Crop Profile for Wild Rice in Minnesota

Prepared: January, 2000

General Production Information

(*Zizania palustris* L.)

Wild rice is a cereal grain which is native to Minnesota, and has been successfully cultivated in the state since the 1960s. In the past, natural stands of this plant provided a staple in the diets of local Native American tribes. Today, this nutritious and flavorful grain is cultivated, and is used in a variety of products and marketed worldwide.

Minnesota ranks 2nd nationally in production of wild rice; during 1994–1998, Minnesota contributed an average of 44% to the total U.S. production.[15] California accounts for nearly all of the remaining national production.[19] During 1994–1998, Minnesota growers harvested an average of 5.5 million processed pounds of wild rice from an average of 18,715 acres annually; this represents an average of 296 processed pounds per acre per year.[5] Virtually all wild rice grown in Minnesota is grown for processing; only 1-2% of wild rice produced is used for seed.[6,8]

Production Regions

Wild rice is cultivated in the northern third of Minnesota. The counties of Aitkin, Beltrami, Clearwater, and Polk usually produce a majority of the state's crop. Cass, Crow Wing, Itasca, Koochiching, Lake of the Woods, Pennington, and Red Lake counties also contribute to the state's production of cultivated wild rice.[5]

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Cultural Practices

Wild rice cultivation is unique in that the plant must grow in flooded soils until it is nearly mature. This grain is grown on fields that are relatively flat and low-lying but above the flood plain, with soil and subsoil characteristics which will enable the field to be flooded for most of the growing season. Most fields are constructed on peat soils, and some are constructed on clay loam soils. Fields and the surrounding dikes must be constructed to allow for proper flooding, drainage, and water depths of a minimum of 6 inches on the shallow end and 14 inches on the deep end.[14] Some growers will carry 24-30 inches of water in the early part of the season for weed control. [6,13]

Wild rice is typically grown continually in a field for 5 years (occasionally up to 10-15 years) prior to either rotation or fallowing the land. It is commonly rotated with potatoes, oats, canola, barley, and timothy; other crops such as horseradish and grass seed are also sometimes used. Typically a field is planted to an alternative crop for 1-2 years, sometimes 3 years, prior to seeding again to wild rice.[8]

Selection of varieties is important in successful wild rice cultivation. Over the past 30 years, wild rice has been bred, resulting in several varieties which are more resistant to shattering than the type of wild rice which occurs in natural stands in the state.[18] A plant with non-shattering characteristics is one where more of the kernels will stay on the panicle longer as the panicle matures, allowing more kernels to be harvested before they fall to the ground and are lost.[14] When asked, growers rated non-shattering characteristics as the most important criteria in varietal selection. Other important factors are early maturity, disease resistance, and yield.[8] Several of these criteria are related. For example, higher yield is often characteristic of plants which have been bred for non-shattering; also, shattering is reduced when plants are more resistant to disease.[18] Franklin and Petrowske BB are the most commonly grown varieties in the state; other varieties commonly used are K2 and Voyager.[8]

Almost all wild rice fields are seeded in the fall prior to the first year of production or the first year returning to production after rotation or fallow. Some fields in the state are seeded in the spring.[8] In subsequent years of continuous production wild rice fields will reseed themselves effectively.[14] Seed is collected in the fall by most growers and stored in pits filled with water or in stock ponds. Seed is stored for up to two months when a grower is fall-seeding wild rice fields, and about eight months when the grower is spring-seeding. Many growers store and use seed themselves; some sell seed to other growers.[6,8] No pesticides are used by growers in this process.[8] Certified seed is used when it is available; it is only available for two years following a variety release, during which time certified seed producers make it available to growers.[6]

Wild rice germinates in late April through May. The early stages of development (germination and emergence) occur entirely underwater. The third or forth leaf which develops reaches the water surface and floats; this is the floating leaf stage. A small number of fields more than one year old are thinned at the floating leaf stage with an airboat equipped with a thinning attachment to produce stands of optimal density. The aerial leaf stage follows when the next leaf emerges from the water. Tillering occurs shortly

thereafter; this is the stage where the number of kernels is determined, thus nutrient levels should be optimal at this point. When the flag leaf has emerged the plant is at the boot stage and disease monitoring becomes critical, as does nitrogen level. The flowering stage follows, and the kernels form and fill. Wild rice worm monitoring is critical during grain fill. Depending on the variety, the plant will be ready to harvest 90 - 120 days after germination.[7,12]

Fields are drained over a period of about four weeks prior to harvest, beginning with a very slow draw-down over the first couple weeks followed by the main draw-down during the last couple weeks. The fields then dry for a period of at least one week prior to harvest.[13]

Depending on variety, weather, and age of the stand, harvest begins around early August, and may last throughout the month.[12] Virtually all cultivated wild rice is harvested with a combine, vs. the older technology of a multiple-pass harvester which is used for shattering lake types.[8] Wild rice is harvested before it is fully mature. After harvest, the grain is taken to a processing plant where it is separated.[14] Then it is cured, or fermented, in narrow rows or large piles for four to five days.[6,13] During this process, water is added and the grain is turned regularly to get uniform browning of kernels. After curing, the browned kernel with its seed hull intact goes to the parchers where moisture is dried out. During parching, starches gelatinize and a roasted nutty flavor develops. Then wild rice is cleaned and hulled, exposing the shiny black seed. Kernels may be scarified, then are cleaned, graded, and transported to a storage facility where it is warehoused.[14]

After harvest, fields are tilled in preparation for the next growing season. This cuts and buries debris and weed rootstocks and buries a portion of seed which fell to the ground. If wild rice is the intended crop in the next year, fields may or may not be flooded. [7,8,13]

Less than one-fifth of wild rice fields receive fall post-harvest applications of herbicides to gain control of perennials for the next growing season.[8] The effectiveness of this practice is compromised by debris covering the ground after harvest, and by the fact that many of the weeds have been cut and run over, leaving a poorly growing weed and reduced weed tissue to treat. A weed problem usually has to be severe to justify fall herbicide applications. When fall herbicide applications are done, fields are typically spot-treated, instead of spraying the entire field. Post-harvest herbicide applications alone will not fully control the weeds of wild rice.[7,13] Post-harvest herbicide applications are typically done with a ground applicator.[8]

Virtually all wild rice fields are fertilized with NPK annually;[8] around 1-2% of acreage may also be amended with minor elements.[6,7,13] Phosphorus and potassium are tilled in after harvest in the fall. Nitrogen is applied as a split application; it is tilled in with phosphorus and potassium in the fall, and may be topdressed during the following growing season, after the aerial leaf stage, if plants begin to yellow.[7,13]

About 90-100% of the state’s growers have their fields scouted for pests during the growing season.

Usually the grower scouts his or her own fields; sometimes University of Minnesota personnel assist with scouting. Scouting is typically done for the following insects: wild rice worm, midge, and rice stalk borer. Disease, weeds, algae, crayfish, and blackbirds are also evaluated. Trapping is not used to detect pests.[8]

Pesticide usage in the state has remained the same over the past 10 years, showing no evidence of trends toward either increasing or decreasing usage.[8] Pesticide usage is detailed at the end of each of the following sections (Insect Pests, Diseases, and Weeds). In addition to insects, diseases, weeds, and other pests, wind can severely damage a wild rice field. Severe spring winds can uproot and damage seedlings by causing water turbulence, and winds during the time when the grain is maturing can cause panicles to shatter and result in kernels falling to the ground where they cannot be recovered.[16]

Insect Pests

Wild rice worm is the most important insect pest of Minnesota's cultivated wild rice fields. Midge is the second most important pest, followed by rice stalk borer. Less important, but necessary to consider, are rice water weevil, rice leaf minor, and rice stem maggot.[17]

Wild Rice Worm (*Apamea apamiformis* [Guenee])
The wild rice worm is the most important insect pest of wild rice in the state. Adult moths emerge in late June and are active until early August; they oviposit shortly after emergence until early August. During this period the adults feed mostly on milkweed. Eggs are laid inside florets of young panicles of wild rice. Eggs are pearly white, darken to yellow, and turn gray prior to hatching 8-9 days after oviposition. Larvae emerge and consume the ovary; larvae pass through the sixth instar feeding in the panicle, mining out developing kernels. The larger instars can be found under leaf sheaths and occasionally in stalks. Most larvae are fifth, sixth, or seventh instars at harvest. The seventh instar overwinters in plant stalks within and around fields. Overwintered larvae become active in May, feed, molt to the eighth instar, and pupate in June. The pupal stage lasts for about three weeks, and a new generation of adults emerges in late June.[17]

Larvae damage wild rice by feeding on kernels, mining them out and leaving silk and starchy frass behind. One larvae causes an average yield loss of 11% in trials; if not treated losses of 50% or more can occur under field conditions.[12] Estimates indicate that typical loss is 5-15% (with control), and could reach 75% without control. Wild rice worm is a pest every year, and infests an estimated 70-100% of acreage.[8,13] Malathion provides fair to good control of wild rice worm.[8] There are no cultural or biological controls.[6,12]

Wild Rice Midge (a variety of midges from the families *Chironomidae* and *Dixidae*, particularly *Cricotopus* spp., a Dixid midge)
The wild rice midge adult is a small fly that resembles a mosquito, but lacks functional mouthparts and also lacks scales along the wing veins and margins. Adults lay eggs in gelatinous masses in soil. Egg masses are present prior to flooding the field and hatch when the field is flooded. Larvae construct silken webbing in which they hide and mature through the larval stages.[14,17]

Larvae feed on leaves of wild rice, abrading the leaf surface and edges, and then feed on tissue; damage usually occurs prior to the floating leaf stage. Silken tubes adhere to the plant, interfering with leaf emergence and elongation. Plants lose their distinctive structure, and it is likely that photosynthesis is also affected. Damage is more severe in warmer springs and in fields where the overall water depth is less (more shallow waters warm more quickly). Within a field, however, the greatest damage is usually noted in the deeper parts of that field, possibly because of the greater time the plant spends under water. The density of many first year stands is reduced at an economically important rate, and occasionally entire fields are destroyed.[17] Algae growth is also associated with midge infestations.[14] The wild rice midge causes the most severe damage to fields in the first year of production. They are actually present in higher numbers in the second year and subsequent fields, but damage is most critical in the first year when the field is being established. The first year is when the midge can easily reduce the density of the stand.[17] Estimates indicate that 5-30% of acreage is infested annually, typical yield losses are estimated at 5-25%, with potential losses reaching 100% in specific fields.[8] Malathion provides fair to good control.[8] There is no effective cultural or biological control for midge.[6,12]

Rice stalk borer (*Chilo plejadellus* [Zincken])
The adult rice stalk borer is light tan with a row of black spots along the distal margin of the forewing. Adults first emerge in early to mid June, and are present through late July or early August. During this period, circular, flat, cream colored eggs are laid, usually on floating leaves in masses of overlapping rows. They hatch in about 6 days, and turn orange just prior to hatching. Larvae feed on leaves, then bore into plants, tunneling down the stem to just above the water line, where they feed until October. In October, these larger larvae then search for dry overwintering areas. Rice stalk borers overwinter as larvae, inside stems of wild rice and weeds (primarily cattails and pigweed), in the field or within several meters of the field. Larvae pupate in stems during late May and early June, when they emerge as adults. There is one generation per year.[17]

Young larvae feed on leaves and leaf sheaths, creating elongated holes in the foliage. Older larvae bore into stems, and damage plants by tunneling to just above the water line and feeding until October. Damage can occur in several ways, "white head" or "dead heart", lodging, yield loss, and quality loss. The first three are insignificant in Minnesota wild rice. Loss in yield is significant but not severe; when 30-50% of stems are infested, loss appears to be around 5-10%. Loss in quality is the result of poorly

filled kernels in the panicles of infested stems. Infested stems may have a 25% reduction in the number of plump kernels per panicle.[17] The braconid wasp *Chelonus knabi* provides good control of the stalk borer. Wasps oviposit in the eggs of the stalk borer; larvae hatch and develop normally until the next spring, when parasitized larvae die prior to pupation.[17] Depending on conditions, 30-80% of overwintering larvae may be parisitized.[14] Rotovating fields after harvest provides excellent control of the overwintering larvae. Post-harvest burning is less effective because larvae will survive in unburned stems, and reinfest the field in the next year. Because larvae will overwinter outside the field, it is important to destroy vegetation on ditch banks also.[17] This, combined with fall flooding will partially control wild rice stem borer.[12] There is no registered chemical control of rice stalk borer; the combination of cultural and biological controls currently provide a level of control which lessens the need for chemical control.[13,17]

Rice water weevil(*Lissorhoptrus oryzophilus* [Kuschel] and *L. buchanani* [Kuschel])
Two species of rice water weevils are found in wild rice in Minnesota.[14] In both species, adults overwinter in debris along ditch banks, and migrate to wild rice fields in mid to late May. Females deposit eggs in leaf sheaths. Larvae emerge, feed on and prune roots, then pupate in dark balls attached to the roots of plants in late July and August. Adults emerge in mid August and feed for a while on the floating leaves, leaving characteristic long, narrow holes between leaf veins. Adults then migrate to overwintering sites. There is one generation per year in Minnesota.[17]

No economic damage is evident in Minnesota.[14] There are no chemical controls registered for use on rice water weevil. Drainage of fields to kill larvae is one method of controlling rice water weevil. In Minnesota, fields are drained in late July to early August for harvest, which is when rice water weevil is in the larval stage; this appears to provide control of this insect.[17]

Rice leafminer(*Hydrellia girseola* [Fallen] and *H. ischiaca* [Loew])
Two kinds of rice leafminers are found in wild rice fields in Minnesota.[14] Eggs are laid in masses on the erect plant and the floating leaf. After 2-7 days they hatch; larvae progress through three instars in 9-18 days, then pupate. Adults, which are small olive-green flies, emerge after 4-20 days. There are several generations per growing season. Larvae feed on leaves by mining the mesophyll layer. This damage is most apparent on the floating leaf stage. Damage disrupts the flow of nutrients to the leaf tip and causes a chlorotic appearance. Both leafminer species are abundant in Minnesota but typically do not cause economically important damage in cultivated fields. Although there are many parasites of this pest, biological control does not seem to be effective. In trials, chemical control with malathion has not been effective, and there is no chemical control registered for use. There has been little focus on finding a successful control of these pests because it is rarely economically important. [17]

Wild Rice stem maggot (*Eribolus longulus* [Loew])
The adult fly is yellowish-black, and lays eggs inside the rolled leaf sheath. Larvae burrow through the leaf and into the flower panicle.[14] This pest probably has more than one generation per year; the second generation is the one believed to infest wild rice.[17]

Larvae feed on leaves at the boot stage, causing perforation. At the same wild rice growth stage, if feeding occurs on the stalk tip, it will cause damage/deformations of the panicle and affect flowering.[17] The panicle will sometimes break off.[14] There is no registered chemical control for wild rice stem maggot, and because it is of little importance economically, control methods have not yet been thoroughly researched.

Chemical Control for Insect Pests:

Chemical Name: malathion
Trade Names: Malathion 57EC and Malathion 5E
Target Insects: wild rice worm and midge
Percent of acres treated: 27%[9] – 75%[4] of acreage may be treated in a given year for wild rice worm. Around 5% of total acreage (new seedings only) is treated for midge.[13]
Average rate and frequency: Typically applied at the label rate of 1.5 pints per acre (.93 lb.AI/ Acre) 10-20 days prior to harvest for wild rice worm. For midge, typically applied at the label rate near the floating leaf stage. Applied aerially, typically after water is off the fields when used for wild rice worm.
PHI: 10 days label PHI. 10-20 days typical PHI when used for wild rice worm. About 90 days typical PHI when used for midge. REI 12 hours.
comments: For wild rice worm apply 14-21 days after eggs are visible in hulls at the label rate. For midge apply at the floating leaf stage. It is critical not to lengthen the label PHI to more than 10 days; for wild rice worm control, malathion must be applied in a narrow time period based on insect development, which in some cases necessitates use of the insecticide up to 10 days prior to harvest. Malathion is a contact insecticide. If not applied at the correct stage of development of the wild rice worm, control will not be effective. Even with malathion use, only a part of the population is controlled; some wild rice worms will survive, and some will hatch after the chemical has lost its effectiveness. This further necessitates the ability for growers to apply malathion at the optimum time in order to receive the highest efficacy possible.[6,7,13]

Critically Needed Insecticides:
Malathion is the only product available for use in Minnesota on wild rice. It is available under a 24(c) registration. If this product is no longer available to Minnesota wild rice growers, the industry would be devastated. This product provides good control of the wild rice worm, previously stated as the most

important pest of wild rice, and midge, which is also critical to control. Without control of wild rice worm alone, our growers stand to lose up to 75% of current yields, perhaps more. Loss of control for midge would compound the loss. There are no effective cultural or biological controls of wild rice worm or midge. There are no pending registrations which could replace malathion, and research efforts to find biological and/or cultural controls for wild rice worm and midge have had limited success. [6,7,13]

Outlook for New Insect Controls:
In 1998, four commercial formulations of *Bacillus thuringiensis* were evaluated for effectiveness against wild rice worm larvae at rates of 1.5 and 3.0 lb.AI/Acre. Results indicate that all formulations failed to provide effective control.[2]

Diseases

The most severe diseases of cultivated wild rice in Minnesota are fungal brown spot and spot blotch. Other common diseases in the state are leaf sheath and stem rot, leaf blotch, stem smut, bacterial brown spot, and bacterial leaf streak. Currently the following diseases are rare on wild rice in Minnesota: ergot, eyespot, and wheat streak mosaic virus. With the exception of ergot, which has potential human health concerns, the rare diseases are not covered in detail in this report. Little is known about smut on wild rice, other than its presence.

Fungal Brown Spot(*Bipolaris oryzae* [Breda de Haan])
This is the most severe disease of wild rice in Minnesota, and is caused by the pathogen *Bipolaris oryzae*. It was previously named *Helmithosporium* brown spot, and was thought to also be caused by the pathogen *Bipolaris sorokiniana (*[Sacc.] Shoemaker), which for the purposes of this report is considered a separate fungal disease named Spot Blotch. It can infect all parts of a plant. Leaves exhibit tiny brown or purple lesions that develop into elongated lesions ½ inch long, which are straw-colored to brown with a yellow halo. Stem lesions begin the same way. Leaves may shrivel and die. Stems may become girdled and break causing the panicle to fall, and seed to be lost. If flowers and seed are infected, they become grey; often spore masses are present.[16]

Under controlled conditions, infections can occur at 41-97o F with wet periods 2-36 hours after inoculation. The highest infection rates can occur at 77-86o F with continuous wet periods of 24 hours. This fungus will infect and possibly survive on wild rice, oats, wheat, corn, and many wild grasses.[16]

Growers report that this pathogen infects up to 100% of wild rice acreage in most, if not all, years.[8] Growers and experts estimate that typical losses are 5-30%, but without control losses may reach 75-100%.[8,16] Propiconazole (Tilt®) can be applied at the maximun rates of either two 6 oz. applications

per acre or one 8 oz. application per acre. Application of 6 oz. per acre twice during the season usually reduces disease severity and increases yield regardless of environmental conditions favoring disease development One application produces inconsistent results.[11,16] (See the "Chemical Control for Diseases" section for further discussion on rates used.)

There are currently no resistant cultivars, however, resistant cultivars are in the latter stages of development.[18] Standard recommendations for cultural control include: plant at least one cultivar which has earlier flowering and harvest dates to reduce exposure of the plants to the conditions favorable to brown spot development,[16] do not exceed 4-6 plants per square foot in fields,[6,11,13,18] and immediately after harvest incorporate debris into the soil.[16] Recent research suggests that inoculum comes from sources outside the field; thus, managing plant material on the dikes may be helpful; this research also indicates that inoculum is killed by flooding.[11] Additionally, the application of recommended fertilizers may increase the plant's ability to defend itself against this pathogen. It was previously recommended (although it was not always feasible in practice) to practice crop rotation or fallow the land after two years of wild rice production;[16] however, in light of the research mentioned above, this is no longer recommended.[11]

Spot blotch (*Bipolaris sorokiniana* [Sacc.] Shoemaker)
Spot blotch is severe in the state, and often occurs and is treated concurrently with fungal brown spot. Previously fungal brown spot was considered also to be caused by this pathogen. Spot blotch causes disease earlier in the year than fungal brown spot, and under conditions less favorable for disease development, will be more prevalent than fungal brown spot. This pathogen causes lesions which are small, circular, and dark brown. They become larger and may grow together as the disease progresses. Lesions are found on floating leaves and all aerial parts of the plant. It will survive in plant residue and grasses. This fungus has shown the ability to become resistant to fungicides. The control measures used for fungal brown spot are used for spot blotch.[16]

Leaf Sheath and Stem rot *(Nakataea sigmoidea* [Cavara] K. Hara; sclerotial state *Sclerotium oryzae* [Catt.] and *Sclerotium hydrophilum* Sadd. *apud* Rothert)
These pathogens are widespread in both commercial and natural wild rice stands in Minnesota. The fungi produce dark lesions on floating leaves; later they may be associated with lesions on aerial leaves and a rot of the lower stem and crown. The fungi produce dark brown sclerotia up to 1 mm in diameter, which form in stems and sheaths. Sclerotia float to infect new plants and may overwinter on the soil. Association with insect infestations and secondary bacterial and fungal pathogens may cause lodging. The fungi will survive winters in debris and perhaps by sclerotia in soil. Studies indicate that they do not cause economic loss on wild rice.[16]

There are no effective measures to manage leaf sheath and stem rot. The pathogens will survive in

residue which is not incorporated into soil as well as in incorporated residue which is not decomposed completely. Continuous wild rice production increases incidences of these diseases.[16]

Leaf blotch (identity is in doubt, perhaps *Phaeoseptoria oryzae* Miyake)
This disease causes black lesions which grow to 1.0 x 2.5 cm. and may cover the entire leaf surface. The interior of a lesion becomes necrotic, turns light tan, and develops tiny black pycnidia which produce conidia. It typically infects mature aerial leaves and occasionally floating leaves; infection usually begins at the margin or base of the leaf blade. Survival, infection, dispersal, effect, and control measures are unknown.[16]

Stem smut (*Entyloma lineatum* [Cke.] Davis and Fisher)
Stem smut is found in all areas where wild rice is grown. It is dispersed by wind and rain, and infects at 82-86o F, usually not until plants are nearly mature. It overwinters in diseased leaf and stem tissue. The stem, culm, and panicle may be infected. Infected tissue produces glossy black lesions which turn to gray as plants mature and dry. Lesions may girdle stems near the panicle, and affect all parts of the panicle. There is no evidence that stem smut will kill immature plants. This disease results in insignificant yield losses. Some resistance may have been observed in particular breeding lines and selections. No control measures are available or necessary at this time.[16]

Ergot (*Claviceps zizaniae* [Fyles] Pantidou)
This disease is distributed wherever wild rice is grown, but is rare in commercial production. Ergot initially appears as a sticky liquid which attracts insects on the panicle of the plant. Then sclerotia which are pink to purple colored replace kernels; sclerotia are 3-6 mm in diameter and 3-20 mm in length. They turn black and harden when mature, and are the overwintering structures of this fungus. Yield loss information is unavailable.[16]

Ergot sclerotia can be harmful if they are consumed, but are easily separated from grain during processing, which is the only control available. During processing, sclerotia can be floated out with water.[16]

Bacterial brown spot (*Pseudomonas syringae* pv. nov. *zizaniae* [Bowden & Percich])
Bacterial brown spot is found wherever wild rice is grown. It causes a small water-soaked spot of streak on the leaf. As it develops, a greenish-brown halo with a dark brown margin develops and becomes tan

as small lesions become dark brown. Lesions are typically elliptical to spindle-shaped, 2-12 mm long and 1-10 mm wide, though they can be as long as 25 cm and may be diffuse or irregularly shaped. White bacterial exudate may be evident in the center of the lesion; in older lesions the center may fall out. The overwintering mechanism is not known. This pathogen can infect rotational crops. This disease can occur during all parts of the growing season; development occurs at 70-86o F during periods of wetness. Plant wounding is an important method of infection. Bacterial brown spot may infect more that 5% of the leaf area. There are no resistant varieties, and no control measures (other than those for diseases in general) are recommended.[16]

Bacterial leaf streak (*Xanthomonas campestris* and *Pseudomonas syringae* pv. *zizaniae* pv. nov.) Bacterial leaf streak causes water-soaked spots 1-3 mm wide which may expand lengthwise along the leaf blade up to 25 cm; the width of the lesion is limited by leaf veins. Infected tissue becomes necrotic in 1-7 days; leaves then appear to be striped with brown or black. A white or yellow flaky bacterial exudate is often present on the lesion surface. This disease can occur during all parts of the growing season; development occurs at 70-86o F during periods of wetness. Plant wounding is an important method of infection. This disease is found in all areas where wild rice is grown. There are no resistant varieties, and no control measures (other than those for diseases in general) are recommended.[16]

Recommended Cultural Control for Diseases:

Select varieties for earlier maturity and a more upright leaf structure. Fertilize properly; avoid excess nitrogen early in plant growth or deficiencies during flower fertilization. Do not drain field water too early as this may interfere with nutrient uptake. Maintain plant populations of 4-6 per square foot, which will help eliminate prolonged wet periods and promote proper nutrient uptake. After harvest, chop and incorporate crop residue to eliminate areas where diseases can survive. Practice crop rotation or fallow the field for at least one year after several years of wild rice; for crop rotation select crops which do not support wild rice pathogens. Practice good weed control, as many weeds are alternate hosts for wild rice pathogens. For the same reason, manage weeds and grasses in dikes. Flooding will kill disease organisms which exist in the flooded areas, and when done in the fall after harvest, will also help reduce weed populations[11,12] Disease organisms can still survive on other hosts, and in unflooded areas, and thus provide inoculum.[11]

Chemical Control for Diseases:

Chemical Name: propiconazole
Trade Name: Tilt®
Target disease: fungal brown spot, spot blotch
Percent of acres treated: 25 - 40% [9,11]

Average rate and frequency: The recommended rate is two 6 oz. applications per season (two 0.17 lb.AI/Acre applications per season). Depending on conditions, some acreage receives this rate. Alternately, some acreage is treated with one 4 oz. and one 6 oz. application (one 0.11 lb.AI/Acre application plus one 0.17 lb.AI/Acre application per season), and some is treated with one 6 oz. *or* one 8 oz. application (either 0.17 lb.AI/Acre once per season or 0.23 lb.AI/Acre once per season).
PHI: REI 24 hours. No labeled PHI; this product is only labeled for use at the booting and early flowering stages.
comments: Applied aerially, typically after water is off the fields.

Critically Needed Fungicides:
Tilt® is the only fungicide registered for use on wild rice in Minnesota. It is critical to maintain this registration for the fair to good control it provides for fungal brown spot and spot blotch. There are no biological controls of these diseases. Cultural controls alone are not always effective and are used in conjunction with Tilt® . Without Tilt® , a severe outbreak of fungal brown spot or spot blotch could destroy the entire crop.[6,7,11,13] Even resistant cultivars which are being developed will provide only partial control.[18]

Additionally, it would be wise to have another fungicide available for use to fight resistance.

Outlook for new disease controls and disease issues:

- *Quadris* – Active ingredient is azoxystrobin. Zeneca is currently pursuing a registration of Quadris for wild rice. In trials at the University of Minnesota, this fungicide did not show higher efficacy than Tilt®.[6,13] Additionally, this is a more expensive fungicide.

- *Stratego* – Stratego is a combination of propiconazole and trifloxystrobin (the new strobilurin compound from Novartis). Currently the product is registered for use only on peanuts. Novartis is not currently pursuing registration for use on wild rice. However, University of Minnesota researchers have been studying the compound's efficacy for disease control on wild rice in research plots. This research has shown that Stratego may be as good as, or a little better, than Tilt®. However, this product is more expensive than Tilt®.

Weeds

The most severe weeds in wild rice in Minnesota are common waterplantain, giant burreed, cattail, small pondweed, and sago pondweed. Other common weeds in Minnesota rice fields are common arrowhead,

cursed crowfoot, and water starwort. Broadleaf weeds are more serious than grasses. In addition to competing with wild rice and shading seedlings, weeds are alternate hosts to several wild rice pathogens.[12]

Common waterplantain (*Alisma plantago – aquatica* L.)
Common waterplantain is the most severe weed pest of wild rice in Minnesota. It is an aquatic perennial, can grow to 48 inches tall, and reproduces by seed and corms. Plants which grow from rootstocks emerge from the water prior to wild rice; they form a dense canopy which shades the wild rice, and their extensive root system also competes with wild rice. Competition from plants developed from corms is greatest after eight weeks of growth. Thus, it is critical to control common waterplantain prior to eight weeks of weed growth.[14] Seeds are viable in the soil for several years.[3] Seedlings germinate during the growing season, and do not harm wild rice in their first year, but they will grow to develop corms which will be damaging in subsequent years. The canopy formed by early-emerging waterplantain reduces tillering and kills some plants.[12] An average yield loss of 43% with one plant per square foot which grew from corms was shown experimentally.

This weed is most severe in water 1-6 inches deep, but will grow and cause damage to wild rice stands in water up to 30 inches deep.[3,12] According to grower estimates, common waterplantain infests up to 10-50% of wild rice acreage, and is a problem in every year. Typical yield loss is estimated at 5-10%, and potential yield loss is estimated at 30-50%.[8]

Cultural controls as detailed below provide fair control. Chemical controls are necessary. The herbicide 2,4-D amine (Weedar®) at 0.25 lb. per acre is the only herbicide which has been available to growers, and was available only because an emergency exemption had been granted.

Giant Burreed (*Sparganium eurycarpum* Engelm)
The perennial monocot giant burreed is 3-4 feet tall with a branched, leafy stem. It grows in shallow waters and spreads quickly, reproducing by seeds and rhizomes.[12] About 90% of wild rice fields in Minnesota are infested.[1] Infestations are spotty; estimates indicate that in terms of total acreage, 10-40% of wild rice acreage is infested. Typical yield loss is estimated at 5-10%, potential average yield loss at 30-50%. Burreed is a problem in most, if not all, years.[8,13]

In experiments, the label rate of .25 lb. per acre of 2,4-D amine is not effective (this information is for evaluation only; 2,4-D amine is not registered for use on burreed in wild rice in Minnesota). Fall plowing will provide fair control of burreed but will not eliminate it.[8,12] Roundup applied post-harvest provides fair control for some growers.[8]

Cattail(Typha latifolia L.)
This perennial grows where drainage is poor. It has long, narrow leaves and grows 4-8 feet tall. Flowers are arranged in a dense spike which produces airborne seeds which are viable in soil for more than five years.[14] It reproduces by seeds and rhizomes.[12]

Estimates indicate that up to 10% of Minnesota wild rice acreage is infested with cattails; this weed is a problem every year, and may cause 5-10% reduction in yield.[8]

Small pondweed (*Potamogeton pusillus* Fern.)
This aquatic perennial is found in shallow areas of fields where rice stands are thin. All leaves are submerged; seeds are borne on spikes. It reproduces both by seed and underground buds.[12]

Small pondweed is a pest in many years, infesting 15-30% of acreage in some locales. In infested areas, yield loss estimates range from 5-50%. Tillage, draining and flooding, and fallowing land are all used for control of this weed.[8]

Sago pondweed (*Potamogeton pectinatus* L.)
This aquatic perennial has a bushy, branched appearance, with all leaves submerged. It is able to grow in deeper waters. It reproduces by seeds and tubers.[12]

This weed is more severe than small pondweed; it is estimated to infest up to 75% of some areas, causing estimated yield loss of 5-30%, with potential of 50%. It is a problem in most or all years. Tillage, draining and flooding, and fallowing land are all used for control of this weed.[8]

Common arrowhead (*Sagittaria latifolia* Willd)
This perennial is 1-2 feet tall with basal, arrow-shaped leaves and white flowers. It reproduces by seeds and tubers, and grows in shallow water. It is not a severe weed pest of cultivated wild rice.[12]

Cursed crowfoot (*Ranunculus sceleratus* L.)
This is an annual or short-lived perennial which produces yellow flowers on the water surface; most of the plant is submersed. It grows in shallow sections of fields where rice stands are thin.[12]

Water starwort (*Callitriche heterophylla* Pursh)
This weed reproduces by seed, and can reduce wild rice stands. It grows in all parts of a field where rice stands are poor. Leaves are opposite below water and whorled above water.[12]

Cultural Control of Weeds:
Only weed-free rice seed should be used when seeding a new field. Fall moldboard plowing to bury weeds will prevent some plants from reproducing from rootstock in the following year. This is moderately effective for common waterplantain and cattail, and less effective for burreed. Fall plowing will not eliminate these weeds.[12] Fall flooding is used to manage weeds, especially common waterplantain, burreed, and cattail, on a small percentage of land; this provides partial control,[8] and is becoming more common among growers.[6,13]

It is important to manage fields to produce an optimal stand in the first year, which will help to prevent weeds from becoming established. When a field is in wild rice production, it is useful to keep a water depth at a minimum of 10 inches on the shallow end during the early part of the growing season for weed control.[7,13] Rotation with a different crop will help control the aquatic weeds.

Chemical Control of Weeds:

Chemical Name: 2,4-D amine
Trade Name: Weedar®64
Target Weed: common waterplantain
Percent of acres treated: typically 10-11%[4,6,10] , ranging from 5-25% [6,8]
Average rate and frequency: Typically applied at ½ pint per acre, equivalent to 0.24 lb. AI per acre, once per growing season [4]
PHI: REI 12 hours. Not to be applied after plant reaches boot stage.
comments: Must not be applied after wild rice reached boot stage, or damage to the crop will occur. Apply only when water plantain has emerged from water and wild rice is at the early tillering stage. Half-life of 10 days, therefore do not drain fields for 10 days after application. Treated water may not be used for irrigation or livestock.

Critically Needed Herbicides:
It is critical to have an effective herbicide available to wild rice growers. Common waterplantain can not be controlled solely by cultivation practices. 2,4-D amine is the only herbicide which was available for use in wild rice fields in Minnesota, and that has been available only through an emergency exemption.

Additionally, a more effective herbicide is desired. Although only about 10% of acreage is treated, our growers need an herbicide which will effectively control the weed pests of wild rice, to prevent infested

areas from spreading. Growers also desire a control for pondweeds.[6,8,13]

Outlook for New Weed Controls:
Shark – Active ingredient is carfentrazone. Registration for the herbicide Shark® is being pursued in California for use on wild rice. If it is cleared in California, Minnesota may pursue a registration. The recommended rate on other crops such as corn is 0.008 lb.AI/Acre; the recommended rate in rice and on the Section 18 in California is 0.2–0.3 lb.AI/Acre. The higher rate is needed for wild rice because by the time the weeds emerge from the water they are considerably older than they are in crops such as corn. In University of Minnesota trials, a rate of 0.4 lb.AI/Acre was needed to achieve good control of common waterplantain (applied when plants had 3-4 leaves and were 8-10 inches tall). At this rate wild rice growth was not affected; wild rice plants did show considerable leaf spotting, but this did not affect yield. Shark provides burnback control, which can allow wild rice to grow through a canopy of waterplantain and become established. However, Shark will not translocate; thus, it will not kill rootstocks of weeds in wild rice, and could not be considered an adequate replacement for an herbicide such as Weedar®.[13] In addition to this, Shark is considerably more expensive to growers than Weedar®.

Other Pests

Algae
Algae can reduce the density of wild rice fields; it forms a mat on the water surface before wild rice emerges, which can prevent seedlings from reaching the floating leaf stage.[3] Algae can be treated with copper sulfate at 15 lb. per acre as needed. Algae in the following spring can be reduced by incorporating fall fertilizer, especially phosphorus,[12] or by not applying phosphorus unless indicated by a soil test.[18]

Blackbirds
Blackbirds can potentially cause very high yield losses. They are a problem in most, if not all, years; control should begin when the birds first appear. Damage occurs during grain fill as the birds feed on soft kernels.[14] Blackbirds are estimated to cause 5-30% loss in most years, and could potentially cause higher losses. Shotguns, cannons, and similar forms of harassment are used to drive the birds from a field.[8]

Crayfish
Crayfish cause severe problems for growers on occasion by damaging seedlings,[14] and can completely destroy fields by killing all seedlings.[13] No controls are used.[8]

Tadpole shrimp
Tadpole shrimp also cause damage to seedlings and disrupt soil. They occur most often in new stands that tend to be thinner. They are more common than crayfish.[12] There are no controls used, other than

draining fields to dry and kill shrimp.[13,18]

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