EFFECT OF METHYL JASMONATE AND HEADLINE ON ROOT AND SUCROSE YIELD

Methyl jasmonate (MeJA) is widely investigated for its ability to enhance yield and protect crop plants and products from environmental stress and disease (Rohwer and Erwin, 2008). For many crop species and plant products, MeJA application improves resistance against pathogens and insect pests and provides protection against environmental stresses including cold, drought, and high soil salinity. MeJA also influences plant development, growth, and metabolism, and increases in biomass and alterations in carbohydrate partitioning have been attributed to its use (Pelacho and Mingo-Caster, 1991; Wang and Zheng, 2005). Previous research established that sugarbeets respond to MeJA and documented the ability of postharvest MeJA treatments to reduce rot caused by three storage pathogens (Fugate et al., 2012). The effect of preharvest MeJA treatment on sugarbeet production and storage properties, however, has not been previously studied.

Research to determine the effects of early or late season MeJA treatment on sugarbeet root yield, sucrose content, and storage properties was initiated in 2014. Treatments were applied singly or in combination with a late season Headline treatment. In 2014, Headline was a commonly used fungicide for Cercospora leaf spot (causal agent *Cercospora beticola*) control and was also applied for possible plant health benefits due to purported hormone-like properties (Köhle et al., 2003). Because of the potential of Headline's hormonal effects to interact with MeJA, Headline treatments were included in the experimental design.

In 2014, root yield and recoverable sugar per acre increased for plants receiving an early MeJA treatment + a late Headline treatment (Fugate et al., 2016). Plants that received the early MeJA + Headline treatment yielded 3.5 tons acre^{-1} more than untreated controls. Recoverable sugar per acre (RSA) for the early MeJA + Headline treatment was 1856 lbs acre^{-1} greater than the RSA of controls. No significant effects on storage traits including root respiration rate, sucrose loss in storage, invert sugar accumulation, or root firmness were observed due to the early MeJA + Headline treatment.

In a 2015 repetition of this experiment, MeJA had no beneficial effects on root yield, sucrose content, or sucrose yield at time of harvest. The experiment, however, was compromised by a late season Cercospora infection, and Headline-containing treatments outperformed treatments without Headline. An early season MeJA + Headline treatment, however, affected storage traits, and roots that received this treatment had reduced respiration rates after 30 days in storage, reduced loss to molasses after 30 and 90 days in storage, and improved recoverable sugar per ton after 30 days in storage (Fugate et al., 2017).

In 2016 the experiment was repeated. In this experiment, MeJA treatments had no effect on root yield, sucrose content or sucrose yield at harvest (Fugate et al., 2018). Storage properties were mostly unaffected by MeJA treatment, although an increase in root respiration rate after 100 days in storage for roots that received an early season MeJA treatment and an increase in recoverable sugar per ton after 100 days in storage for roots that received a late season MeJA treatment + Headline were noted.

In 2017, the experiment was redesigned to include only early season MeJA treatments with or without a Headline treatment. To determine if differences in MeJA application time in 2014, 2015, and 2016 were responsible for the variable results between experiments, two application times that differed by approximately 1 month were used. Additionally, a higher rate of MeJA was added to the experiment. The redesigned experiment was repeated in 2018. Results of the 2017 and 2018 field experiments are reported here.

MATERIALS AND METHODS

Field studies were conducted near Mooreton, ND in 2017 and near Foxhome, MN in 2018. Fields were planted to two varieties (Hilleshög 4062 and Betaseed 73MN in 2017 and Hilleshög 4302 and Betaseed 7099 in 2018) using a split plot design with 6 replications and varieties as the main plots. Treatments included (1) an untreated control, (2) a 30-day preharvest Headline treatment, (3) a mid-June MeJA treatment at 0.01 µM, (4) a mid-June MeJA treatment at 10 µM, (5) a mid-July MeJA treatment at 0.01 µM, (6) a mid-July MeJA treatment at 10 µM, (7) a mid-June MeJA treatment at 0.01 µM + 30-day preharvest Headline treatment, (8) a mid-June MeJA treatment at 10 µM + a 30-day preharvest Headline treatment, (9) a mid-July MeJA treatment at 0.01 µM + a 30-day preharvest Headline treatment, and (10) a mid-July MeJA treatment at 10 µM + a 30-day preharvest Headline treatment. MeJA solutions contained 10 ppm (v/v) Tween 20 and were applied as foliar sprays; Headline was applied at a rate of 9 oz/acre. Planting, treatment, and harvest dates for the 2017 and 2018 experiments are reported in Table 1.

At harvest, plants were mechanically defoliated, and roots were unearthed with 1-row (2017) or 3-row (2018) lifters. Harvested roots were washed and stored at 5°C (41°F) and 95% relative humidity for up to 90 days for the 2017 study. Respiration rate, sucrose content, loss to molasses, recoverable sugar yield, and invert sugar concentration were determined after 30 and 90 days in storage using established protocols (Campbell et al., 2012).

Table 1. Planting, treatment, and harvest dates for the 2017 and 2018 field experiments conducted near Mooreton, ND (2017) and Foxhome, MN (2018).

	2017	2018
Planting date	9 May	11 May
MeJA treatment dates		
June	8 June	14 June
days after sowing	30	34
July	14 July	13 July
days after sowing	66	63
Headline treatments		
date	21 Aug	28 Aug
days before harvest	46	31
Harvest date	6 Oct	28 Sept

Data were analyzed by ANOVA with α = 0.05 using Minitab Statistical Software (ver. 16; State College, PA).

RESULTS

In the 2017 field experiment, MeJA treatments had no effect on root yield, sucrose content, loss to molasses or recoverable sugar per ton at time of harvest relative to untreated controls (Table 2). Recoverable sugar per acre (RSA) was similar to controls for all treatments except for a mid-June MeJA application at 0.01 μM with a 30-day preharvest Headline application. This treatment yielded an additional 1149 lbs/acre than the controls.

Storage properties were generally unaffected by MeJA treatments (Tables 3 and 4). After 30 or 90 days in storage, root respiration rate, sucrose content, loss to molasses, recoverable sugar per ton and invert sugar concentration for all MeJA treatments were similar to controls. The only exception was a small decrease in respiration rate after 90 days storage for roots that received a mid-July MeJA application at the 0.01 μM rate.

In the 2018 field experiment, MeJA treatments had no effect on root yield, sucrose content, loss to molasses, recoverable sugar per ton, or recoverable sugar per acre at harvest (Table 5). Since MeJA had no or minimal effect on storage properties in previous experiments, no storage study was conducted with these roots.

CONCLUSION

A MeJA + Headline treatment increased root yield and recoverable sugar per acre in a field experiment conducted in 2014. These beneficial effects, however, were not reproduced in subsequent repetitions of the experiment. It is suspected that differences in results between experimental repetitions are due to environmental differences between field studies. However, the environmental conditions affecting the MeJA + Headline treatment are presently unknown.

Table 2. Harvest data from 2017 field experiment. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05.

Treatment	yield (tons/acre)		sucrose (%)		loss to molasses (%)		Recoverable sugar per ton (lbs/ton)		Recoverable sugar per acre (lbs/acre)	
control--untreated	32.4	ab	16.2	ab	1.58	a	293	a	7993	bc
Headline (HDL)	29.9	b	15.9	ab	1.66	a	285	a	7454	c
Jun MeJA, 0.01 μM	30.1	b	16.2	ab	1.62	a	292	a	7497	c
Jun MeJA, 10 μM	31.4	b	15.8	b	1.49	a	286	a	7644	bc
Jul MeJA, 0.01 μM	32.4	ab	16.3	ab	1.45	a	297	a	8520	ab
Jul MeJA, 10 μM	30.8	b	15.9	b	1.53	a	287	a	7646	bc
Jun MeJA, 0.01 μM + HDL	35.4	a	16.4	a	1.18	a	299	a	9142	a
Jun MeJA, 10 μM + HDL	33.4	ab	16.2	ab	1.43	a	295	a	8438	abc
Jul MeJA, 0.01 μM + HDL	31.8	ab	16.0	ab	1.46	a	291	a	8045	bc
Jul MeJA, 10 μM + HDL	30.8	b	16.1	ab	1.53	a	291	a	7678	bc

Table 3. Respiration rate and invert sugar concentration 30 and 90 days after harvest (DAH) for the 2017 field experiment. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05. Treatment means that are significantly different from the control are highlighted in red.

Treatment	**respiration ($mg\ CO_2/kg/h$)**				**inverts (g/100 g sucrose)**			
	30 DAH		**90 DAH**		**30 DAH**		**90 DAH**	
control--untreated	4.32	a	3.98	ab	0.61	ab	0.82	a
Headline (HDL)	4.21	a	3.70	ab	0.63	ab	0.79	a
Jun MeJA, 0.01 µM	4.14	a	3.79	ab	0.71	ab	0.79	a
Jun MeJA, 10 µM	4.09	a	3.81	ab	0.73	ab	0.84	a
Jul MeJA, 0.01 µM	4.03	a	3.57	c	0.59	b	0.73	a
Jul MeJA, 10 µM	4.09	a	3.70	ab	0.63	ab	0.81	a
Jun MeJA, 0.01 µM + HDL	4.06	a	4.00	ab	0.63	ab	0.88	a
Jun MeJA, 10 µM + HDL	4.02	a	3.66	bc	0.69	ab	0.76	a
Jul MeJA, 0.01 µM + HDL	4.34	a	4.08	a	0.59	ab	0.84	a
Jul MeJA, 10 µM + HDL	4.19	a	3.89	ab	0.74	a	0.80	a

In all repetitions of the experiment, MeJA treatments had few effects on storage properties. Where any statistical difference in a storage property was noted, these were not reproduced in other repetitions of the experiment. It is therefore concluded that MeJA, as used in these studies, had no beneficial effect on sugarbeet root yield, sucrose yield, or storage, and its use is not recommended. No further repetitions of the experiment will be conducted.

Table 4. Sucrose content, loss to molasses and recoverable sugar per ton 30 and 90 days after harvest (DAH) for the 2017 field experiment. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05.

Treatment	**sucrose (%)**				**loss to molasses (%)**				**recoverable sugar per ton (lbs/ton)**			
	30 DAH		**90 DAH**		**30 DAH**		**90 DAH**		**30 DAH**		**90 DAH**	
control--untreated	16.2	abc	16.8	ab	1.56	abc	1.91	ab	292	ab	298	abc
Headline (HDL)	15.9	bc	16.5	ab	1.69	a	1.97	a	285	b	291	bc
Jun MeJA, 0.01 µM	16.1	abc	16.9	ab	1.53	abc	1.97	a	292	ab	298	abc
Jun MeJA, 10 µM	15.9	c	16.4	b	1.67	ab	1.90	ab	284	b	290	c
Jul MeJA, 0.01 µM	16.6	a	17.1	a	1.39	c	1.71	b	304	a	308	a
Jul MeJA, 10 µM	16.1	abc	16.3	b	1.57	abc	1.88	ab	291	ab	289	c
Jun MeJA, 0.01 µM + HDL	16.5	ab	17.1	a	1.47	bc	1.74	ab	301	a	307	ab
Jun MeJA, 10 µM + HDL	16.3	abc	16.8	ab	1.52	abc	1.76	ab	296	ab	300	abc
Jul MeJA, 0.01 µM + HDL	16.3	abc	16.8	ab	1.48	abc	1.76	ab	296	ab	301	abc
Jul MeJA, 10 µM + HDL	16.3	abc	16.9	ab	1.46	c	1.75	ab	296	ab	303	abc

Table 5. Harvest data for the 2018 field experiment. Means within a column followed by similar letters are statistically similar based upon Tukey's range test, with α = 0.05.

Treatment	yield (tons/acre)		sucrose (%)		loss to molasses (%)		Recoverable sugar per ton (lbs/ton)		Recoverable sugar per acre (lbs/acre)	
control--untreated	22.0	a	17.8	a	1.01	a	336	a	7423	a
Headline (HDL)	22.1	a	17.1	a	1.05	a	320	a	7095	a
Jun MeJA, 0.01 µM	21.7	a	17.5	a	1.06	a	329	a	7164	a
Jun MeJA, 10 µM	20.4	a	17.7	a	1.08	a	332	a	6878	a
Jul MeJA, 0.01 µM	20.3	a	17.7	a	0.99	a	335	a	6801	a
Jul MeJA, 10 µM	20.7	a	17.6	a	1.08	a	330	a	6835	a
Jun MeJA, 0.01 µM + HDL	23.1	a	17.5	a	1.11	a	328	a	7557	a
Jun MeJA, 10 µM + HDL	21.3	a	18.0	a	1.15	a	336	a	7179	a
Jul MeJA, 0.01 µM + HDL	19.4	a	17.5	a	1.07	a	329	a	6383	a
Jul MeJA, 10 µM + HDL	21.4	a	18.0	a	1.14	a	337	a	7208	a

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