

Management of Potato Diseases in Montana-2015

Barry J. Jacobsen and Nina Zidack

Disease	Active Ingredient (FRAC Group)	Rate Product/A	PHI days	Comments
Bacterial Ring Rot Bacterial Black leg	Sodium /calcium hypochlorite, Quaternary ammonium compounds, Peroxyacetic acid, hydrogen peroxide, Formaldehyde, Phenol, copper quinolate, iodine compounds	See product labels. Use at highest label rate. See table on disinfectants		Use only approved tissue culture derived nuclear stocks Wash and disinfect cellars, air duct pipe, all handling and cutting equipment with soapy water then with disinfectant keeping wet for 10-15 min. Disinfect cutter between each lot Do not allow any trucks from off the farm to be cleaned out on premises, do not use old sacks. When possible have truck prewashed with soapy water followed by quaternary ammonium compound. Be sure to use quaternary ammonia disinfectant foot baths Work with Potato lab on any suspected infections
Bacterial Soft Rot	Same as above The following products can be used on potatoes: Chlorine dioxide, sodium/calcium hypochlorite, mixtures of peroxyacetic acid and hydrogen peroxide	See product labels. Use at highest label rate. See table on disinfectants		Avoid harvest at > 65-75F-especially when wet Have good skin set before harvest-10-14 days post vine kill Provide protection from sunscald of harvested tubers-tarp loads if long exposure Remove symptomatic or damaged tubers before binning No drops >6-8” during harvest, handling, binning Place in disinfected storage with “clean” equipment Allow for suberization for 10-14 days @50-55F , aeration with no moisture condensation <i>If frost damage or significant damage from dry soil-separate if possible-consider use of BioSave, Oxidate, SaniDate, StorOx, Jet Oxide, Jet -Ag. Do not use BioSave with other products.</i> <i>If possible wait to harvest so symptomatic tubers are obvious</i> <i>Pile separately- use as shallow a pile as possible</i> <i>Use dry air to dry out as fast as possible</i> <i>Use lower temperatures – get to 38-40F as fast as possible</i>
Black dot	Planting time Azoxystrobin 11 ¹ Penthiopyrad Fluapyroxad 7 + Pyraclostrobin 11	Quadris Vertisan Priaxor	na na	Plant disease free seed Apply infurrow 0.4-0.8 fl oz /1000 row ft Apply infurrow 0.7-1.6 fl oz/1000 row ft-max rate/A=24 oz Apply infurrow at 0.48-0.6 fl oz/1000 row ft., apply again foliar (4-8 Oz/A)when plants are 6-12 inches and again before row closure

	Post emergence Azoxystrobin + Chlorothalonil Pyraclostrobin 11 Mancozeb M3 Chlorothalonil M5 Difenconazole 3 Penthiopyrad 7 Fluapyroxad 7 + Pyraclostrobin 11 Pyrclostrobin11 + Metiram M3 Metconazole 3	Quadris Opti Headline Many product names Top MP Vertisan Priaxor Cabrio Plus Quash	14 3 7 14 7 7 3 1	Apply Quadris Opti, Headline, mancozeb or chlorothalonil when plants are 6-12” No more than 2 consecutive applications no more than 28 oz/A /season No more than 2 consecutive applications no more than 28 oz/A /season No more than two consecutive applications and no more than 72 fl oz/season/A No more than two consecutive applications and no more than 3 applications (4-8 oz/A) or 24 oz/season No more than two consecutive applications of group 11 fungicide No more than 4 applications per season, no more than 16 oz, no more than 2 sequential applications
Early Blight	Use adequate Nitrogen for yield objectives, Use P day forecasting system to initiate fungicide applications- uspest.org			
Late Blight	Eliminate cull piles before crop emergence, plant disease-free seed, control volunteers, Scout fields for symptoms, use weather based late blight prediction system- uspest.org			
Early Blight Late Blight	Azoxystrobin-11 ¹	Quadris 6.2-14 fl oz	14	Use no more than 2.88qt/a per season
	Azoxystrobin+ chlorothalonil	Quadris Opti 1.6 pt	14	Use no more than 3 gal/a per season
	Azoxystrobin + difenoconazole 3	Quadris Top	14	
	Chlorothalonil M5	Bravo, Equus, Echo, Initiate, Applause, etc	7	Many formulations follow label
	Cymoxanil+ famoxadone 11	Tanos-6 oz for early blight, 8 Oz for late blight	14	Mix with M5 group fungicide
	Fenamidone 11	Reason 5.5-8.2 fl oz	14	30 day PHI for wheat, 1 year all other crops. Do not exceed 24.6 oz/season
	Fluoxastrobin 11	Evito 3.8 fl oz Aftershock 2.0-3.8 oz	7	Do not exceed 22.8 oz/season

	Pyraclostrobin 11	Headline 6-9 fl oz for early blight 6-12 oz for late blight	3	Do not exceed 2.25 qt/a per season
	Pyraclostrobin 11 + metiram M3	Cabrio Plus 2-2.9 lb/a	14	No more than 2 consecutive applications. No more than 17.4 lbs/season
	Metconazole 3 Fluapyroxad 7 + Pyraclostrobin 11	Quash 2-4 oz Priaxor 4-8 oz/A	1 7	No more than 2 consecutive applications. No more than 16 oz/A/season No more than two consecutive applications and no more than 3 applications (4-8 oz/A) or 24 oz/season
	Trifloxystrobin 11	Gem 6-8 oz , Gem 500SC 2.9-3.8 fl oz use highest rate for late blight	7	Do not exceed 48 oz (23 fl oz-Gem 500SC)/ season
	Boscalid 7	Endura 2.5-4.5 oz	30	Early Blight only No more than 2 sequential applications, no more than 4 applications/season
	Maneb M3	Maneb 80 WP- 1.5 -2.0 lb Manex 4F 1.2- 1.5qt	3	Do not exceed more than 11.2 lb ai/season
	Mancozeb-M3	Dithane F45-1- 2 lb Manzate 200, Penncozeb-1- 2lb	3	Do not exceed more than 11.2 lb ai/season
	Mandiproamide 40+ Difenoconazole 3	Revus Top 5.5-7.0 fl oz	14	Use primarily for Late blight. No more than 2 consecutive applications. No more than 28 fl oz/season
	Difenoconazole 3	Top MP	14	No more than 2 consecutive applications. No more than 28 fl oz/season Maybe tank mixed with Omega for late blight
	Pyrimethanil-9	Scala 7 fl oz	7	Early Blight only Does not control late blight –use in combination with a class M , 7 or 30 material
	Fluopyram 7 + pyrimethanil 9	Luna Tranquility	7	Early Blight only No more than consecutive applications, no more than 43.6 fl oz/A (ground application) or 33.6 fl oz/A (aerial application)

	TPTH-triphenyltin hydroxide 30	SuperTin 4L 4-6 fl oz, SuperTin 80 WP, Agri Tin 80WP 2.5-3.75 oz	7 21	Do not use more than 18 oz/season SuperTin4L or 11.25 oz/ season of 80WP formulations. Do not use with emulsifiable pesticides or MH30. Some phytotoxicity to Superior and Norland varieties. Note 24 hr reentry period. May be mixed with maneb or mancozeb products for improved early blight control
	Zoximid-22 + Mancozeb M3	Gavel 1.5-2.0 lb	3	Do not exceed 12lb/season Primarily for late blight. Note field workers should be advised that this fungicide is dermal and oral sensitizer
	Metiram M3	Polyram 1.5-2.0 lb	14	No more than 14 lb/ season-do not feed to livestock
	Penthiopyrad-7	Vertisan	7	Early blight only No more than two consecutive applications and no more than 72 fl oz/season/A
Late Blight-only	cymoxanil	Curzate	14	Do not use alone, mix with FRAC M3, M5, 30 protective fungicide
	Cyazofamid-21	Ranman 1.4-2.75 fl oz	7	No more than 27.5 fl oz/season. Note for crops not on label 30 day limit before planting
	Dimethomorph 15	Forum 4-6 oz	4	Tank mix with M class fungicide. Do not mix with mefenoxam or metalaxyl. Do not exceed 30 oz/season. May be used after vine kill to prevent tuber infection
	Ametoctradin + Dimethomorph	Zampro 11-14 oz	4	
	Propamocarb hydrochloride 28	Previcur Flex 0.7-1.2 pt	14	Tank mix with M class fungicide. No more than 6 oz/season
	Fluazinam 29	Omega 5.5 fl oz	14	Tank mix with M class fungicide. No more than 3.5 pt/season
	Mandipropanid 40	Revus 5.5-8.0 fl oz	14	Do not apply more than 32 fl oz/A/season
	Fluopicolide 43	Presidio 4.0 fl oz	7	Tank mix with other than group 43 fungicide that is effective against late blight. Use a 7-10 day schedule
Rhizoctonia stem canker and black scurf-infurrow	Azoxystrobin	Quadris 0.4-0.8 fl oz/1000 row ft	na	Apply in-furrow at planting. Will also control Silver Scurf and Black dot. See seed treatment label for Dynasty
SEE seed treatments	PCNB	Blocker 10G 1.65 lb/1000 row ft	na	Apply in-furrow over the seed piece at planting in 8.5 inch band
	Pyraclostrobin 11	Headline 4-8 fl oz/1000 row ft	na	Apply in-furrow at planting
	Flutolanil-7	Moncut 70-F 0.71-1.1lb	na	Apply in-furrow over the seed piece at planting in 4-8 inch band- Use a minimum of 3 gal/a water

	Penthiopyrad-7	Vertisan-0.7- 1.6 fl oz/1000 row ft	na	max rate/A=24 oz
	Fluapyroxad 7 + Pyraclostrobin 11	Priaxor 0.48-0.6 fl oz/1000 row ft	na	No more than 24 fl oz or Priaxor may be applied per season
Pythium leak and Pink Rot	Mefenoxam 4	Ridomil Gold EC 0.42 oz/1000 row ft Ultra Flourish 0.84 fl oz/1000 row ft	na	Use a minimum of 3 gal/a water in 6-8 inch band over seed piece. Apply at planting with Quadris=Quadris Ridomil Gold
	Mefenoxam + Chlorothalonil	Ridomil Gold Bravo Flouronil 2 lb	14	At total of 3 applications at 14 day intervals starting at flowering
	Mefenoxam + mancozeb	Ridomil Gold MZ 2.5 lb	3	At total of 3 applications at 14 day intervals starting at flowering
	cyazofamid	Ranman 0.42fl oz/1000 row ft 2.75 fl oz at layby		Use full label rate
	fluopicolide	Presidio 4 fl oz	7	Apply in 6-8 inch band directly over the seed piece or as side dress at hilling
	Phosphoric acid	Phostrol See label	0	Apply in-furrow with Ultra Flourish and with foliar sprays. Start at tuber initiation use 3 applications at 14 day interval. May be used postharvest 12.8 fl oz/ton in 0.5 gal/ton
White Mold	Boscalid	Endura 5.5-10 oz	30	1-2 applications starting at 1 st flower. Can be used to replace early blight spray
	Fluazinam	Omega 5.5-8.0 fl oz	14	1-2 applications starting at 1 st flower. Must combine with M class fungicide to control early blight. This is a very good late blight fungicide Tank mix with Top MP, chlorothalonil, mancozeb to control early blight
	Fluopyram 7 + pyrimethanil 9	Luna Tranquility 11.2 fl oz	7	1-2 applications starting at 1 st flower. Can be used to replace early blight spray

	iprodione	Rovral 50 WP, 4F Nevado \$F 2.0 lb or 2 pt	14	2 applications starting at 1 st flower.
	Thiophanate - methyl	Topsin M 75WP-1-1.5 lb/A or 20-30 oz of 4.5 FL	21	Make first application at row closure with subsequent applications 7-14 days later
	Coniothyrium minitans	Contans	0	Apply 1-4 lbs/a in fall (preferred) or spring- incorporate lightly
Fusarium Dry rot- storage	metconazole Pseudomonas syringae	Quash BioSave	1 0	Apply at row closure and 14 days later Apply with 1-2 qt/ton of water. Avoid bruising Note ~ 50% of isolates in MT are resistant to thiabendazole (Mertect). However combinations of BioSave with 0.42 oz/ton Mertect 340F have given the best results.
Scab	Our trials have shown the Blocker as applied for Rhizoctonia or Maxim MZ seed treatment plus Quadris applied in-furrow will give partial control. Be sure that soil moisture is >80% field holding capacity from tuber set through bulking. Use resistant varieties where possible. Integrated management is critical.			

FRAC Group # refer to fungicides with similar modes of action with the exception of group M or 30 never use the same fungicide FRAC group in consecutive sprays. For example Quadris, Headline, and Gem are all group 11, therefore another fungicide group should be alternated before a group 11 fungicide is sprayed again. Group 11 fungicides must be used at high label rates for good late blight control

Table 2. Information on fungicide controls and their effectiveness for control of early blight, late blight, Pythium leak and Phytophthora pink rot.

N= no control, P=poor control, G= good control, E= excellent control

Fungicide	Late Blight	Early Blight	Leak	Pink Rot	White Mold
<i>Type</i>					
Protective Contact					
Chlorothalonil	G	G	N	N	P
Bravo 720					
Bravo Ultrex					
Bravo Weather Stik					
Bravo weather Stik Zn					
Bravo Zn					
Echo 720					
Echo 90 DF					
Echo Zn					
Dithiocarbamate	G	G	N	N	N
Dithane 75DF					
Dithane Rainshield NT					
Maneb 75 DF					
Maneb plus Zinc					
Manzate Flowable					
Manzate Pro-Stik					
Pencozeb 75DF					
Polyram 80DF					
Triphenyltin hydroxide	E	E	N	N	N
Super-Tin 80 WP, 4L					
Agri Tin 80WP					
Benzamide					
Gavel 75 DF	E	G	N	N	N
(zoxamide + mancozeb)					
Systemic/translaminar					

Fungicide	Late Blight	Early Blight	Leak	Pink Rot	White Mold
QoI, Strobilurin, Group 11	F-E	E	N	N	N
<i>To get best control of late blight higher label rates should be used</i>					
Gem	F-G	E	N	N	N
Headline	F-G	E	N	N	N
Tanos (famoxadone + Cymoxanil)	E	E	N	N	N
Reason 500SC					
Quadris					
Quadris Opti (Quadris + Bravo)	F-G	E	N	N	N
Evito 480 SC	P-F	E	N	N	N

11)

Phenyl Amide

(most strains of late blight are resistant to Ridomil (metalaxyl or mefoxam)- control of late blight and early blight will be from partner)

Ridomil Gold MZ	F-G	F	G	G	N
Ridomil Gold/Bravo	F-G	F-G	G	G	N
Ridomil Gold/Bravo L	F-G	F-G	G	G	N
Metastar	P	N	G	G	N
Ultra Flourish	P	N	G	G	N

Carboxamid-7

Endura	N	G	N	N	G-E
Luna Tranquility	N	G-E	N	N	G-E
Vertisan	N	G-E	N	N	P
Priaxor (Fluapyroxad 7 + Pyraclostrobin)	F-G	E	N	N	G

Other

Acrobat	E	N	N	N	N
Curzate DF(Cymoxanil)	E	N	N	N	N
(Mix with protective contact for early blight)					
Forum	E	P	N	N	N
Omega 500F	E	P	N	N	G-E
Scala SC	N	G	N	N	N
(use Scala with protective contact for late blight)					

Fungicide	Late Blight	Early Blight	Leak	Pink Rot	White Mold
Previcur Flex	E	P	N	N	N
Quash	N	G	N	N	G
Ranman	E	N	N	E	N
Revus Top	E	E	N	N	N
Revus	E	N	N	N	N

Phosphorous acid

Compounds

Crop-Phite, Fosphite

Phostrol, Resist 57, Topaz

These phosphorus acid compounds are most effective against pink rot and late blight tuber decay. Recent data from North Dakota indicates that these products may be useful for control of both silver scurf and Fusarium dry rot

Additional Comments for late blight

Disease level	Fungicides
none	Chlorothalonil, maneb, mancozeb, metiram, Omega, Curzate, Tanos, Forum, Gavel, Previcur-Flex, Revus Top, Revus, Ranman, Headline, Gem, Quadris, Reason- apply on 7 to 10 day interval
Trace to 1% foliar infection	Curzate, Tanos, Previcur-Flex, Revus Top, these fungicides +SuperTin or AgriTin-apply on 5-7 day interval
Overall field <1% but with heavily infected loci	Kill heavily infected area with Regalone, spray with Curzate, Tanos, Previcur-Flex, Revus Top, Ranman these fungicides +SuperTin or AgriTin-apply on 5-7 day interval
20-100% crop infected	Kill with Regalone, apply SuperTin or AgriTin, Ranman

Comparison of late blight control fungicides based on the highest labeled rate

Fungicide	Effectiveness				Mode of action			Rain fastness	Type of fungicide
	Leaf Blight	New growth	Stem blight	Tuber Blight	Protectant	Curative	Anti-sporulant		
Chlorothalonil Many products	G	NO	P	NO	G	NO	NO	G	PROTECTIVE CONTACT
Mancozeb, Maneb metiram Many products	G	NO	P	NO	G	NO	NO	F	PROTECTIVE CONTACT
Curzate	G	?	F	NO	G	E	P	G	TRANSLAMINAR
Forum	G	?	F	F	G	P	G	G	TRANSLAMINAR
Gavel	E	NO	P	F	E	NO	NO	G	PROTECTIVE CONTACT
Omega	E	NO	P	G	E	NO	NO	G	PROTECTIVE CONTACT
Previcur-Flex	G	G	G	NO	G	G	G	E	SYSTEMIC
Phosporus acid Several products	P	P	P	G	P	NO	?	G	
Ranman	E	NO	P	E	E	NO	NO	E	PROTECTIVE CONTACT
Tanos	G	?	F	NO	G	E	P	G	TRANSLAMINAR
Revus Top	E	?	F	G	E	P	F	E	TRANSLAMINAR PROTECTIVE CONTACT
TPTH SuperTin, AgriTin	E	NO	E	E	G	NO	E	F	PROTECTIVE CONTACT
Headline, Gem, Quadris, Reason	G-E	P-F	F	NO	G	G	P	G-E	TRANSLAMINAR

NO= no effect; P=poor; G=good; E=excellent; ? = unknown

Table 3. Potato Fungicide Seed Treatments

Fungicide/ FRAC Group #	Trade name	Rate /CWT	comments
Fludioxonil -12+ Mancozeb-M3	Maxim MZ	0.5 lb	Excellent seed piece treatment will provide control of Fusarium seed piece decay, scab, silver scurf, seed born late blight
Fludioxonil-12	Maxim FS	0.08 fl oz	DO NOT USE UNLESS MANCOZEB OR MANEB IS ADDED*** Resistance has been reported and as seed producing state we do not want to ship Fusarium resistant to this important fungicide.
Flutolanil-7 + Mancozeb-M3	MonCoat MZ	0.75 lb	Excellent seed piece treatment will provide control of Fusarium and Rhizoctonia seed piece decay, scab, silver scurf.
Thiophanate-Methyl-B1 + Mancozeb-M3	Tops MZ	0.75	Good seed treatment for seed- borne but not soilborne Rhizoctonia and scab. Because of resistance it may not be effective for Fusarium or Silver Scurf
Maneb/ mancozeb-M3	Many products	Rate varies with formulation	Good for seed borne scab- good fungicide resistance management partner for fludioxonil and cymoxanil
Cymoxanil-27	Curzate 60 DF	0.25-1 oz	Excellent where seed borne late blight is suspected-use with maneb or mancozeb
Thiophanate methyl B1+ Mancozeb M3+Cymoxanil 27	Evolve		Dust treatment where seed borne late blight is suspected
azoxystrobin	Dynasty	0.1-3.75 fl oz/cwt	Excellent for seed-borne Rhizoctonia, Silver Scurf, And Black dot- also some soil activity but perhaps not as good as in-furrow application of Quadris. Note- Still labeled but Syngenta will no longer sell for potato
Penflufen 7 + prothioconazole 3	Emesto Silver	0.31 fl oz/cwt	Suppression of Rhizoctonia, Silver Scurf, Fusarium seed piece decay. Add mancozeb for better Fusarium control

Disinfectants

The first step in disinfecting surfaces contaminated with potato residues and potential pathogens is to remove soil and potato residues by washing with soapy water and scrubbing to remove heavy deposits of potato residue. This is an important step since many disinfectants are inactivated by soil or organic matter and bacteria can live in the heavier residues and are protected from disinfectants. The second step is to disinfect with a labeled disinfectant. It is important to

keep all surfaces wet with the disinfectant solution for 10-15 minutes and to use the highest labeled rate of the disinfectant chemical. See Table 4. below for disinfectants that can be used.

Table 4. Disinfectants for potato storage and handling equipment.

Type	Active ingredient	Products	Comments
Chlorine generating products- note chlorine has significant human inhalation problems-follow safety precautions			
Bleach	Sodium hypochlorite	Many- rate will depend on product – concentrations will vary from 3.25-12%	Strong oxidizer (corrosive), rapidly inactivated by soil or organic matter, no residual activity. Water pH must be 4-8.
Calcium hypochlorite	Calcium hypochlorite	Many-rate will depend on product label	Strong oxidizer (corrosive), rapidly inactivated by soil or organic matter, no residual activity. Water pH must be 4-8. Can be applied directly to potatoes.
Chlorine dioxide	Chlorine dioxide	Oxine Sanitizer, SNI _{PER} , EnviroCON, Clorodisys, CDG Solution 3000, Purogene	Less corrosive than bleach, no residual activity, water pH not as critical
Non Chlorine generating			
Quaternary Ammonium products	Quaternary Ammonium, benzalkonium chloride, n-alkyl dimethyl benzyl ammonium chloride, N,N,-didecyl-N,N-dimethyl ammonium chloride, etc.	De-Bac, Virex, Roccal-D, AFBC, Breakthru, Micro Q64, Micro Q128, Pro-San, many others	Only slightly corrosive, relatively safe for humans when diluted, some residual activity, much less affected by organic matter or soil. Water pH not critical

Hydrogen peroxide/Peroxyacetic acid products	Hydrogen dioxide (hydrogen peroxide)	StorOx, Oxidate, Jet Oxide, Jet Ag, SaniDate 12.0	Can be applied directly to potatoes, no residual. Low corrosiveness. With use of heat JetAg can be used as fumigant in air system.
Iodine, Iodophores	Iodine, povidone iodine	Code Blue Iodine disinfectant, many others look for iodine in label name	Corrosive, will stain treated areas, some residual activity. Less affected by organic matter or water pH than bleach.
Phenol-glutaraldehyde	Phenol-glutaraldehyde	Sporocidin, Hospiseptic Disinfectant Wex-cide, Birex, etc- look for Phenol in name	Oral poison.
Formaldehyde	Formaldehyde	Many products	Potential human carcinogen! Follow OSHA directions regarding exposure
Copper quinolinolate	Copper 8 quinolinolate	Many purchase as generic chemical. ISK Biotech PQ-57, PQ-80	Good residual activity, may cause some staining.