Project Title:
Evaluation of Systemic Acquired Resistance Products and Biologicals for the Control of Spinach Downy Mildew

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Abstract:
Spinach downy mildew (SDM) has been identified by the Leafy Greens Board as the most important disease in spinach production. It is responsible for significant crop losses each year, as many fields cannot be profitably harvested, due to severe SDM infection. A large number of fields impacted by spinach downy mildew, are in organic production, which has few viable options for disease control. Although there are genetically resistant (to SDM) varieties currently available, new strains of the fungus are constantly evolving, rendering them essentially useless. Identifying new management strategies is critically important, not only for the organic spinach industry, but also for spinach produced by conventional methods as well. Systemic acquired resistance (SAR) is a method of "turning on" a plant's genetic resistance to environmental stress, insect pressure and plant disease by use of biological or chemical materials. Several SAR materials were evaluated in 2013 to discover whether any might be useful in the management of downy mildew in spinach. Of these, spinach crops treated with Mono, dipotassium phosphite and acibenzolar-S-methyl exhibited perceptible efficacy in reducing the incidence of SDM.

The ever-evolving nature of the fungus also presents a problem for breeders, who have a particularly difficult task - to produce new resistant varieties - quickly, and in turn, seed companies must rapidly produce enough seed to meet demand. The breeding of new varieties and the production of seed is a long-term process that can take several years. Their work is consistently hampered by SDM, due to poor availability of resistant varieties.

Long-Range Objectives:
Over the long-term, the goal of this project was to identify new management strategies to combat spinach downy mildew (SDM), identify *commercially available* SAR products that may be used to enhance genetic resistance to SDM, and/or increase the efficacy of chemical and biological fungicides.

Procedures:
A savory type spinach variety was planted on 10/1/13 onto 30 inch beds, center to center with three seed lines per bed. The field was sprinkler irrigated on a daily basis until the stand was established. Weeds were controlled by pre-plant application of phenmaedipham (Ro-Neet) and post-plant with S-ethyl cyclohexylethylthiocarbamate (Spin-Aid).

After the appearance of 4 true leaves, applications of SAR products were made on a 14-day schedule. In order to ensure delivery of the required amount of product, applications were made using a calibrated garden pump sprayer. The plots were 20 feet in length by one 30 inch row. The field experiment used a complete randomized block design with 5 replications. Spinach plants infected with SDM were transplanted from a commercial, organic field onto the border rows in order to increase the likelihood of developing downy mildew within the plot.

The following list of SAR treatments were evaluated for disease control efficacy:

1. K-Phite (mono and dipotassium phosphite)	Plant Food Systems	3 qt/A
2. Pro-TeKt (potassium silicate)	Dyna-Gro	1:1500
3. Double Nickel 55 (Bacillus amyloliqesfaciens)	Certis USA	3 lbs/A
4. Actigard (acibenzolar-S-methyl)	Syngenta	0.75 oz/A
5. Regalia (Reynotria sachalinensis)	Marrone	4 qt/A
6. Companion (B. subtilis GB03)	Growth Products LTD	4 qt/A
7. SiTKo (salicylic acid, silica & phosphite)	Growth Products LTD	2 qt/A
8. Keyplex 350 (amino acids)	Keyplex	1 qt/A
9. KP 1000 DPX & Fungi Phite	Keyplex	2 qt/A & 2 qt/A
10. Ridomil Gold (menfenoxam)	Syngenta	0.25 pt/A
11. Control		

Treatment Dates	Disease Rating (SDM) Dates
10/22/13	11/25/13
11/5/13	12/3/13
11/18/13	12/11/13
12/3/13	12/17/13 (fig 1)
12/17/13	

Results and Discussion:

The results were mixed from the trial mainly due to the fact that non-treated control plots did not develop a more severe SDM infection rate as compared to most treatments (figure 1). Significant differences, however, were recorded each week that the downy mildew ratings were made. These differences were mainly due to the excellent disease control that Ridomil Gold provided, and that Regalia seemed to increase the amount of disease present. K-Phite and Actigard did numerically reduce the level of downy mildew - but not significantly. By the end of the study, Ridomil Gold was the only product able to control downy mildew.

Combinations of SAR products may prove to be more efficacious on SDM than applications of a single product alone. Additionally, the combination of a fungicide with one or two SAR products may further enhance the level of control, and prove more beneficial than relying on fungicides alone. The potential of combinations such as these, will be explored in the upcoming season.

Figure 1. Percent downy mildew leaf infection.

	25-Nov	3-Dec	11-Dec	17-Dec
1. K-Phite	8 de	11 abcd	16 bcd	26 de
2. Pro-TeKt	37 a	23 abcd	24 bc	28 de
3. Double Nickel 55	26 abcde	27 abc	20 bcd	32 cde
4. Actigard	11cde	20 abcd	14 cd	32 cde
5. Regalia	29 abc	38 a	40 a	58 a
6. Companion	17 abcde	32 ab	24 bc	38 bcd
7. SiTKo	20 abcde	14 bcd	24 bc	34 cd
8. Keyplex 350	32 ab	39 a	28 ab	50 abc
9. KP 1000 DPX & Fungi Phite	26 abcd	26 abcd	26 bc	54 ab
10. Ridomil Gold	5 e	5 d	8 d	14 e
11. Control	21 bcde	14 bcd	16 bcd	26 de
Probability=	0.0485	0.0234	0.0023	0.0005
%CV	78.65	70.31	46.81	41.04
LSD $_{P=0.05}$	20.33	20.34	13.06	18.70

Figure 2. Percent downy mildew leaf infection averaged over time.

1. K-Phite	15.25
2. Pro-TeKt	28.0
3. Double Nickel 55	26.25
4. Actigard	19.25
5. Regalia	41.25
6. Companion	27.75
7. SiTKo	23.0
8. Keyplex 350	37.25
9. KP 1000 DPX & Fungi Phite	33.0
10. Ridomil Gold	8.0
11. Control	19.25
Probability=	0.0000
%CV	57.51