Project Title: Effect of methyl jasmonate and Headline™ on root and sucrose yield properties

Project Number/Description: continuation of project funded in FY 2017-2018

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Project Location: USDA-ARS, Northern Crop Science Laboratory, Fargo, ND

Justification for Research:

For a number of crop plants and plant products, methyl jasmonate (MeJA) application improves resistance against a range of pathogens and insect pests and protects against environmental stresses including cold temperature, drought, and high soil salinity. MeJA also affects plant development, growth, and metabolism, and increased biomass and improved carbohydrate partitioning to storage organs have been attributed to its use.

Research was initiated in 2014 to determine the effect of MeJA on sugarbeet root yield, sucrose content, and storage properties. In these studies, MeJA was applied to field grown sugarbeets, with and without Headline™. Initial research found beneficial effects of an early season MeJA application with a late season Headline application. These beneficial effects included a 3.5 ton/acre increase in yield in 2014, and a reduction in storage respiration rate after 30 days storage in 2015. This research was repeated in 2016 and 2017 and a combined analysis of the multiyear data is ongoing. An additional experiment was conducted in collaboration with Mike Metzger to determine the effects of MeJA application rates and application times on sugarbeet yield, quality, and storage properties. In this study, in 2016, plants that received a MeJA treatment, regardless of application time or rate, had sucrose contents that were 0.5-1% greater than untreated controls at harvest. This experiment was repeated in 2017 and will be repeated in 2018. At the conclusion of the 2018 experiment, data from all experiments will be collectively analyzed to determine the feasibility of using foliar applications of MeJA to improve sugarbeet recoverable sucrose yield at harvest and after storage.

Summary of Literature Review and Progress toward Objectives of Ongoing Project:

Jasmonic acid and its methylated derivative, methyl jasmonate, are natural plant compounds that trigger native plant defense mechanisms. In a number of crop plants, application of jasmonates provides protection against a wide range of pathogens, insect pests, and environmental stresses including drought and cold temperature (Rohwer and Erwin, 2008). Beneficial effects on yield and quality have also been observed including increases in tuber weight of potatoes (Pelacho and Mingo-Castel, 1991), sugar content of raspberries (Wang and Zheng, 2005), and reduced sugar losses in stored radishes (Wang, 1998).

In initial research to determine the effect of MeJA on sugarbeet root yield, sucrose yield, and storage properties, MeJA was applied to field grown-sugarbeets, with and without a late season (30 days before harvest) Headline treatment, in Fargo in 2014, 2015, and 2016. Salicylic acid (SA), another plant compound that triggers plant defense mechanisms, was also tested in this research. MeJA and SA treatments were applied as early season treatments with and without a late season Headline treatment. MeJA was also applied as a late season treatment, with or without Headline. Yield data was collected at harvest and the harvested roots were evaluated for storage properties under temperature-controlled storage conditions.

In 2014, root yield and recoverable sugar per acre were significantly elevated for plants that received an early MeJA treatment + a late Headline treatment. Plants that received this treatment yielded 3.5 ton/acre more than untreated controls, and yielded 1856 lbs more sugar per acre than controls. No yield or recoverable sugar per acre (RSA) gain was observed with MeJA or Headline alone. Storage properties including root respiration rate, invert sugar accumulation, and root firmness were unaffected by MeJA treatment (Fugate et al., 2016).

In 2015, a late season *Cercospora* infection compromised the experiment, and all Headline-containing treatments had greater root yields than treatments that did not include Headline. No MeJA treatment had any effect on root yield, sucrose content, loss to molasses, or RSA. Beneficial effects of an early season MeJA treatment + Headline on storage properties, however, were observed, 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 early MeJA + Headline treatment provided no statistically significant benefits at harvest or during storage in roots grown in Fargo (Table 1). An additional field experiment was carried out near Mooreton, ND that examined the effects of MeJA rate and application time on production and storage properties (Table 2). In the Mooreton experiment, MeJA treatments without Headline had sucrose concentrations at harvest that were 0.5 to 1.0% greater than controls. Recoverable sugar per ton at harvest was significantly greater in two of these treatments (MeJA applied at 10 µM in mid-June and MeJA applied at 0.01 µM in mid-July), and RSA was significantly greater in one (MeJA applied at 10 µM in mid-June). This treatment yielded an additional 1468 lbs/acre in recoverable sugar compared to untreated controls. Treatments had no statistically significant effect on any storage property.

In 2017, the Mooreton experiment was repeated at both a Mooreton and a Fargo location (Tables 3 and 4). At Mooreton, all treatments had similar root yield, sucrose content, recoverable sugar per ton, and loss to molasses at time of harvest. A significant 1149 lbs/acre increase in RSA, however, was found for plants receiving a mid-June MeJA treatment of 0.01 µM + a late August Headline treatment. In Fargo, no significant treatment differences were found at time of harvest. Storage studies for roots from these two locations are in progress.

Table 1: 2016 Fargo harvest and storage data. Values that are statistically different from untreated controls are highlighted in red. DAH = days after harvest

Treatment	yield		recoverable sugar		recoverable sugar				sucrose content				loss to molasses				respiration rate			
					0 DAH		90 DAH		0 DAH		90 DAH		0 DAH		90 DAH		30 DAH		90 DAH	
	tons/acre		lbs/acre		lbs/ton				%				%				mg CO_2/kg/h			
control--untreated	17.4	ab	5287	a	303	ab	308	b	16.8	ab	17.2	ab	1.66	a	1.94	a	3.67	a	3.88	b
early MeJA	17.5	ab	5212	a	299	ab	303	b	16.7	ab	16.7	b	1.73	a	1.77	a	3.49	a	4.82	a
late MeJA	20.1	a	6011	a	298	ab	308	b	16.6	ab	17.3	ab	1.68	a	2.04	a	3.90	a	3.93	ab
early SA	18.0	ab	5049	a	285	b	301	b	16.1	b	16.7	b	1.88	a	2.01	a	3.71	a	4.25	ab
late Headline	19.5	ab	6082	a	311	ab	311	ab	17.2	ab	17.2	ab	1.62	a	1.92	a	3.60	a	4.18	ab
early MeJA + Headline	18.1	ab	5643	a	311	ab	310	ab	17.0	ab	17.2	ab	1.41	a	1.91	a	3.75	a	3.80	b
late MeJA + Headline	18.1	ab	5723	a	318	a	331	a	17.6	a	18.3	a	1.63	a	1.92	a	4.01	a	4.17	ab
early SA + Headline	18.7	ab	5491	a	294	ab	301	b	16.5	ab	16.7	b	1.84	a	1.87	a	3.66	a	3.96	ab
Stadium	16.9	b	5124	a	303	ab	300	b	16.7	ab	16.7	b	1.55	a	2.00	a	3.85	a	4.43	ab
Stadium + Headline	20.1	a	5932	a	296	ab	306	b	16.5	ab	17.0	b	1.69	a	1.99	a	3.59	a	3.94	ab

Table 2: 2016 Mooreton harvest and storage data. Values that are statistically different from untreated controls are highlighted in red.

Treatment	yield		recoverable sugar		recoverable sugar				sucrose content				loss to molasses				respiration rate			
					0 DAH		90 DAH		0 DAH		90 DAH		0 DAH		90 DAH		30 DAH		90 DAH	
	tons/acre		lbs/acre		lbs/ton				%				%				mg CO_2/kg/h			
control--untreated	35.6	a	8853	b	253	b	262	ab	15.2	b	15.5	ab	2.49	a	2.48	a	3.60	a	3.54	a
Headline (HDL)	36.8	a	9391	ab	259	ab	265	ab	15.4	ab	15.6	ab	2.45	a	2.43	a	3.68	a	3.45	a
Jun MeJA, 0.01 µM	34.9	a	9237	ab	266	ab	271	ab	15.7	ab	16.0	ab	2.31	a	2.53	a	3.47	a	3.51	a
Jun MeJA, 10 µM	37.5	a	10321	a	278	a	274	a	16.2	a	16.0	ab	2.25	a	2.37	a	3.40	a	3.43	a
Jul MeJA, 0.01 µM	34.4	a	9482	ab	278	a	271	ab	16.1	a	16.0	ab	2.21	a	2.49	a	3.57	a	3.55	a
Jul MeJA, 10 µM	35.5	a	9779	ab	276	ab	275	a	16.1	a	16.1	a	2.28	a	2.44	a	3.63	a	3.61	a
Jun MeJA, 0.01 µM + HDL	35.5	a	9390	ab	265	ab	262	ab	15.5	ab	15.5	ab	2.29	a	2.42	a	3.52	a	3.54	a
Jun MeJA, 10 µM + HDL	36.0	a	9302	ab	259	ab	262	ab	15.5	ab	15.6	ab	2.53	a	2.60	a	3.55	a	3.61	a
Jul MeJA, 0.01 µM + HDL	37.7	a	9640	ab	258	ab	256	b	15.4	ab	15.4	b	2.48	a	2.62	a	3.57	a	3.44	a
Jul MeJA, 10 µM + HDL	37.5	a	9895	ab	265	ab	265	ab	15.6	ab	15.7	ab	2.37	a	2.47	a	3.57	a	3.48	a

Table 3: 2017 Mooreton harvest and storage data. Values that are statistically different from untreated controls are highlighted in red.

Treatment	yield		recoverable sugar		recoverable sugar		loss to molasses		sucrose content				respiration rate 30 DAH	
									0 DAH		30 DAH			
	tons/acre		lbs/acre		lbs/ton		%		%				mg CO_2/kg/h	
control--untreated	32.4	ab	7993	bc	293	a	1.58	a	16.2	ab	16.2	abc	4.32	a
Headline (HDL)	29.9	b	7454	c	285	a	1.66	a	15.9	ab	15.9	bc	4.21	a
Jun MeJA, 0.01 µM	30.1	b	7497	c	292	a	1.62	a	16.2	ab	16.1	abc	4.14	a
Jun MeJA, 10 µM	31.4	b	7644	bc	286	a	1.49	a	15.8	b	15.9	c	4.09	a
Jul MeJA, 0.01 µM	32.4	ab	8520	ab	297	a	1.45	a	16.3	ab	16.6	a	4.03	a
Jul MeJA, 10 µM	30.8	b	7646	bc	287	a	1.53	a	15.9	b	16.1	abc	4.09	a
Jun MeJA, 0.01 µM + HDL	35.4	a	9142	a	299	a	1.18	a	16.4	a	16.5	ab	4.06	a
Jun MeJA, 10 µM + HDL	33.4	ab	8438	abc	295	a	1.43	a	16.2	ab	16.3	abc	4.02	a
Jul MeJA, 0.01 µM + HDL	31.8	ab	8045	bc	291	a	1.46	a	16.0	ab	16.3	abc	4.34	a
Jul MeJA, 10 µM + HDL	30.8	b	7678	bc	291	a	1.53	a	16.1	ab	16.3	abc	4.19	a

Table 4: 2017 Fargo harvest and storage data.

Treatment	yield		recoverable sugar		recoverable sugar		loss to molasses		sucrose content				respiration rate 30 DAH	
									0 DAH		30 DAH			
	tons/acre		lbs/acre		lbs/ton		%		%				mg CO_2/kg/h	
control--untreated	16.8	abcd	5552	abc	330	a	1.42	a	17.9	a	18.7	a	4.24	ab
Headline (HDL)	16.1	bcd	5052	cd	316	a	1.90	a	17.5	a	18.8	a	3.80	b
Jul MeJA, 0.01 µM	16.7	abcd	5534	abc	331	a	1.51	a	18.1	a	18.7	a	4.31	ab
Jul MeJA, 10 µM	16.1	bcd	5150	bcd	319	a	1.65	a	17.6	a	19.3	a	4.40	ab
Jul MeJA, 0.01 µM + HDL	17.5	abc	5703	ab	326	a	1.54	a	17.8	a	19.3	a	4.16	ab
Jul MeJA, 10 µM + HDL	15.9	cd	5060	cd	318	a	1.59	a	17.5	a	19.0	a	4.38	ab

Objective:

Determine the effect of methyl jasmonate, with or without Headline treatment, on root yield, sucrose content, and root quality using two rates and two application dates for MeJA.

Materials and Methods

Field studies will be conducted in cooperation with Mike Metzger. A split plot design using two commercial varieties (Betaseed 73MN and Hilleshög 4062), ten treatments, and six replications will be used, with varieties as the main plots. Treatments include:

1. untreated control
2. Headline , applied 1 month before harvest
3. MeJA (0.01 µM), applied early June
4. MeJA (10 µM), applied early June
5. MeJA (0.01 µM), applied early July
6. MeJA (10 µM), applied early July
7. MeJA (0.01 µM), applied early June + Headline, applied 1 month before harvest
8. MeJA (10 µM), applied early June + Headline, applied 1 month before harvest
9. MeJA (0.01 µM), applied early July + Headline, applied 1 month before harvest
10. MeJA (10 µM), applied early July + Headline, applied 1 month before harvest

Four rows plots, 25 feet in length will be used. Standard agronomic practices for fertilization and pathogen control will be used. MeJA at concentrations of 0.01 or 10 µM will be applied to foliage in early June and early July. Headline will be applied at a rate of 9 oz/acre in late August or early September, approximately 30 days before harvest. Roots will be harvested from the middle two rows of a plot at the end of September or early October depending on weather conditions. Root yield will be determined at harvest by determining the weight of roots in a 25' row. Ten root samples will be collected at harvest from each plot and used to determine sucrose concentration, invert sugar concentration, sucrose loss to molasses, sodium and potassium concentrations, amino-nitrogen concentration, extractable sugar yield per acre, and extractable sugar yield per ton. A multi-year analysis of results will be conducted using data collected from 2016, 2017 and 2018 repetitions of this experiment.

Time Line of Anticipated Accomplishments:

Apr 2018	Field plots planted
Oct 2018	Roots harvested
Dec 2018	Chemical analysis complete
Feb 2019	Data analysis complete

References:

Fugate, K., Campbell, L., Eide, J., Lafta, A., and Khan, M. (2017). Effect of methyl jasmonate, salicylic acid, Headline™ and Stadium™ on sucrose yield and storage properties. 2016 Sugarbeet Res. Ext. Rep., Coop. Ext. Serv., North Dakota State Univ. 47:88-92.

Fugate, K., Campbell, L., Eide, J., Ribeiro, W., de Oliveira, L. (2016). Effect of methyl jasmonate, salicylic acid, Headline and Stadium on sucrose yield and storage properties. 2015 Sugarbeet Res. Ext. Rep., Coop. Ext. Serv., North Dakota State Univ., 46:73-76.

Pelacho, A.M., Mingo-Castel, A.M. (1991). Jasmonic acid induces tuberization of potato stolons cultured in vitro. Plant Physiol. 97: 1253-1255.

Rohwer, C.L., and Erwin, J.E. (2008). Horticultural applications of jasmonates: A review. J. Hort. Sci. Biotech. 83:283-304.

Wang, C.Y. (1998). Methyl jasmonate inhibits postharvest sprouting and improves storage quality of radishes. Postharvest Biol. Technol. 14: 179-183.

Wang, S.Y., Zheng, W. (2005). Preharvest application of methyl jasmonate increases fruit quality and antioxidant capacity in raspberries. Internatl. J. Food Sci. Technol. 40: 187-195.

Budget:

Labor	$5500.00
Equipment (over $250.00)	0.00
Supplies	500.00
Travel	0.00
Leases	0.00
Other	0.00
Total	**$6,000.00**

TOTAL FUNDING REQUEST: $6,000.00