cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Pseudomonas syringae pv. *syringae* van Hall 1902

Bacterial canker and blast of stone and pome fruits

& bacterial brown spot of beans

Current Pest Rating: C

Proposed Pest Rating: C

Kingdom: Bacteria; Phylum: Proteobacteria;

Class: Gammaproteobacteria; Order: Pseudomonadales;

Family: Pseudomonadaceae

Comment Period: 9/18/2020 through 11/2/2020

Initiating Event:

On August 9, 2019, USDA-APHIS published a list of "Native and Naturalized Plant Pests Permitted by Regulation". Interstate movement of these plant pests is no longer federally regulated within the 48 contiguous United States. There are 49 plant pathogens (bacteria, fungi, viruses, and nematodes) on this list. California may choose to continue to regulate movement of some or all these pathogens into and within the state. In order to assess the needs and potential requirements to issue a state permit, a formal risk analysis for *Pseudomonas syringae* pv. *syringae* is given herein and a permanent pest rating is proposed.

History & Status:

Background:

Pseudomonas syringae is one of the most-studied bacterial plant pathogens and is used as a model for understanding host–pathogen interactions and bacterial virulence mechanisms, microbial evolution, ecology, and epidemiology. *Pseudomonas syringae* is commonly found on the phyllosphere of its hosts,

where it can live as an epiphyte. Pathovar *syringae* was originally isolated from lilac but is pathogenic on many dicotyledonous and monocotyledonous hosts (Hirano and Upper, 2000).

The *P. syringae* species complex forms a monophyletic group in the *Pseudomonas fluorescens*-like division of *Pseudomonas*. *Pseudomonas syringae* strains are split into 13 phylogroups. Strains of *P. syringae* have been subdivided into more than 60 pathovars based on host of original isolation, host range, and biochemical properties. *Pseudomonas syringae* pathogenicity is strongly influenced by external environmental conditions, such as humidity and temperature and the other microbiota that live on plants (Young, 1991).

Pseudomonas syringae pv. *syringae* attacks plants at all stages from seedlings through maturity. Two of the most important hosts in California are beans and fruit trees. On beans, it affects leaves, stems, pods, and seeds. On stone fruit, pome fruit, and citrus trees, it attacks leaves, stems, trunks, bark, limbs, branches, twigs, buds, flowers, and fruit. It survives on several crop and non-crop species, which serve as sources of primary inoculum for infection (Hall, 1991; Strand, 1999).

Hosts: Abelmoschus esculentus (okra), *Aconitum* (monkshoods), *Actinidia chinensis* (Chinese gooseberry), *Actinidia deliciosa* (kiwifruit), *Allium cepa* (onion), *Allium chinense* (spring onion), *Allium fistulosum* (Welsh onion), *Allium porrum* (leek), *Alnus glutinosa* (European alder), *Aralia*, *Arbutus*, *Atriplex hortensis* (garden orache), *Beta vulgaris* var. *cicla*, *Beta vulgaris* var. *saccharifera*, (sugarbeet), *Betula pendula* (common silver birch), *Brassica rapa* subsp. *pekinensis*, *Calystegia sepium* (great bindweed), *Capsicum annuum* (bell pepper), *Carthamus tinctorius* (safflower), *Centaurea stoebe* subsp. *micranthos* (spotted knapweed), *Chenopodium quinoa* (quinoa), *Chrysanthemum indicum* (chrysanthemum), *Cinnamomum camphora* (camphor laurel), *Citrus aurantium* (sour orange), *Citrus limon* (lemon), *Citrus maxima* (pummelo), *Citrus medica* (citron), *Citrus reticulata* (mandarin), *Citrus sinensis* (navel orange), *Citrus* x *paradisi* (grapefruit), *Coffea arabica* (arabica coffee), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita melo* (pumpkin), *Cucurbita maxima* (giant pumpkin), *Cucurbita pepo* (marrow), *Cyamopsis tetragonoloba* (guar), *Cydonia oblonga* (quince), *Cyphomandra betacea* (tree tomato), *Dahlia pinnata* (garden dahlia), *Daphne odora* (Winter daphne), *Desmodium* (tick clovers), *Diospyros kaki* (persimmon), *Echinochloa crus-galli* (barnyard grass), *Erysimum cheiri* (wallflower), *Forsythia intermedia* (golden bells), *Fortunella* (kumquats), *Fragaria vesca* (wild strawberry), *Glycine max* (soyabean), *Hibiscus* (rosemallows), *Hibiscus rosa-sinensis* (China-rose), *Hordeum vulgare* (barley), *Impatiens balsamina* (garden balsam), *Juglans regia* (walnut), *Lablab purpureus* (hyacinth bean), *Lactuca sativa* (lettuce), *Ligustrum ovalifolium* (California privet), *Magnolia*, *Magnolia grandiflora* (southern magnolia), *Malus domestica* (apple), *Mangifera indica* (mango), *Matthiola incana* (stock), *Medicago sativa* (lucerne), *Miscanthus sinensis* (eulalia), *Mucuna pruriens* (velvet bean), *Musa x paradisiaca* (plantain), *Nerium oleander* (oleander), *Nicotiana tabacum* (tobacco), *Oryza sativa* (rice), *Panax ginseng* (Asiatic ginseng), *Panicum* (millets), *Panicum miliaceum* (millet), *Passiflora edulis* (passionfruit), *Pennisetum glaucum* (pearl millet), *Pennisetum purpureum* (elephant grass), *Persea americana* (avocado), *Phaseolus coccineus* (runner bean), *Phaseolus lunatus* (lima bean), *Phaseolus vulgaris* (common bean), *Philadelphus*, *Pinus radiata* (radiata pine), *Piper nigrum* (black pepper), *Pisum sativum* (pea), *Populus* (poplars), *Populus balsamifera* (balm of Gilead), *Populus balsamifera* subsp. *trichocarpa* (black cottonwood), *Populus nigra* (black poplar), *Populus*

tremula (European aspen), *Prunus amygdalus*, *Prunus armeniaca* (apricot), *Prunus avium* (sweet cherry), Prunus cerasifera (myrobalan plum), *Prunus cerasus* (sour cherry), *Prunus domestica* (plum), *Prunus laurocerasus* (cherry laurel), *Prunus mume* (Japanese apricot tree), *Prunus persica* (peach), *Prunus salicina* (Japanese plum), *Prunus serrulata* (Japanese flowering cherry), *Pyrus communis* (European pear), *Quercus agrifolia* (California live oak), *Quercus wislizenii* (Interior live oak), *Rhododendron* (azalea), *Rosa* (roses), Rubus ursinus (boysenberry), *Salix* (willows), *Solanum lycopersicum* (tomato), *Sorghum bicolor* (sorghum), *Sorghum halepense* (Johnson grass), *Sorghum sudanense* (Sudan grass), *Syringa vulgaris* (lilac), *Trifolium alexandrinum* (Berseem clover), *Trifolium dubium* (yellow suckling clover), *Trifolium hybridum* (alsike clover), *Trifolium incarnatum* (crimson clover), *Trifolium pratense* (red clover), *Trifolium repens* (white clover), *Trigonella foenum-graecum* (fenugreek), *Triticum aestivum* (wheat), *Vaccinium* (blueberries), *Vernicia fordii* (tung-oil tree), *Vicia faba* (faba bean), *Vicia villosa* (hairy vetch), *Vigna angularis* (adzuki bean), *Vigna unguiculata* (cowpea), *Vitis* (grape), *Vitis vinifera* (grapevine), and *Zea mays* (maize) (CABI-CPC, 2020).

Symptoms:

Beans: The disease on beans is called bacterial brown spot which describes an important symptom. It affects leaves, pods, stems, and seeds. Symptoms appear on the lower sides of leaves as small, water-soaked spots. The spots can grow, coalesce, and form large areas that become brown and necrotic. Bacteria may also enter the vascular tissues of the leaves and spread into the stems. On the stem, water-soaked sometimes sunken lesions form gradually and enlarge, turning brown, splitting, and releasing bacterial exudate. These lesions can girdle the stems and the plant often breaks at that point. On pods, there are water-soaked spots that turn reddish-brown with age. If the vascular systems of the pods are infected, seed can be internally infected. Seeds may rot or shrivel. There are two other bean bacterial diseases, common blight caused by *Xanthomonas phaseoli*, and halo blight caused by *P. syringae* pv. *phaseolicola*. The three diseases have some overlapping symptoms and should be diagnosed by laboratory tests (Davis et al., 2013).

Stone fruit, pome fruit and citrus: Diseases caused by *P. syringae* pv. *syringae* on trees are called bacterial canker and gummosis. The most diagnostic symptom is the formation of cankers with gumballs and gum exudation on trunks and scaffolds. Cankers will also develop at the base of infected spurs, in pruning wounds, and at bud unions. Infected areas of bark are sunken and dark brown; internal tissues are bright orange to brown. The canker will give off a sour or fermented scent. In the spring, gum is produced in cankers that breaks through the bark and runs down the limbs. If cankers are on the main trunk, the entire tree above the canker can collapse. Frequently, trees sucker from near ground level as cankers do not extend below ground. Flower and leaf buds can be “blasted”, a symptom where large numbers of buds fail to develop or die. Leaf infections are water-soaked spots that later become brown, dry, and brittle and can fall out giving a shot-hole or tattered appearance. Infected fruit has dark brown to black spots. *Pseudomonas syringae* pv. *morusprunorum* is a pathovar that can cause similar symptoms but is restricted mainly to cherry and plum (Day et al., 1999; Ogawa and English, 1991).

Transmission: Pseudomonas syringae is often an epiphytic member of the phyllosphere of healthy plants. It is spread by wind, rain, rain splash, windblown rain, direct contact with the host, insects such as flies and bees, and hands, handling of plants and tools, and movement of infected nursery stock. Under favorable conditions, they enter the plant through wounds or natural openings such as stomata, and multiply rapidly within the apoplast. Water soaking of tissues during heavy rains greatly favors penetration and invasion. Bacteria multiply on the walls of host cells, which collapse after disruption of the cell membranes (Agrios, 2005).

Bacteria can overwinter in infected bean seeds and stems. From seed they infect the cotyledons and spread to leaves or enter the vascular system causing systemic infections. They can ooze out through splits in the stems and survive ephytically on healthy plants or saprophytically in plant debris (Davis, 2013).

On trees, the pathogen overwinters in active cankers, in infected buds and leaves, systemically in the xylem, epiphytically on buds and limbs of infected or healthy trees, and possibly on weeds and non-hosts. Infection usually happens during the rainy periods of fall or early winter. Cankers can develop rapidly in the early spring. Leaf infections appear on young succulent leaves, during cool, wet springs, and flowers are blasted as they form (Day et al., 2013).

Damage Potential: Most strains of *P. syringae* pv. *syringae* are ice nucleation active; they serve as nuclei for ice formation and cause frost injury to plants at relatively high freezing temperatures. The wounding from ice crystal formation increases bacterial infection. Brown spot of beans is uncommon when clean seed is planted, but epidemics can occur with environmental conditions are favorable and it is a phytosanitary issue for bean seed grown for export.

This is one of the most economically important diseases of stone-fruit trees; it occurs world-wide in commercially grown *Prunus* spp. For fruit trees, stress plays a major role in predisposing trees to this disease, which is worse in orchards in sandy soils with a history of bacterial canker or ring nematodes (*Criconemella xenoplax*) (Gordon and Yahgmour, 2020). For French prunes (*Prunus domestica*), the disease occurs only in trees that are predisposed by factors including type of rootstock, poor soil nutrition, soils of low pH or sandy texture, a shallow hardpan, the presence of ring nematode, and environmental factors such as high rainfall and freezing temperatures (Sayer and Kirkpatrick, 2003). For citrus, bacterial blast damage has mainly been reported in the Sacramento Valley where wet, cool, and windy conditions favor disease development and spread, and can result in bud blast and black spots on the fruit (Eskalen and Adaskaveg, 2019).

Worldwide Distribution: Africa: *Algeria, Egypt, Ethiopia, Kenya, Lesotho, Libya, Malawi, Morocco, Nigeria, South Africa, Tanzania, Tunisia, Uganda, Zimbabwe*. Asia: *Afghanistan, Azerbaijan, Bangladesh, China, Georgia, India, Iran, Israel, Japan, Kazakhstan, Kyrgyzstan, Lebanon, North Korea, Pakistan, South Korea, Sri Lanka, Thailand, Turkey, Uzbekistan, Vietnam*. Europe: *Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Cyprus, Federal Republic of Yugoslavia, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Moldova, Netherlands, North Macedonia, Poland, Portugal, Romania, Russia, Serbia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom*. North America: *Barbados, Canada, El Salvador, Guatemala, Honduras, Mexico, Panama,*

Puerto Rico, United States (Alabama, Alaska, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming). Oceania: *Australia, New Zealand. South America: Argentina, Brazil, Chile, Uruguay, Venezuela* (CABI-CPC).

Official Control: This pathogen is on the USDA PCIT's harmful organism list for Australia, Canada, Colombia, Ecuador, Egypt, French Polynesia, Jordan, Mexico, Nauru, New Caledonia, Peru, Syrian Arab Republic, Taiwan, Viet Nam (USDA PCIT, 2020). It is a regulated non-quarantine pest in Egypt, a quarantine pest in Mexico, and on the EPPO's A2 list for Jordan (EPPO, 2020)

California Distribution: Alameda, Butte, Colusa, Contra Costa, El Dorado, Fresno, Humboldt, Kern, Lassen, Los Angeles, Madera, Marin, Mariposa, Monterey, Orange, Placer, Plumas, Riverside, Sacramento, San Diego, San Joaquin, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, Stanislaus, Tehama, Tuolumne, Ventura, and Yolo counties.

California Interceptions: Detected occasionally on incoming shipments of nursery and florist's stock (French, 1989; CDFA PDR database)

The risk *Pseudomonas syringae* pv. *syringae* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** *Pseudomonas syringae* pv. *syringae* epidemics are more frequent and more severe in wetter climates as water is needed for bacterial dissemination and infection. California climates are less favorable except on the north coast and parts of the Sacramento Valley where citrus is grown, but disease outbreaks can occur sporadically in warmer areas and in greenhouses.

   Evaluate if the pest would have suitable hosts and climate to establish in California.

   Score: **2**

   - Low (1) Not likely to establish in California; or likely to establish in very limited areas.
   - **Medium (2) may be able to establish in a larger but limited part of California.**
   - High (3) likely to establish a widespread distribution in California.

2) **Known Pest Host Range:** the host range is extremely wide, including monocots, dicots, herbaceous, and woody plants.

   Evaluate the host range of the pest.

   Score: 3

   - Low (1) has a very limited host range.
   - Medium (2) has a moderate host range.

- High (3) has a wide host range.

3) **Pest Reproductive Potential:** *Pseudomonas syringae* pv. *syringae* can live as an epiphyte on the surface of healthy plants. Under favorable environmental conditions, they can invade and reproduce at an exponential rate.

Evaluate the natural and artificial dispersal potential of the pest.

Score: 3

- Low (1) does not have high reproductive or dispersal potential.
- Medium (2) has either high reproductive or dispersal potential.
- High (3) has both high reproduction and dispersal potential.

4) **Economic Impact:** Disease on beans affects yield, seed quality, and export markets. Disease on fruit trees can be severe, especially in orchards with other stressors, and can include blossom blast, fruit damage, and loss of trees**.**

Evaluate the economic impact of the pest to California using the criteria below.

Economic Impact: A, B, C, D

A. The pest could lower crop yield.
B. The pest could lower crop value (includes increasing crop production costs).
C. The pest could trigger the loss of markets (includes quarantines).
D. The pest could negatively change normal cultural practices.
E. The pest can vector, or is vectored, by another pestiferous organism.
F. The organism is injurious or poisonous to agriculturally important animals.
G. The organism can interfere with the delivery or supply of water for agricultural uses.

Economic Impact Score: **3**

- Low (1) causes 0 or 1 of these impacts.
- Medium (2) causes 2 of these impacts.
- High (3) causes 3 or more of these impacts.

5) **Environmental Impact:** Only certified disease-free bean seed should be planted. Fruit trees are treated with bactericides with limited success. Pruning should be done in dry weather and trees should be planted in areas free from ring nematodes.

Environmental Impact: C, D

A. The pest could have a significant environmental impact such as lowering biodiversity, disrupting natural communities, or changing ecosystem processes.
B. The pest could directly affect threatened or endangered species.
C. The pest could impact threatened or endangered species by disrupting critical habitats.
D. The pest could trigger additional official or private treatment programs.
E. The pest significantly impacts cultural practices, home/urban gardening or ornamental plantings.

Environmental Impact Score: 3
- Low (1) causes none of the above to occur.
- Medium (2) causes one of the above to occur.
- High (3) causes two or more of the above to occur.

Consequences of Introduction to California for *Pseudomonas syringae* pv. *syringae:* High

Add up the total score and include it here. **14**
-Low = 5-8 points
-Medium = 9-12 points
-High = 13-15 points

6) **Post Entry Distribution and Survey Information**: Evaluate the known distribution in California. Only official records identified by a taxonomic expert and supported by voucher specimens deposited in natural history collections should be considered. Pest incursions that have been eradicated, are under eradication, or have been delimited with no further detections should not be included.

Evaluation is 'high'. *Pseudomonas syringae* pv. *syringae* has been observed statewide on a variety of hosts.

Score: -3
-Not established (0) Pest never detected in California or known only from incursions.
-Low (-1) Pest has a localized distribution in California or is established in one suitable climate/host area (region).
-Medium (-2) Pest is widespread in California but not fully established in the endangered area, or pest established in two contiguous suitable climate/host areas.
-High (-3) Pest has fully established in the endangered area, or pest is reported in more than two contiguous or non-contiguous suitable climate/host areas.

7) **The final score is** the consequences of introduction score minus the post entry distribution and survey information score: (Score)

Final Score: *Score of Consequences of Introduction – Score of Post Entry Distribution and Survey Information* **= 11**

Uncertainty:

None

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Pseudomonas syringae* pv. *syringae* is C.

References:

Agrios, G. N. 2005. Plant Pathology, 5th Edition. Elsevier Academic Press. 922 pg

CABI Crop Production Compendium 2020. *Pseudomonas syringae* pv. *syringae*. https://www.cabi.org/cpc/datasheet/45014 . Accessed 8/4/2020

Davis, R.M., Hall, A.E. and Gilbertson, R., 2013. UC IPM Pest Management Guidelines: dry beans. Statewide IPM Program, University of California Agriculture and Natural Resources. ANR Publication 3446.

Day, K. R., Tollerup, K., Duncan, R., Roncoroni, J. A., Westerdahl, B. B., Adaskaveg, J. E., Hasey, J. K., Wright, S. D. 1999. UC IPM Integrated Pest Management for Stone Fruits. Publication 3389. 264 pages

EPPO Global Database. 2020. https://gd.eppo.int/taxon/PSDMSY. Accessed 8/3/2020

Eskalen, A., and Adaskaveg, J. E., 2019. Bacterial blast (citrus blast) UC IPM Pest Management Guidelines: Citrus UC ANR Publication 344

French, A. M. 1989. California plant disease host index. CA Division of Plant Industry. 2nd Ed. 394 pg

Gordon, P. and Yaghmour, M. 2020. Bacterial canker and blast of California fruit and nut trees. UCCE San Joaquin Valley trees and vines. https://www.sjvtandv.com/blog/bacterial-canker-and-blast-in-california-fruit-and-nut-trees

Hall R, 1991. Compendium of Bean Diseases. St Paul, Minnesota, USA: APS Press

Hirano, S. S. & Upper, C. D. Bacteria in the leaf ecosystem with emphasis on *Pseudomonas syringae*-a pathogen, ice nucleus, and epiphyte. Microbiol. Mol. Biol. Rev. 64, 624–653 (2000).

Lindow, S.E., Arny, D.C. and Upper, C.D., 1982. Bacterial ice nucleation: a factor in frost injury to plants. Plant physiology, 70(4), pp.1084-1089.

Ogawa, J.M. and English, H., 1991. Diseases of temperate zone tree fruit and nut crops (Vol. 3345). UCANR Publications.

Sayler, R.J. and Kirkpatrick, B.C., 2003. The effect of copper sprays and fertilization on bacterial canker in French prune. Canadian journal of plant pathology, 25(4), pp.406-410.

Strand, L.L., 1999. Integrated pest management for stone fruits (Vol. 3389). University of California, Agriculture and Natural Resources.

Xin, X.F., Kvitko, B. and He, S.Y., 2018. *Pseudomonas syringae*: what it takes to be a pathogen. Nature Reviews Microbiology, 16(5), p.316.

Young, J. M. 1991. Pathogenicity and identification of the lilac pathogen, *Pseudomonas syringae* pv. *syringae* van Hall 1902. Ann. Appl. Biol. 118, 283–298

Responsible Party:

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*Comment Period: 9/18/2020 through 11/2/2020

*NOTE:

You must be registered and logged in to post a comment. If you have registered and have not received the registration confirmation, please contact us at permits[@]cdfa.ca.gov.

Comment Format:

- Comments should refer to the appropriate California Pest Rating Proposal Form subsection(s) being commented on, as shown below.

  Example Comment:

  Consequences of Introduction: 1. Climate/Host Interaction: [Your comment that relates to "Climate/Host Interaction" here.]

- Posted comments will not be able to be viewed immediately.
- Comments may not be posted if they:

  Contain inappropriate language which is not germane to the pest rating proposal;

  Contains defamatory, false, inaccurate, abusive, obscene, pornographic, sexually oriented, threatening, racially offensive, discriminatory or illegal material;

  Violates agency regulations prohibiting sexual harassment or other forms of discrimination;

  Violates agency regulations prohibiting workplace violence, including threats.

- Comments may be edited prior to posting to ensure they are entirely germane.
- Posted comments shall be those which have been approved in content and posted to the website to be viewed, not just submitted.

Proposed Pest Rating: C