Can low rates of precipitated calcium carbonate (PCC) be used to reduce soil borne disease impact on Sugar Beets?

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Justification: Participated calcium carbonate (PCC) has been found to reduce the impact of aphanomyces root rot in Minnesota and phytophora root rot in California. Most of the published research indicates a minimum of 10 tons (wet weight) of PCC/acre should be applied to reduce the effect of soil borne diseases on sugar beets. However, these studies had an initial application rate of 3 tons PCC per acre or greater, lower rates were not used. Most extension publications from Minnesota/North Dakota suggest PCC be applied and incorporated a minimum of 6 months prior to planting of sugar beet. Some beet producers have asked if surface application near planting is feasible. Multiple research projects currently conducted in the Imperial Valley are examining the response of sugar beets to high rates of PCC, both incorporated and unincorporated, applied at or near planting or multiple years in advance of planting. However, little information is available to determine if low rates of PCC would economically affect sugar beet yield or quality and how these applications should be made.

Objectives: With these ideas in mind, a study was conducted with the objectives of 1) determine the yield and quality response of disease susceptible and resistant sugar beet varieties to low rates of PCC, and 2) investigate the effect of application timing and incorporation of low rates of PCC on sugar beet tolerance to late root rot (phytophthora) disease.

Method and Materials: To meet the objectives stated above, a field experiment was conducted at the Imperial Valley Research Farm during the 2015-2016 and 2016-2017 growing seasons. The treatments were four application rates of PCC (0, 1, 2, and 4 lb/acre), two application times (spring and fall), and two varieties (one resistant and one susceptible to phytophthora). The treatment design was a factorial. The experimental design was a split plot with PCC application and time of application as the whole plot and the variety as the split plot. The treatments will be in a randomized complete block design with four replications. In the 2015-2016 growing season, the whole plot area was laid out in June before the growing season. The first application of PCC was applied August 13, 2015 and the second application was applied October 12, 2015 just before planting. Both applications were broadcast applied and then incorporated. The sugar beets were planted October 13, 2015 and harvested on July 8, 2016. The resistant variety was Beta 52RR45 and the susceptible variety was SES 2013. In the 2016 – 2017 growing season the first application of PCC was August 17, 2016 and the second application was October 20, 2016. The plots were seeded October 17, 2016 and harvested July ???? 2017.

Results and Discussion:

Growing season 2015-2016:

The statistical analysis reported in Table 1, indicates that variety affected rot occurrence, sucrose concentration, root yield, percent and lb/ton extractable sucrose. There was also a PCC rate by variety interaction for root yield. Table 2, reports the lack of response to all parameters

measured to the time of PCC application while Table 3, reports the lack of response to all parameters measured to the rate of PCC application.

Table 1. The statistical analysis on the effect of PCC application time, PPC application rate, and sugar beet variety on stand, rot, sucrose, beet nitrate-N, purity, root yield, and extractable sucrose (%, lb/ton, and lb/acre) in the 2015 – 2016 growing season.

	Stand	Rot	Sucrose	Nitrate-N	Purity	Root yield	Extractable sucrose		
	Number per plot		%	ppm	%	ton/A	%	lb/ton	lb/A
Term	Probability of a greater F								
Application time	NS	NS	NS	NS	NS	NS	NS	NS	NS
PCC rate	NS	NS	NS	NS	NS	NS	NS	NS	NS
Application time * PCC rate	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety	NS	0.004	0.0001	NS	NS	0.0001	0.0001	0.0001	NS
Application time * Variety	NS	NS	NS	NS	NS	NS	NS	NS	NS
PCC rate * Variety	NS	NS	NS	NS	NS	0.05	NS	NS	NS
Variety * Application time * PCC rate	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	2.2	74	4.7	41	2.1	4.3	7.7	7.7	8.1
Grand mean	107.3	2.9	14.3	135	86.3	56.4	11.2	224	12575

Table 2. The effect of PCC application time on stand, rot, sucrose, beet nitrate-N, purity, root yield, and extractable sucrose (%, lb/ton, and lb/acre) in 2015 – 2016 growing season.

Application time	Stand	Rot	Sucrose	Nitrate-N	Purity	Root yield	Extractable sucrose		
	Number per plot		%	ppm	%	ton/A	%	lb/ton	lb/A
Spring	107	3.6	14.4	128	86.5	55.9	11.3	225	12572
Fall	107	2.2	14.2	144	86.2	56.8	11.1	222	12578
Statistic	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. The effect of PCC application rate on stand, rot, sucrose, beet nitrate-N, purity, root yield, and extractable sucrose (%, lb/ton, and lb/acre) in 2015 – 2016 growing season.

Application rate (ton/A)	Stand	Rot	Sucrose	Nitrate-N	Purity	Root yield	Extractable sucrose		
	Number per plot		%	ppm	%	ton/A	%	lb/ton	lb/A
0	107	4.6	14.5	123	89.7	55.8	11.4	228	12686
1	107	2.6	14.2	134	85.9	56.2	11.1	221	12409
2	108	2.1	14.4	137	86.4	56.8	11.3	225	12755
4	107	2.2	14.1	147	86.1	56.6	11.0	220	12427
Statistic	NS	NS	NS	NS	NS	NS	NS	NS	NS

The susceptible variety had a greater occurrence of rot compared to the resistant variety, Table 4. Sucrose concentration, extractable sucrose (% and lb/ton) were less for the resistant variety when compared to the susceptible variety. The was an interaction between the PCC rate and variety for root yield, Table 5. There was one rate of application, 2 ton/A, that had a greater yield for the resistant variety than the other PCC rates. This did not occur for the susceptible variety. Overall, the root yield was greater for the resistant variety than the susceptible variety. This is not unusual. When the effects of the use of PCC on root yield and sucrose with resistant and susceiptible varieties are integrated into the calculation of extractable sucrose per acre, there was no difference caused by variety.

Table 4. The effect of variety on stand, rot, sucrose, beet nitrate-N, purity, root yield, and extractable sucrose (%, lb/ton, and lb/acre) in 2015 – 2016 growing season.

Application time	Stand	Rot	Sucrose	Nitrate-N	Purity	Root yield	Extractable sucrose		
	Number per plot		%	ppm	%	ton/A	%	lb/ton	lb/A
Resistant	108	2.0	13.7	139	86.1	58.7	10.6	213	12497
Susceptible	107	3.8	14.9	132	86.5	54.0	11.7	235	12653
Statistic	NS	0.004	0.0001	NS	NS	0.0001	0.0001	0.0001	NS

Table 5. The interaction of PCC rate and variety on root yield in the 2015 – 2016 growing season.

	Resistant	Susceptible
PCC application rate	Root yield	
ton/A	tons/acre	
0	58.0	53.6
1	57.2	55.2
2	60.8	52.7
4	58.7	54.5

In the 2015 – 2016 research study, only variety affected sucrose and root yield. There was no difference for extractable sucrose per acre between susceptible and resistant varieties in this study. The amount and time of PCC application did not affect any parameters measured in this study.

Growing season 2016-2017:

The statistical analysis for the results from the growing season of 2016-2017 are reported in Table 6. Variety significantly affected root rot, root yield, sucrose concentration, extractable sucrose concentration, extractable sucrose per ton, extractable sucrose per acre, and beet brei nitrate. Purity was not affect by variety. The application of PCC did not affect any parameter measured. Table 7 reports the means for all treatments. While the root yields were above average, the extractable sucrose concentration and extractable sucrose per ton were very poor. It means that the root rot affected extractability of sucrose from the root even though the measured purity was not effected by variety.

Table 8. Reports the means for the effect of the resistant verses the susceptible varieties. The resistant variety had greater root yield, extractable sucrose per acre, and brei nitrate-N compared to the susceptible variety. The resistant variety had less root rot, sucrose concentration, extractable sucrose concentration, extractable sucrose per ton than the susceptible variety. The greater root yield for the resistant variety overcame the reduction in sucrose concentration and thus generated greater extractable sucrose per acre.

Table 6. Statistical analysis for root rot, root yield, sucrose, extractable sucrose concentration, extractable sucrose per ton, extractable sucrose per acre, root purity and beet nitrate for growing season 2016 to 2017.

				Extractable sucrose				
Source of variation	Root rot	Root yield	Sucrose	%	lb/ton	lb/A	Purity	Beet nitrate
PCCApplication	0.15	0.88	0.76	0.91	0.94	0.84	0.76	0.80
Variety	0.03	0.0001	0.0001	0.002	0.002	0.0002	0.91	0.0001
PCCA*Variety	0.38	0.51	0.72	0.95	0.96	0.74	0.91	0.59
C.V. (%)	154	5.3	4.2	7.7	7.7	8.9	2.1	14.7
Grand mean	0.6	55.7	12.5	8.6	173	9624	80.3	664

Table 7. The effect of PCC application time and rate on root rot, root yield, sucrose, extractable sucrose concentration, extractable sucrose per ton, extractable sucrose per acre, root purity and beet nitrate-N for growing season 2016 to 2017.

	Root rot	Root yield	Sucrose	Extractable sucrose			Purity	Beet nitrate-N
Treatment*	Number of beets in harvest area	ton/acre	%	%	lb/ton	lb/acre	%	ppm
F0	1.4	55.3	12.4	8.8	176	9713	81.7	681
F0.5	0.5	55.2	12.4	8.4	168	9243	79.7	687
F1	0.6	55.8	12.6	8.5	171	9535	79.8	708
F2	0.5	55.1	12.7	8.8	175	9621	80.5	669
F4	0.9	54.8	12.8	8.7	174	9570	79.8	646
S0	0.6	57.1	12.7	8.9	178	10148	80.9	632
S0.5	0.4	55.2	12.4	8.4	169	9288	80.0	694
S1	0.3	58.7	12.5	8.7	175	10294	80.9	546
S2	0.4	56.0	12.5	8.6	173	9632	80.2	639
S4	0.4	54.8	12.4	8.5	170	9279	80.0	722

* S = PCC application on August 17, 2016, F = PCC application on October 10, 2016. The number following the time of application is amount of PCC applied in tons wet weight per acre.

Table 8. The effect of variety (resistant is Beta 52RR45 and susceptible is SES 2013) on root rot, root yield, sucrose, extractable sucrose concentration, extractable sucrose per ton, extractable sucrose per acre, root purity and beet nitrate-N for growing season 2016 to 2017.

	Root rot	Root yield	Sucrose	Extractable sucrose			Purity	Beet nitrate-N
Variety	Number of beets in harvest area	ton/acre	%	%	lb/ton	lb/acre	%	ppm
Beta 52RR45	0.4	59.7	12.2	8.4	167	10016	80.3	722
SES 2013	0.8	51.7	12.9	8.9	178	9222	80.3	604

In the 2016-2017 growing season, the timing of the application of PCC did not affect any of the measured parameters. There was no interaction between Variety and PCC application. Variety did not affect purity. Variety did affect the rest of the parameters measured. The susceptible variety (SES 2013) had more root rot, increased sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton than the resistant variety (Beta 52RR45). The resistant variety had a greater root yield, extractable sucrose per acre and beet nitrate-N concentration than the susceptible variety. Overall, the quality of the sugar beet harvested in this study was poor, high nitrate-N and low extractable sucrose.

Summary:

In both years of this study, the application and time of application of PCC did not affect the measured parameters. The use of a resistant variety resulted in a greater root yield in both years. The susceptible variety had a greater occurrence of late season root rots compared to the resistant variety. Sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton was reduced for the resistant variety compared to the susceptible variety. In the first year, the extractable sucrose per acre was not affected by the variety while in the second year the resistant variety did have a greater extractable sucrose per acre.