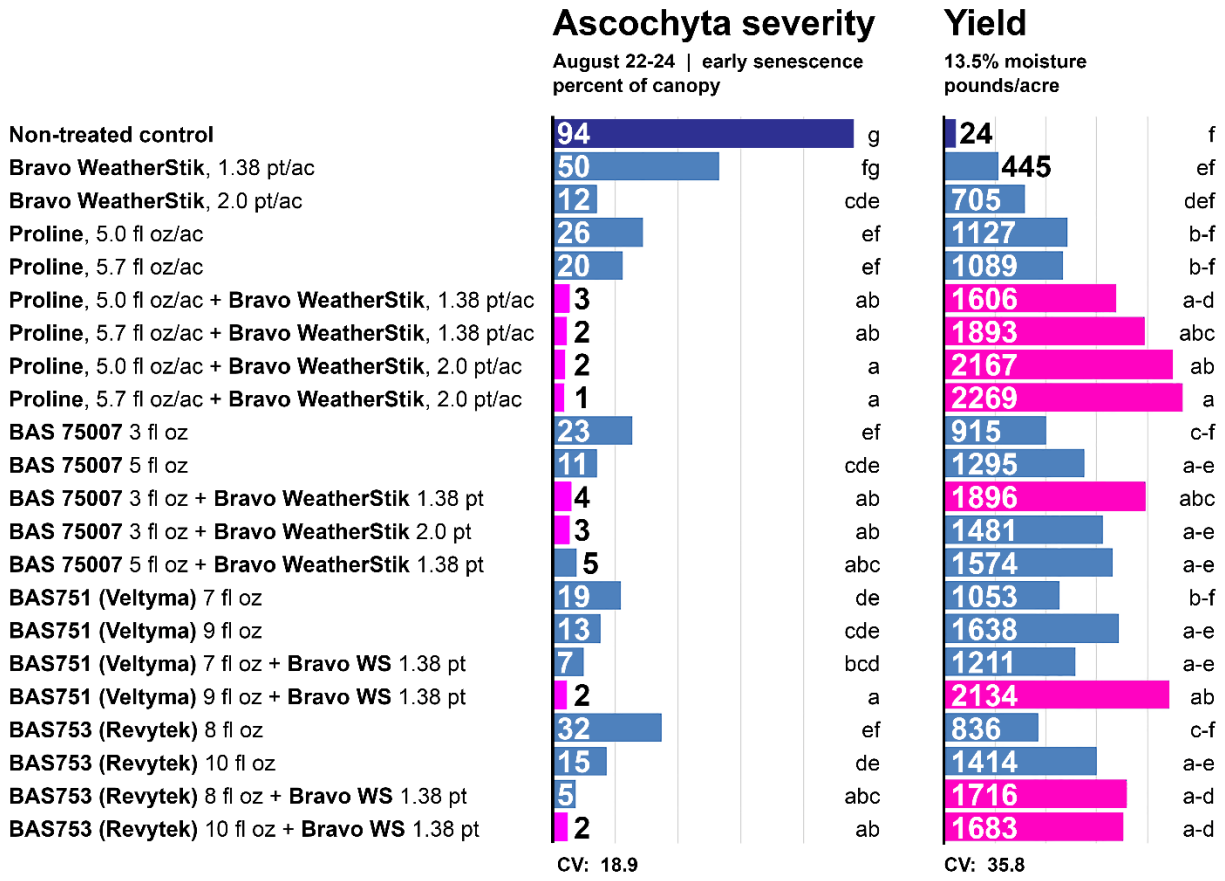


**FIGURE 2. Optimizing fungicide application rates in tank-mixes with Proline and Bravo WeatherStik; efficacy of tank-mixing Bravo WS and new fungicides from BASF containing the triazole (FRAC 3) active ingredient mefentrifluconazole.**

Applications were made in 15 gal/ac at 30 psi using a hand-held boom equipped with XR11002 flat-fan nozzles (fine droplets). Within-column means followed by different letters represent statistically significant differences ($P < 0.05$; Tukey multiple comparison procedure).

**Provysol** (BAS75007) contains the active ingredient mefentrifluconazole (FRAC 3).
**Veltyma** (BAS 751) is a premix of mefentrifluconazole and pyraclostrobin (FRAC 3, 11).
**Revytek** (BAS 753) is a premix of mefentrifluconazole, pyraclostrobin, and fluxapyroxad (FRAC 3,11,7).

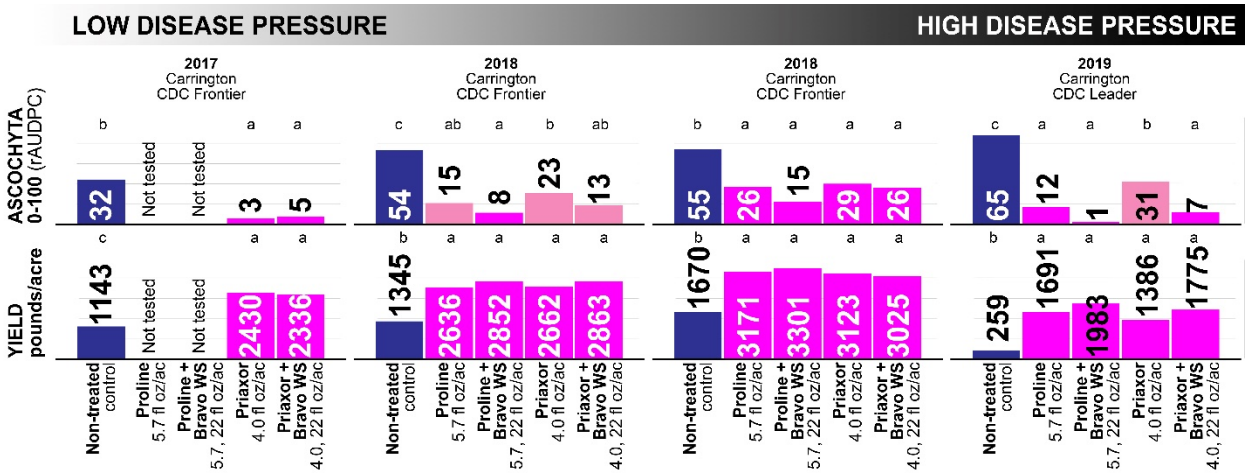


## FIGURE 3 and TABLE 1. Impact of tank-mixing Bravo WeatherStik and Priaxor.

In 2019, applications were made in 15 gal/ac at 30 psi using a hand-held boom equipped with XR11002 flat-fan nozzles (fine droplets). In 2017 and 2018, applications were made in 15 gal/ac at 30 or 40 psi with flat-fan nozzles emitting fine or medium droplets. Within-column means followed by different letters represent statistically significant differences ($P < 0.05$; Tukey multiple comparison procedure).

**Priaxor** contains the active ingredients fluxapyroxad (FRAC 7) and pyraclostrobin (FRAC 11). Due to the development of resistance to the FRAC 11 fungicides by the Ascochtya pathogen, Priaxor functions as primarily a FRAC 7 fungicide against Ascochyta blight of chickpeas.

### (1) Impact of tank-mixing Bravo WS and Priaxor (Carrington, ND; 2017-2019):




### (2) Impact of tank-mixing Bravo WS with Priaxor, Endura, Proline and Delaro (Carrington, 2019):

| | Treatment | Ascochyta severity: July 23 % necrosis | Ascochyta severity: Sept. 10 % necrosis | Ascochyta rAUDPC: June 18 - Sept. 10 % necrosis | Yield 13.5% moisture lbs/ac |
|---|---|---|---|---|---|
| 1 | **Non-treated control** | **72** e*‡ | **100** f* | **65** f* | **259** b* |
| 2 | **Bravo WeatherStik,** 1.38 pt/ac | **19** d | **79** def | **33** e | **1186** ab |
| 3 | **Proline 480SC,** 5.7 fl oz/ac | **3** abc | **37** a-d | **12** a-d | **1691** a |
| 4 | **Proline 480SC,** 5.7 fl oz/ac + **Bravo WeatherStik,** 1.38 pt/ac | **1** a | **2** a | **1** a | **1983** a |
| 5 | **Priaxor 500SC,** 4.0 fl oz/ac | **10** cd | **89** ef | **31** e | **1386** a |
| 6 | **Priaxor 500SC,** 4.0 fl oz/ac + **Bravo WeatherStik,** 1.38 pt/ac | **8** bcd | **12** ab | **7** abc | **1775** a |
| 7 | **Delaro 325SC,** 12.0 fl oz/ac | **6** a-d | **58** c-f | **20** cde | **1702** a |
| 8 | **Delaro 325SC,** 12.0 fl oz/ac + **Bravo WeatherStik,** 1.38 pt/ac | **5** abc | **5** a | **4** ab | **2011** a |
| 9 | **Delaro 325SC,** 12.0 fl oz/ac + **Proline 480SC,** 1.2 fl oz/ac | **4** abc | **49** b-e | **16** bcd | **2040** a |
| 10 | **Delaro 325SC,** 12.0 fl oz/ac + **Proline 480SC,** 1.2 fl oz/ac + **Bravo WS,** 1.38 pt/ac | **1** ab | **1** a | **1** a | **2057** a |
| 11 | **Endura 70WG,** 6.0 oz/ac | **22** de | **79** def | **34** e | **1177** ab |
| 12 | **Endura 70WG,** 6.0 oz/ac + **Bravo WeatherStik,** 1.38 pt/ac | **5** a-d | **18** abc | **8** abc | **1785** a |
| 13 | **Proline** 5.7 fl oz/ac / **Priaxor** 4.0 fl oz/ac | **7** bcd | **72** def | **25** de | **1645** a |
| 14 | **Proline** 5.7 fl oz/ac + **Bravo WS** 1.38 pt/ac / **Priaxor** 4.0 fl oz/ac + **Bravo WS** 1.38 pt/ac | **2** ab | **3** a | **2** ab | **2032** a |
| | *F:* | 14.39 | 17.81 | 37.62 | 5.66 |
| | *P>F:* | < 0.0001 | < 0.0001 | < 0.0001 | < 0.0001 |
| | CV: | 31.0 | 44.6 | 35.3 | 28.6 |

* **Within-column means followed by different letters are significantly different** ($P < 0.05$; Tukey multiple comparison procedure).

‡ To meet model assumptions of normality and/or homoskedasticity, analysis of variance was conducted on data subjected to a systematic natural-log transformation. For ease of interpretation, treatments means are presented for the non-transformed data.

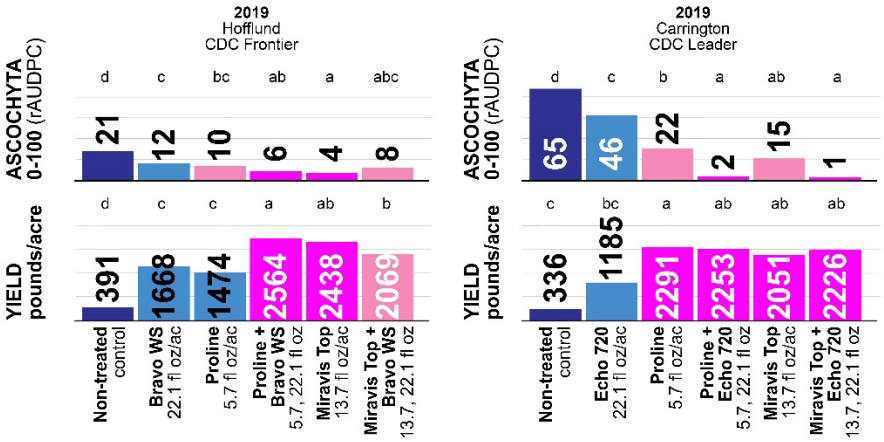
## FIGURE 4 and TABLE 2. Impact of tank-mixing chlorothalonil and Miravis TOP and Miravis NEO.

**Echo 720 and Bravo WeatherStik** are different commercial brands of chlorothalonil. The concentration of the active ingredient is the same in both products.
**Miravis Top:** pydiflumetofen (FRAC 7, 0.63 lb ai/gal) + difenoconazole (FRAC 3, 1.04 lb ai/gal)
**Miravis Neo:** pydiflumetofen (0.63 lb ai/gal) + azoxystrobin (FRAC 11, 0.83 lb ai/gal) + propiconazole (FRAC 3, 1.04 lb ai/gal). *Due to the development of resistance to the FRAC 11 fungicides by the Ascochtya pathogen and poor efficacy of propiconazole against Ascochyta blight, Miravis NEO likely functions as primarily a FRAC 7 fungicide against Ascochyta blight of chickpeas.*

### (1) Impact of tank-mixing Echo 720/ Bravo WS and Miravis TOP (Carrington and Hofflund, 2019):

Applications were made in 15 gal/ac at 30 psi and XR11002 flat-fan nozzles (fine droplets; Carrington) or 40 psi and Wilger ER110-015 nozzles (fine droplets; Hofflund).

Within-column means followed by different letters represent statistically significant differences ($P < 0.05$; Tukey multiple comparison procedure).




### (2) Impact of tank-mixing Echo 720 and Miravis TOP and Miravis NEO (Carrington, 2019):

| | Treatment | Ascochyta severity: July 22-23 % necrosis | Ascochyta severity: Sept. 10 % necrosis | Ascochyta rAUDPC: June 18 - Sept. 10 % necrosis | Yield 13.5% moisture lbs/ac |
|---|---|---|---|---|---|
| 1 | **Non-treated control** | **72** c*‡ | **100** e*‡ | **65** f*‡ | **336** c |
| 2 | **Echo 720** 22 fl oz/ac **(A,B,C,D,E)** | **44** c | **83** e | **46** f | **1185** bc |
| 3 | **Proline 480SC**, 5.7 fl oz/ac + NIS 0.125% v/v **(A,B,C,D,E)** | **4** ab | **69** de | **22** ef | **2291** a |
| 4 | **Proline 480SC**, 5.7 fl oz/ac + **Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(A,B,C,D,E)** | **2** ab | **2** ab | **2** abc | **2253** a |
| 5 | **Miravis NEO 300SE**, 13.7 fl oz/ac + NIS 0.125% v/v **(A,B,C,D,E)** | **5** ab | **76** de | **25** ef | **1857** ab |
| 6 | **Miravis NEO 300SE**, 13.7 fl oz/ac + **Echo 720 22 fl oz/ac** + NIS 0.125% v/v **(A,B,C,D,E)** | **3** ab | **2** ab | **2** abc | **2523** a |
| 7 | **Miravis TOP 200SC**, 13.7 fl oz/ac + NIS 0.125% v/v **(A,B,C,D,E)** | **4** ab | **43** cde | **15** de | **2051** ab |
| 8 | **Miravis TOP 200SC,** 13.7 fl oz/ac **+ Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(A,B,C,D,E)** | **3** ab | **0** a | **1** ab | **2226** a |
| 9 | **Quadris Opti**, 25 fl oz/ac + NIS 0.125% v/v **(A,D) / Miravis TOP**, 13.7 fl oz/ac + NIS 0.125% v/v **(B,E) / Miravis NEO**, 13.7 fl oz/ac + NIS 0.125% v/v **(C)** | **12** b | **16** bc | **11** cde | **1945** ab |
| 10 | **Quadris Opti**, 25 fl oz/ac + **Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(A,D) / Miravis TOP**, 13.7 fl oz/ac + **Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(B,E) / Miravis NEO,** 13.7 fl oz/ac + **Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(C)** | **6** ab | **2** a | **4** a-d | **2301** a |
| 11 | **Miravis NEO**, 13.7 fl oz/ac + NIS 0.125% v/v **(A,D) / Miravis TOP**, 13.7 fl oz/ac + NIS 0.125% v/v **(B,E) / Proline**, 5.7 fl oz/ac + NIS 0.125% v/v **(C)** | **3** ab | **11** bc | **5** a-d | **2009** ab |
| 12 | **Miravis NEO**, 13.7 fl oz/ac **+ Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(A,D) / Miravis TOP**, 13.7 fl oz/ac **+ Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(B,E) / Proline,** 5.7 fl oz/ac **+ Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(C)** | **4** ab | **1** a | **2** ab | **2066** ab |
| 13 | **Miravis TOP**, 13.7 fl oz/ac + NIS 0.125% v/v **(A,D) / Miravis NEO**, 13.7 fl oz/ac + NIS 0.125% v/v **(B,E) / Proline**, 5.7 fl oz/ac + NIS 0.125% v/v **(C)** | **1** a | **28** cd | **9** b-e | **2245** a |
| 14 | **Miravis TOP**, 13.7 fl oz/ac + **Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(A,D) / Miravis NEO**, 13.7 fl oz/ac **+ Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(B,E) / Proline**, 5.7 fl oz/ac **+ Echo 720** 22 fl oz/ac + NIS 0.125% v/v **(C)** | **1** a | **1** a | **1** a | **2028** ab |
| | *F:* | 15.66 | 31.36 | 23.19 | 8.59 |
| | *P>F:* | < 0.0001 | < 0.0001 | < 0.0001 | < 0.0001 |
| | CV: | 36.8 | 28.8 | 27.3 | 21.8 |

*** Within-column means followed by different letters are significantly different** ($P < 0.05$; Tukey multiple comparison procedure).

‡ To meet model assumptions of normality and/or homoskedasticity, analysis of variance was conducted on data subjected to a systematic natural-log transformation. For ease of interpretation, treatments means are presented for the non-transformed data.