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Management of Phytophthora Root and Stem Rot of Soybean

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Phytophthora root and stem rot of soybean (PRR), caused by the oomycete *Phytophthora sojae*, is one of the most yield-limiting pathogens of soybeans in the United States. This pathogen, present in many Nebraska soybean fields, survives for years primarily as "resting" spores (oospores) in the soil or in association with infected crop debris. When the environment becomes favorable for disease development, the oospores germinate to form infective spores (zoospores), which are attracted to root exudates.

In 2000–2007, *Phytophthora sojae* race, or biotype, surveys for soybean were conducted with funding from the Nebraska Soybean Board. Races 1, 3, 4, 5, 8, 9, 13, 14, 18, 23, 25, 28, 33, 38, 40, 41, 43, and 44 were recovered from soybean fields in Nebraska. Previous surveys were conducted in eastern Nebraska in 1980 and 1981, resulting in recovery of races 1, 3, 9, 14, 18, and 23. From these isolations and surveys, it is apparent that our *P. sojae* population is becoming more diverse and difficult to manage.

Once *P. sojae* is established in a field, it cannot be eradicated. PRR must be managed with the use of seed treatment fungicides and resistant varieties. Many resistant varieties have both *Rps* (Resistant to *Phytophthora sojae*) genes, which are specific to certain races of *P. sojae*, as well as partial resistance that is expressed in the roots. Partial resistance, also known as field tolerance, is a generalized resistance to many races of *P. sojae*. The combination of *Rps* genes and partial resistance provides the best protection, especially in areas that may contain a diverse population of races.

Symptoms

PRR can cause damage throughout the year and can cause seed rots, pre- and post-emergence damping off of seedlings, and stem rot of plants at various growth stages. Damping off may cause a light brown, soft rot to develop on roots or the hypocotyl when the seedlings emerge.

Root and stem rot appears later in the season, and severity is directly related to the level of genetic resistance in the plant. Colonization begins in the roots and moves up the plant. Reddish-brown to black lesions start just below the soil line and may extend several nodes up the stem *(Figure 1)*. The lesion typically encircles the stem and always starts at the plant base. As colonization continues, the roots and stems turn brown and chlorotic leaves wilt, but the petioles remain attached. Cultivars with high levels of partial resistance do not get the stem rot phase, but the plants may be stunted.

Environmental Conditions

Spore germination begins when soil temperatures reach 60°F with high soil moisture. The optimum soil temperature for disease development is 77 to 86°F. This disease is most common in low-lying areas of a field, in poorly drained or compacted soil, and in soils with high clay content. It also may occur in well-drained fields during growing seasons with excessive moisture availability.

Figure 1. Soybean plant with Phytophthora root and stem rot. Note the dark stem discoloration extending from the soil up the stem.

Table I. Seed treatment fungicides[1] labeled for Phytophthora sojae control on soybean.[2]

Product Name	Active Ingredients (%)	Rate (oz per 100 lb)	Comments
Acceleron® DX-309	Metalaxyl 28.35%	0.75–1.5	Insecticide and additional treatments can be added to base fungicide
Acquire®	Metalaxyl 29.99%	0.75–1.5	Acquire comes with Charter seed treatment
Allegiance® Dry	Metalaxyl 12.5%	1.5–2.0	
Allegiance® FL	Metalaxyl 28.35%	0.75–1.5	
Allegiance® LS	Metalaxyl 17.7%	1.2–2.4	Use higher rate for Phytophthora control
Apron XL®	Mefenoxam 33.3%	0.16–0.64	Use higher rate for Phytophthora control
Inovate®	Ipconazole 0.72% + Metalaxyl 1.153% + *Clothianidin 14.34% (I)*	4.74	Add additional metalaxyl or mefenoxam in high Phytophthora pressure areas. Contains insecticide (Group 4A)
Inovate® Pro	Ipconazole 1.203% + Metalaxyl 0.965% + *Clothianidin 24.03% (I)*	2.81	Contains insecticide (Group 4A)
Protector-L-Allegiance®	Metalaxyl 1.61% + Thiram 14.29%	6.7	
ApronMaxx® RFC	Fludioxonil 2.31% + Mefenoxam 3.46%	1.5	Add Apron XL to improve Phytophthora control
ApronMaxx® RTA®	Fludioxonil 0.73% + Mefenoxam 1.1%	5.0	Add Apron XL to improve Phytophthora control
ApronMaxx® RTA + Moly	Fludioxonil 0.68% + Mefenoxam 1.02%	5.0	
Warden® RTA®	Fludioxonil 0.72% + Mefenoxam 2.21%	5.0	
Trilex® 2000	Metalaxyl 5.69% + Trifloxystrobin 7.12%	1.0	
CruiserMaxx®	Fludioxonil 1.12% + Mefenoxam 1.7% + *Thiamethoxam 22.61% (I)*	3.0	Add Apron XL to improve Phytophthora control. Contains insecticide (Group 4A)
CruiserMaxx® Advanced	Fludioxonil 1.15% + Mefenoxam 3.46% + *Thiamethoxam 23.1% (I)*	3.2	Add Apron XL to improve Phytophthora control. Contains insecticide (Group 4A)
CruiserMaxx® EX	Fludioxonil 1.15% + Mefenoxam 3.46% + *Thiamethoxam 23.1% (I)*	3.15	Add Apron XL to improve Phytophthora control. Contains insecticide (Group 4A)
CruiserMaxx® Plus	Fludioxonil 1.07% + Mefenoxam 3.21% + *Thiamethoxam 21.5% (I)*	3.2	Add Apron XL to improve Phytophthora control. Contains insecticide (Group 4A)
UpShot™ Soybean Seed Treatment	Fludioxonil 1.15% + Mefenoxam 3.46% + *Thiamethoxam 23.1% (I)*	2.94	Add Apron XL to improve Phytophthora control. Contains insecticide (Group 4A)
Catapult™ XL	Chloroneb 30.0% + Mefenoxam 1.95%	5.5–7.0	
EverGol® Energy SB	Metalaxyl 5.74% + Penflufen 3.59% + Prothioconazole 7.18%	1.0	Add Allegiance FL in high Phytophthora pressure areas
Intego™ Suite Soybeans	Ethaboxam 2.97% + Ipconazole 0.99% + Metalaxyl 0.79% + *Clothianidin 20.0% (I)*	3.37	Contains insecticide (Group 4A)
Bean Guard®/ Allegiance®	Captan 24.45% + Carboxin 12.5% + Metalaxyl 3.75%	3.3	
CruiserMaxx® Vibrance®	Fludioxonil 1.04% + Mefenoxam 3.13% + Sedaxane 1.04% + *Thiamethoxam 21.5% (I)*	3.22	Add Apron XL to improve Phytophthora control. Contains insecticide (Group 4A)
Warden® CX	Fludioxonil 1.0% + Mefenoxam 5.99% + Sedaxane 1.0% + *Thiamethoxam 20.0% (I)*	3.38	Contains insecticide (Group 4A)
Prevail®	Carboxin 15.0% + PCNB 15.0% + Metalaxyl 3.12%	2.0–4.0 oz per bushel	

1. Product list is intended for information purposes only. No criticism is intended for products not listed nor endorsement for products listed. Always read and follow label directions when applying any pesticide.

2. Table adapted from *2017 Guide for Weed, Disease, and Insect Management*, Nebraska Extension.

3. Application rates on the high end of the labeled amount are generally necessary for adequate *P. sojae* control.

Management

Cultural Management: PRR is more severe in poorly drained or flooded areas. Any management practice that improves soil drainage, such as tillage or placing drain tiles, may reduce the incidence and severity of PRR. Because *P. sojae* oospores can survive in soil for long periods of time, rotation is not an effective management option but will reduce the amount of inoculum, compared with continuous soybeans.

Chemical Control: Seed treatment fungicides can be used for management of early season seed rot and damping off caused by *P. sojae.* The compounds labeled for control are ethaboxam, metalaxyl, and mefenoxam. Mefenoxam is

one of the chemical compounds that has been isolated from metalaxyl and is the most active part of metalaxyl products. As a result of isolating the active component, products containing mefenoxam are typically used at half the active ingredient rate of metalaxyl products.

A list of products containing these compounds and their recommended rate of application is provided in *Table I*. Generally, all varieties of soybean grown in problem fields should be treated since conditions favoring *P. sojae* also favor *Pythium spp.*, which commonly also causes seedling problems in Nebraska. While all products listed in *Table I* have activity against *P. sojae*, the higher rate is needed for control in most fields with a history of PRR.

Table II. A list of the races of Phytophthora sojae identified in Nebraska through 2007 and the soybean plant's Rps gene reaction to these races (R=Resistant and s=susceptible).

Race	*Rps* Resistance Genes							
	1-a	1-b	1-c	1-d	1-k	3a	6	7
1	R	R	R	R	R	R	R	s
3	s	R	R	R	R	R	R	s
4	s	R	s	R	R	R	R	s
5	s	R	s	R	R	R	s	s
8	s	R	R	s	R	R	s	s
9	s	R	R	R	R	R	s	s
13	R	R	R	R	R	R	s	s
14	R	R	s	R	R	R	R	s
18	R	R	s	R	R	R	R	R
23	s	s	R	R	R	R	s	s
25	s	s	s	R	s	R	R	s
28	s	s	R	R	s	R	R	s
33	s	s	s	s	s	R	R	s
38	s	s	s	s	s	s	s	s
40	s	R	s	s	s	R	R	s
41	s	s	R	s	s	R	R	s
43	s	R	s	s	R	R	R	s
44	s	R	R	s	R	R	R	s

Genetic Resistance

The use of resistant varieties is the most effective way to manage Phytophthora root and stem rot of soybean. Genetic resistance in the host is expressed in terms of *Rps* genes. The race-specific genes confer complete resistance to a specific race of *P. sojae*. The *Rps* gene differentials used in race testing are denoted as *Rps* 1a, 1b, 1c, 1d, 1k, 3a, 6, 7. The pathogen exists in races or biotypes that interact with these genes. A race is identified by its interaction with eight of the 14 known *Rps* genes. In a resistant reaction, the plant survives infection; susceptible varieties are killed when infection occurs *(Table II)*. Race-specific resistance is effective in the early stages of germination.

Soybean varieties are marketed on the basis of their genetic makeup in relation to the predominant *P. sojae* races in a given area. The predominant races in Nebraska are 3 and 33. The most widely available resistance genes in the Midwest are 1c and 1k, commonly referred to as "c" or "k" in seed company literature. Gene 1c protects against races 1, 3, 8, 9, 13, 23, 28, 41, and 44, and gene 1k protects against races 1, 3, 4, 5, 8, 9, 13, 14, 18, 23, 43, and 44. Gene 3a is the only gene that protects against 99 percent of the races that occur in Nebraska. Currently, 89 percent of the maturity group 2 and group 3 soybean varieties marketed in Nebraska contain some resistance to *P. sojae*. Resistance within these maturity groups is listed in *Table III*. Growers should consult local seed company representatives to request varieties with different *Rps* genes than those marketed in a specific area.

The other parameter on which soybean varieties are rated for *P. sojae* is partial resistance (also called field resistance or tolerance). Soybean varieties with high levels of partial resistance may become infected with *P. sojae,* but symptoms are less severe compared with highly susceptible

Table III. Number of varieties with Phytophthora sojae resistance genes available in Nebraska for maturity groups two and three in 2015 seed catalogs[1].

Maturity Group	Percent Nebraska Marketed Varieties With *Rps* Gene Resistance										
	1-a	1-b	1-c	1-d	1-k	3a	6	7	1c/3a	1k/3a	1k/7
Group 2	1	0	55	0	49	6	0	0	3	1	0
Group 3	1	0	74	0	28	0	0	0	2	1	0

1. Based on a survey of Asgrow®, Channel®, Hoegemeyer™, Latham®, Mycogen®, NK®, Pioneer®, and Producers® 2015 seed catalogs.

varieties. In field research trials conducted in Nebraska, high levels of partial resistance performed as well as varieties with resistance genes and partial resistance.

For fields with a *P. sojae* biotype that is aggressive against the resistance genes available in commercial varieties, this is the only choice for management with genetics. When possible, a combination of good partial resistance and an *Rps* gene is recommended. Partial resistance alone will not be as effective during early growth stages or under high disease pressure.

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