CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Fusarium fujikuroi Nirenberg 1976
≡ *Gibberella fujikuroi* (Sawada) S. Ito 1931

bakanae disease of rice

Current Pest Rating: C

Proposed Pest Rating: C

Kingdom: Fungi, Phylum: Ascomycota,
Subphylum: Pezizomycotina, Class: Sordariomycetes
Subclass: Hypocreomycetidae, Order: Hypocreales
Family: Nectriaceae

Comment Period: 06/23/2022 through 08/07/2022

Initiating Event:

This pathogen has not been through the pest rating system. The risk to California from *Fusarium fujikuroi* is described herein and a permanent rating is proposed.

History & Status:

Background:

California ranks #2 in the US in rice production after Arkansas and accounts for 33% of domestic production. In 2019/2020, there were 496K harvested acres that produced 36.65M centum weight of rice with a value of nearly $900M (CDFA Ag Statistics). Most of the rice (95%) is grown in the Sacramento Valley.

Bakanae disease was first identified in in Japan by Hori (1898). Bakanae is a Japanese word which means “foolish seedling” referring to the primary symptom of abnormal elongation of young rice plants (Sun, 1981). The disease is caused by *Fusarium fujikuroi* Nirenberg [teleomorph: *Gibberella fujikuroi* (Sawada) Ito] and is one of the important diseases in some rice growing areas (Sharma and Thind, 2007). Although there are many hosts of this ascomycete fungus including banana, cotton, cowpea, fig, maize, sorghum, sugarcane, and tomato, the hosts with the most economic importance

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are in the grass family Poaceae, most notably rice. Grass weeds are also hosts. On maize it is known as "maize Fusarium kernel rot". Bakanae is one of the oldest-known diseases of rice in Asia. It has been observed in California rice since 1999 and now occurs in all California rice-growing regions (Greer, 2004).

There has been disagreement among plant pathologists for the nomenclature of bakanae fungus. In 1930s, the imperfect stage of the fungus was described by H. W. Wollenweber (1935) as *Fusarium moniliforme* (Sheldon), and some use the name of the perfect stage, *Gibberella fujikuroi* (Sawada) Wr. The name *Lisea fujikuroi* has also been used (Farr and Rossman, 2022).

The genera *Gibberella* and *Fusarium* encompass a range of reproductive strategies including both homothallic and heterothallic sexual reproduction and asexual reproduction. The teleomorph, *G. fujikuroi*, has been reported on rice in China, Japan, and Taiwan, and ascospores are reported as the primary source of inoculum for bakanae in Taiwan (Sun, 1975). Putative perithecia of *G. fujikuroi* were observed in California, but they lacked viable ascospores (Anderson, 2005). The amount of genetic and genotypic diversity present in the California population was studied by Carter et al. (2008), who found that only two haplotypes encompassed 94% of the collected isolates, suggesting that clonal reproduction is dominant.

When rice seedlings are infected with *F. fujikuroi*, they grow rapidly and become much taller than healthy plants. This is apparently the result of gibberellin secreted by the pathogen. Gibberellins were first isolated from *F. fujikuroi.* They are normal constituents of green plants and are also produced by several microorganisms. Gibberellins have striking growth-promoting effects; they speed the elongation of dwarf varieties to normal sizes and promote flowering, stem and root elongation, and growth of fruit. The best-known gibberellin is gibberellic acid (Agrios, 2005).

Hosts: Primary agronomic hosts are *Oryza sativa* (rice), *Zea mays* subsp. *mays* (maize), *Hordeum vulgare* (barley), *Sorghum* sp., *Saccharum officinarum* (sugarcane), *Triticum aestivum* (wheat), *Pinus* sp. (pine), and *Secale cereale* (rye) (Gupta et al. 2015).

Additional reported hosts include: *Acacia koa* (koa acacia), *Actinidia chinensis* (golden kiwifruit), *Agathis robusta* (kauri-pine), *Ananas comosus*, *Arachnis* sp. (peanut), *Araucaria cunninghamii* (Queensland-pine), *Bletilla striata* (hardy orchid), *Cajanus cajan* (pigeon-pea), *Canna edulis* (purple arrowroot), *Capsella bursa-pastoris* (shepherd's purse), *Capsicum* sp., *Carica papaya* (papaya), *Celosia plumosa* (plumeflower), *Citrus paradisi* (grapefruit), *Citrus* sp., *Cocos nucifera* (coconut), *Conyza canadensis* (Canadian horseweed), *Cucumis sativus* (cucumber), *Cynodon dactylon* (Bermuda grass), *Dalbergia odorifera* (fragrant rosewood), *Dracaena godseffiana*, *Dracaena* sp., *Echinochloa* sp., *Elaeis guineensis* (oil palm), *Ficus carica* (common fig), *Freesia hybrida* (freesia), *Glycine max* (soybean), *Gossypium barbadense* (cotton), *Gossypium hirsutum* (cotton), *Gossypium* sp. (cotton), *Helianthus* sp., *Hordeum vulgare* (barley), *Hylocereus polyrhizus* (dragon fruit), *Juglans sigillata*, *Lactuca sativa* (garden lettuce), *Lasia spinosa*, *Lilium lancifolium* (tiger lily), *Macleaya cordata* (plume-poppy), *Mangifera indica* (mango), *Medicago* sp., *Musa acuminata* (banana), *Musa cavendishii* (banana), *Musa* sp., *Musa textilis* (banana), *Musa × paradisiaca* (banana), *Nicotiana tabacum* (tobacco), *Oryza sativa* (rice), *Panax ginseng* (ginseng), *Passiflora edulis* (passion fruit), *Phaseolus* sp. (bean), *Phaseolus vulgaris* (bean),

Phlox drummondii (annual phlox), *Pinus patula* (Mexican yellow pine), *Pinus taeda* (loblolly pine), *Piper methysticum* (kava), *Poncirus trifoliata* (hardy-orange), *Prunus avium* (cherry), *Prunus domestica* (plum), *Reineckea carnea*, *Rhodiola sachalinensis*, *Saccharum* sp., *Sesamum indicum* (sesame), *Sisymbrium loeselii* (tall hedge mustard), *Solanum melongena* (eggplant), *Solanum lycopersicum* (tomato), *Sorghum bicolor* (great millet), *Sorghum caffrorum*, *Sorghum* sp., *Sorghum vulgare*, *Syzygium cordatum* (water-berry), *Theobroma cacao* (cocoa), , *Trachycarpus princeps*, *Vanilla planifolia* (vanilla), *Vicia faba* (bell-bean), *Vitis* sp., *Zanthoxylum armatum* (winged prickly-ash), *Zea mays* (Indian corn), *Zea mays* var. *rugosa* (maize), *Zea* sp. (corn) (Farr and Rossman, 2022).

Symptoms: The earliest symptoms of bakanae are seen about a month after rice is planted. Infected seedlings can elongate and often grow several inches taller than healthy seedlings, appearing tall, slender, and slightly chlorotic. Alternately, infected seedlings can be stunted as the disease may progress into a seedling crown and root rot. Infected seedlings usually die. Older plants infected with the fungus may exhibit abnormal elongation, stunting or normal growth, and if they survive to maturity, they do not produce a panicle or the panicles are white and chaffy, with no seeds. The leaf sheaths can be covered with a mass of white or pinkish growth with sporulation of the fungus near the waterline. If the pathogen produces the *Gibberella* teleomorph, leaf sheaths of infected plants may turn a blue-black color from the accumulated perithecia.

Transmission: The fungus infects plants through the roots or crowns and grows systemically within the plant where it produces the growth hormone gibberellin, which causes plant elongation, and fusaric acid, which causes stunting. Bakanae is primarily a seedborne disease and may be moved over short or long distances on infested seed (Chan et al., 2004). Airborne spores of the fungus may contaminate seed before or during harvest. The fungus does not appear to infect the seed internally, but rather contaminates the outside of the seed coat. Infected crop residue from previous seasons also serves as a source of inoculum (Sunder and Satyavir, 1998). Water grass (*Echinochloa* spp.) are weeds in rice fields and are also hosts and a source of inoculum (Carter et al., 2008).

Damage Potential: Bakanae is an economically important disease in the Asian rice growing areas where significantly large amount of yield losses estimated at approximately 20% annually with reports ranging from 1% to 40% (Cumagun et al., 2011). It is also a serious problem with similar losses in countries like, Japan, Taiwan, Thailand, Turkey, and Philippines (Webster and Gunnell, 1992). In addition to direct yield loss, the disease has a profound effect of on seed quality (Bashyal and Aggarwal, 2013). Several states have exterior quarantines up against rice from California to prevent the spread of this disease. Although at the time the disease was first discovered there was great concern about its impact on California rice production, today after more than 20 years, reports of significant damage have not been made.

Worldwide Distribution: Africa: *Brunei Darussalam, Cote d'Ivoire, Ghana, KwaZulu-Natal, Malawi, Mauritius, Nigeria, South Africa, Sudan, Tanzania, Zimbabwe.* Americas: *Barbados, Brazil, Costa Rica, Cuba, El Salvador, Guatemala, Haiti, Mexico, Nicaragua, Panama, United States* (California, Florida Georgia, Hawaii, Indiana, Iowa Kansas, Minnesota, Mississippi Missouri, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Tennessee, Texas, Virginia). Asia: *Bangladesh, China, India,*

Indonesia, Japan, Laos, Malaysia, Nepal, Papua New Guinea, Philippines, Sri Lanka, South Korea, Taiwan, Thailand, Turkey, Viet Nam, Uzbekistan. Europe: *Bulgaria, Denmark, Italy, Greece, United Kingdom.* Oceana: *Australia, Cook Islands, Fiji, Samoa.*

Official Control: *Gibberella fujikuroi* is on the USDA PCIT "harmful organism" list for Egypt, European Union, French Polynesia, Mexico, and United Kingdom (USDA, 2022). It is a quarantine pest in Mexico (EPPO, 2022). Arkansas, Mississippi, and Missouri have similar state exterior quarantines to each other against *Gibberella fujikuroi* (bakanae strains) that prevent movement of regulated articles from infested areas that includes rice, rice seed, rice hulls, mill waste and rice equipment. Mississippi and Missouri specifically regulate the entire state of California.

California Distribution: The disease was first found in California rice in 1999 and by 2001 it was found in the majority of rice production regions in the state (Anderson, 2005). Official samples have been collected from Butte, Colusa, Fresno, Glenn, Sacramento, San Joaquin, San Luis Obispo, Stanislaus, Yolo, and Yuba counties (CDFA PDR database).

California Interceptions: none

The risk *Fusarium fujikuroi* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** Bakanae has spread very quickly throughout all the rice growing regions of California. It is known to be widespread on various hosts in tropical and semitropical areas around the world.

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

   Score: **3**
   - 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 large, with hosts in many families

   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:** The pathogen spreads with airborne spores and contaminated seed.

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:** This pathogen is capable of reducing yields up to 40% and is a quarantine pest preventing California rice from entering 3 states (AR, MO, and MS).

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

Economic Impact: A, C

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: 2

- 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:** *Echinochloa* is a known host of *F. fujikuroi* and there are native and nonnative species in California. Some are widely distributed.

Evaluate the environmental impact of the pest to California using the criteria below

Environmental Impact: A

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: 2

- 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 *Fusarium fujikuroi:* High

Add up the total score and include it here. **13**
-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'.

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* ***= 10***

Uncertainty:

More weedy grasses could potentially be hosts of *F. fujikuroi* and contribute to epidemics in the field. There is herbicide resistance in some *Echinochloa* spp., which makes control increasingly difficult (Carter et al., 2008).

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Fusarium fujikuroi* is C.

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Responsible Party:

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***Comment Period: 06/23/2022 through 08/07/2022**

***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