

**Key Words: High Risk, Domesticated, Naturalized, Agricultural Weed, Food & Fodder Grass, Annual**

**Family:** *Poaceae*

**Taxon:** *Pennisetum americanum*

**Synonym:** *Cenchrus americanus* (L.) Morrone  
*Pennisetum glaucum* (L.) R. Br.  
*Pennisetum typhoides* (Burm. f.) Stapf & C.E.  
*Pennisetum spicatum* (L.) Körn.

**Common Name:** Bulrush millet  
 Pearl millet  
 Bajra  
 Cattail millet  
 Horse millet

**Questionnaire :** current 20090513      **Assessor:** Chuck Chimera      **Designation:** H(HPWRA)  
**Status:** Assessor Approved      **Data Entry Person:** Chuck Chimera      **WRA Score** 12

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| 101 | Is the species highly domesticated?   | y=-3, n=0  | y    |
| 102 | Has the species become naturalized where grown?   | y=1, n=-1  | y    |
| 103 | Does the species have weedy races?  | y=1, n=-1  | y    |
| 201 | Species suited to tropical or subtropical climate(s) - If island is primarily wet habitat, then substitute "wet tropical" for "tropical or subtropical" | (0-low; 1-intermediate; 2-high) (See Appendix 2)   | High |
| 202 | Quality of climate match data   | (0-low; 1-intermediate; 2-high) (See Appendix 2)   | High |
| 203 | Broad climate suitability (environmental versatility)   | y=1, n=0   | y    |
| 204 | Native or naturalized in regions with tropical or subtropical climates  | y=1, n=0   | y    |
| 205 | Does the species have a history of repeated introductions outside its natural range?  | y=-2, ?=-1, n=0                                    | y    |
| 301 | Naturalized beyond native range   | y = 1*multiplier (see Appendix 2), n= question 205 | y    |
| 302 | Garden/amenity/disturbance weed   | n=0, y = 1*multiplier (see Appendix 2)             |      |
| 303 | Agricultural/forestry/horticultural weed  | n=0, y = 2*multiplier (see Appendix 2)             | y    |
| 304 | Environmental weed  | n=0, y = 2*multiplier (see Appendix 2)             |      |
| 305 | Congeneric weed   | n=0, y = 1*multiplier (see Appendix 2)             | y    |
| 401 | Produces spines, thorns or burrs  | y=1, n=0   | n    |
| 402 | Allelopathic  | y=1, n=0   | n    |
| 403 | Parasitic   | y=1, n=0   | n    |
| 404 | Unpalatable to grazing animals  | y=1, n=-1  | n    |
| 405 | Toxic to animals  | y=1, n=0   |      |
| 406 | Host for recognized pests and pathogens   | y=1, n=0   |      |
| 407 | Causes allergies or is otherwise toxic to humans  | y=1, n=0   | n    |
| 408 | Creates a fire hazard in natural ecosystems   | y=1, n=0   | n    |
| 409 | Is a shade tolerant plant at some stage of its life cycle   | y=1, n=0   |      |

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| 410 | Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)   | y=1, n=0                                       | y |
| 411 | Climbing or smothering growth habit  | y=1, n=0                                       | n |
| 412 | Forms dense thickets   | y=1, n=0                                       | n |
| 501 | Aquatic  | y=5, n=0                                       | n |
| 502 | Grass  | y=1, n=0                                       | y |
| 503 | Nitrogen fixing woody plant  | y=1, n=0                                       | n |
| 504 | Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)               | y=1, n=0                                       | n |
| 601 | Evidence of substantial reproductive failure in native habitat                                 | y=1, n=0                                       | n |
| 602 | Produces viable seed   | y=1, n=-1                                      | y |
| 603 | Hybridizes naturally   | y=1, n=-1                                      |   |
| 604 | Self-compatible or apomictic   | y=1, n=-1                                      | y |
| 605 | Requires specialist pollinators  | y=-1, n=0                                      | n |
| 606 | Reproduction by vegetative fragmentation   | y=1, n=-1                                      | n |
| 607 | Minimum generative time (years)  | 1 year = 1, 2 or 3 years = 0,<br>4+ years = -1 | 1 |
| 701 | Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas) | y=1, n=-1                                      |   |
| 702 | Propagules dispersed intentionally by people   | y=1, n=-1                                      | y |
| 703 | Propagules likely to disperse as a produce contaminant   | y=1, n=-1                                      | y |
| 704 | Propagules adapted to wind dispersal   | y=1, n=-1                                      | n |
| 705 | Propagules water dispersed   | y=1, n=-1                                      |   |
| 706 | Propagules bird dispersed  | y=1, n=-1                                      | n |
| 707 | Propagules dispersed by other animals (externally)   | y=1, n=-1                                      | n |
| 708 | Propagules survive passage through the gut   | y=1, n=-1                                      |   |
| 801 | Prolific seed production (>1000/m2)  | y=1, n=-1                                      | y |
| 802 | Evidence that a persistent propagule bank is formed (>1 yr)                                    | y=1, n=-1                                      |   |
| 803 | Well controlled by herbicides  | y=-1, n=1                                      | y |
| 804 | Tolerates, or benefits from, mutilation, cultivation, or fire                                  | y=1, n=-1                                      | y |
| 805 | Effective natural enemies present locally (e.g. introduced biocontrol agents)                  | y=-1, n=1                                      |   |

Designation: H(HPWRA)

WRA Score 12

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**Supporting Data:**

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| 101 | 1977. Brunken, J.N.. A Systematic Study of Pennisetum sect. Pennisetum (Gramineae). American Journal of Botany. 64(2): 161-176.   | [Is the species highly domesticated? Yes] "The prime factor maintaining morphological variability in <i>P. americanum</i> is probably of human origin rather than natural. In his planting and weeding practices, the pearl millet farmer acts as an agent of disruptive selection between the wild and cultivated members of section Pennisetum. Man favors the cultivated phenotype when choosing his seed for planting and exerts strong selective pressure against wild and intermediate phenotypes in his weeding activities. In the several millenia since domestication, man's disruptive selection has not, however, led to reproductive isolation between pearl millet and its wild progenitor. They remain today as subunits of the same gene pool."        |
| 101 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a> | [Is the species highly domesticated? Yes] " <i>P. glaucum</i> has a long history of cultivation. From its beginnings in the Sahel region, it reached eastern Africa and India about 3,000 years ago, and southern Africa about 2,000 years ago, and is now grown in much of the world sub-humid and semi-arid tropics and subtropics, sometimes extending into temperate zones." ... "Cultivars vary in time to maturity from 55 to 280 days, but mostly from 75 to 180 days."  |
| 102 | 1979. Smith, A.C.. Flora Vitiensis Nova - A New Flora of Fiji (Spermatophytes Only). Volume 1. Pacific Tropical Botanical Garden, Lawai, HI   | [Has the species become naturalized where grown? Yes] "a very common grass found from sea level to an elevation of several hundred meters along roadsides and tracks, in cultivated areas such as rice fields, on dry open hillsides and open rocky places, in swampy areas, and on the inner edges of mangrove swamps. ...a weed of cultivation and waste places." [Fiji]  |
| 103 | 1977. Brunken, J./de Wet, J.M.J./Harlan, J.R.. The Morphology and Domestication of Pearl Millet. Economic Botany. 31(2): 163-174.   | [Does the species have weedy races? Yes] "In addition to the cultigen and its wild progenitor, the PGP of pearl millet includes a large number of spontaneously occurring, weedy plants which mimic the crop in their vegetative and floral morphologies. Throughout much of West Africa, these mimetic weeds are quite common in fields of pearl millet and are colloquially called shibra. Prior to maturation, shibras are difficult to distinguish from the associated race of pearl millet. Those races having, for instance, extremely long inflorescences or elongated terminal bristles have weeds with identical characteristics."   |
| 103 | 1979. Smith, A.C.. Flora Vitiensis Nova - A New Flora of Fiji (Spermatophytes Only). Volume 1. Pacific Tropical Botanical Garden, Lawai, HI   | [Does the species have weedy races? Yes] "...a weed of cultivation and waste places." [Fiji]  |
| 103 | 1990. Ellstrand, N.C./Hoffman, C.A.. Hybridization as an Avenue of Escape for Engineered Genes. BioScience. 40(6): 438-442.   | [Does the species have weedy races? Yes] "Even before the days of genetic engineering, a few cases of crop weed hybridization are known to have led to the evolution of aggressively weedy crop mimics (reviewed by Barrett 1983). These weeds are difficult to control because they share so many traits with the crop. For example, a common noxious weed of pearl millet ( <i>Pennisetum americanum</i> ) in Africa is a race of the same species. The weed evolved through hybridization of pearl millet with a nonweedy race of <i>P. americanum</i> (Brunken et al. 1977). Therefore, any crop-weed hybridization carries a risk of increased aggressiveness in the weed. To a great extent, the danger depends on how well the crop genes fare in the hybrid." |
| 201 | 2006 (onwards). Clayton, W.D./Harman, K.T./Williamson, H.. Grassbase - The Online World Grass Flora. <a href="http://www.kew.org/data/grasses-db.html">http://www.kew.org/data/grasses-db.html</a> .  | [Species suited to tropical or subtropical climate(s) 2-High] "Distribution: Europe: eastern. Africa: north, west tropical, west-central tropical, northeast tropical, east tropical, southern tropical, south, and western Indian ocean. Asia-temperate: western Asia, Arabia, and China. Asia-tropical: India and Indo-China. Australasia: Australia. South America: Caribbean."  |
| 202 | 2006 (onwards). Clayton, W.D./Harman, K.T./Williamson, H.. Grassbase - The Online World Grass Flora. <a href="http://www.kew.org/data/grasses-db.html">http://www.kew.org/data/grasses-db.html</a> .  | [Quality of climate match data 2-High]  |
| 203 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a> | [Broad climate suitability (environmental versatility)? Yes] "It is grown between sea level and 1,800 m in the tropics, and to about 40° N in the USA. The optimum temperature for germination is 33 - 35°C, and the minimum, 12°C. Sowing is best done when soil temperatures reach 18°C or above, and night temperatures are above 10°C. The optimum temperature for tiller production and development is 21 - 24°C, and for spikelet initiation and development about 25°C. Pollen viability, panicle size and spikelet density are reduced by extreme high temperatures before anthesis, thus reducing seed yield." [Elevation range in tropics exceeds 1000 m]   |
| 204 | 2006 (onwards). Clayton, W.D./Harman, K.T./Williamson, H.. Grassbase - The Online World Grass Flora. <a href="http://www.kew.org/data/grasses-db.html">http://www.kew.org/data/grasses-db.html</a> .  | [Native or naturalized in regions with tropical or subtropical climates? Yes] "Distribution: Europe: eastern. Africa: north, west tropical, west-central tropical, northeast tropical, east tropical, southern tropical, south, and western Indian ocean. Asia temperate: western Asia, Arabia, and China. Asia-tropical: India and Indo-China. Australasia: Australia. South America: Caribbean."  |

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| 205 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>                         | [Does the species have a history of repeated introductions outside its natural range? Yes] "P. glaucum has a long history of cultivation. From its beginnings in the Sahel region, it reached eastern Africa and India about 3,000 years ago, and southern Africa about 2,000 years ago, and is now grown in much of the world sub-humid and semi-arid tropics and subtropics, sometimes extending into temperate zones."   |
| 301 | 1979. Smith, A.C.. Flora Vitiensis Nova - A New Flora of Fiji (Spermatophytes Only). Volume 1. Pacific Tropical Botanical Garden, Lawai, HI   | [Naturalized beyond native range? Yes] "a very common grass found from sea level to an elevation of several hundred meters along roadsides and tracks, in cultivated areas such as rice fields, on dry open hillsides and open rocky places, in swampy areas, and on the inner edges of mangrove swamps. ...a weed of cultivation and waste places." [Fiji]   |
| 301 | 2007. Oppenheimer, H.L.. New plant records from Moloka'i, Lāna'i, Maui, and Hawai'i for 2006. Bishop Museum Occasional Papers. 96: 17-34.   | [Naturalized beyond native range? Yes] "In the most recent update on the naturalized species of Pennisetum in Hawai'i, Herbst & Clayton (1998: 32) did not include this species in their key. It differs from other species of Pennisetum in Hawai'i in being an annual (vs. perennial), and having the bristles about as long as the spikelet (vs. much longer) (Hitchcock 1971: 727)." ... "It is cultivated as a grain in India and Africa and has been reported as an escape from trials in Fiji (as Pennisetum americanum, Smith 1991: 359), and has also been collected from a trial plot at the old Hawai'i Agricultural Experiment Station at Poamoho, O'ahu (Hosaka 2539, 17 Oct 1940, BISH). Material examined. MAUI: West Maui, Lahaina Distr, Māhinahina, 366 m, volunteer in trial plot in former pineapple field, 1 Oct 2004, Oppenheimer, R. Bartlett, & G. Hansen H100402 (BISH); Honokōhau, Kula o Kalāiāloa, 134 m, locally common, possibly planted as forage grass trial, 2 Dec 2004, Oppenheimer & G. Hansen H120401." |
| 301 | 2012. Western Australian Herbarium. FloraBase — The Western Australian Flora - Pennisetum glaucum (L.) R.Br.. Department of Environment and Conservation, <a href="http://florabase.dec.wa.gov.au/browse/profile/537">http://florabase.dec.wa.gov.au/browse/profile/537</a> | [Naturalized beyond native range? Possibly Yes] "Cultivated in some places but may occasionally be naturalized." [Western Australia]  |
| 302 | 1977. Brunken, J./de Wet, J.M.J./Harlan, J.R.. The Morphology and Domestication of Pearl Millet. Economic Botany. 31(2): 163-174.   | [Garden/amenity/disturbance weed? Possibly Yes] "A natural colonizer, it becomes locally common in disturbed sites such as seasonally dry stream beds, roadsides, abandoned fields and human habitations" [A disturbance adapted plant that is recognized as a weed of agriculture. See 3.03]   |
| 303 | 1977. Brunken, J./de Wet, J.M.J./Harlan, J.R.. The Morphology and Domestication of Pearl Millet. Economic Botany. 31(2): 163-174.   | [Agricultural/forestry/horticultural weed? Yes] "In addition to the cultigen and its wild progenitor, the PGP of pearl millet includes a large number of spontaneously occurring, weedy plants which mimic the crop in their vegetative and floral morphologies. Throughout much of West Africa, these mimetic weeds are quite common in fields of pearl millet and are colloquially called shibra." ... "In West Africa, one of the chief competitors of pearl millet has always been its own wild progenitor, a natural colonizer. In removing all spontaneous plants from his field, man created a niche for those individuals which resembled the crop but retained the capacity for natural seed dispersal."   |
| 303 | 1999. Galinato, M.I./Moody, K./Piggin, C.M.. Upland rice weeds of south and southeast Asia. International Rice Research Institute, Los Baños, Philippines   | [Agricultural/forestry/horticultural weed? Yes] "The species can be a weed in waste places, stubble fields, base places, pastures, crops, and meadows. It often finds its way into fields as an impurity in seed."  |
| 304 | 2007. Randall, R.P.. Global Compendium of Weeds - Pennisetum glaucum. <a href="http://www.hear.org/gcw/species/pennisetum_glaucum/">http://www.hear.org/gcw/species/pennisetum_glaucum/</a>   | [Environmental weed? Possibly] P. glaucum appears in references listing actual or potential environmental weeds, but most evidence suggests that this grass (a synonym of P. americanum), is either a disturbance weed or weed of agricultural crops.   |
| 305 | 2003. Weber, E.. Invasive Plant Species of the World. A Reference Guide to Environmental Weeds. CABI Publishing, Wallingford, UK  | [Congeneric weed? Yes] Pennisetum clandestinum, P. macrourum, P. polystachion, P. purpureum and P. setaceum are all listed as significant weeds of natural areas.   |
| 305 | 2010. Chemisquy, M.A. et al.. Phylogenetic studies favour the unification of Pennisetum, Cenchrus & Odontelytrum (Poaceae): a combined nuclear, plastid & morphological analysis, & nomenclatural combinations in Cenchrus. Annals of Botany. 106: 107–130.                 | [Congeneric weed? Genus Pennisetum transferred into Cenchrus] "Species of Pennisetum and Odontelytrum are here transferred into Cenchrus, which has priority. Sixty-six new combinations are made here." ... "Cenchrus americanus (L.) Morrone, comb. nov. Basionym: Panicum americanum L., Sp. Pl. 1: 56. 1753. LECTOTYPE. Illustration in Clusius, Rar. Pl. Hist 2: 215. 1601 (lectotype, designated by Clayton & Renvoize, in Polhill (ed.), Fl. Trop. E. Africa, Gramineae 3: 672.1982)."   |
| 401 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a>                 | [Produces spines, thorns or burrs? No] "A robust and free-tillering annual growing to a height of 3 m. Stems 10-20 mm thick; above each node is a shallow groove containing an axillary bud. Nodes slightly swollen; they bear a ring of adventitious root primordia at the basal end. Leaves flat, dark green and up to 8 cm wide. The inflorescence forms a compact, cylindrical, terminal, spike-like panicle. There are 870-3 000 spikelets on a panicle. Seeds small, 3-4 mm, wedge-shaped of various colours according to variety."   |

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| 402 | 1981. Hussain, F./Gadoon, M.A.. Allelopathic Effects of Sorghum vulgare Pers.. Oecologia. 51(2): 284-288.   | [Allelopathic? No evidence] "Sorghum vulgare Pers. a tropical fodder crop significantly reduced the vertical growth and drymass of Sorghum vulgare, Pennisetum americanum, Zea mays and Setaria italica. Aqueous extracts of various plant parts, field soils and decaying mulch significantly reduced germination, radicle growth and water contents of all test species." [P. americana is impacts by allelopathy of Sorghum vulgare]   |
| 402 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Allelopathic? No evidence]   |
| 403 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>         | [Parasitic? No] "P. glaucum is susceptible to parasitisation by angiosperm species, Striga hermonthica and Striga asiatica."  |
| 403 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Parasitic? No] No evidence [Poaceae]   |
| 404 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Unpalatable to grazing animals? No] "In the United States, three cuts of highly palatable green fodder are taken at six- to seven-week intervals. Late-maturing varieties are favoured for forage production. High regrowth yields after defoliation can best be obtained if the cutting height is above the apical meristem, and it is suggested that the crop be grazed rotationally when about 45 cm tall. Regrowth after later harvests declines rapidly (Begg, 1965)." ... "Pearl millet should be subject to relatively frequent but lenient defoliation to maintain quality. The crop should not be allowed to grow above 1 m high before grazing starts. Forage intake varied from a high of 3.1 kg DM/100 kg body weight on immature forage to a low of 1.4 kg on mature forage over a five year period (Ferraris, 1973). Density of tiller regrowth after cutting was reduced from 54 percent when cut at 4 weeks to about 3 percent when cut at 14-16 weeks." ... "Norman and Stewart (1964) found the crop excellent for dry season grazing by beef cattle, and live-weight gains averaged 296 kg/ha over 16 weeks at Katherine, Northern Territory Australia, during a period when live weight on native pasture declined." |
| 405 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>         | [Toxic to animals? Potentially, under certain conditions] "P. glaucum can develop high levels of nitrates under conditions favouring high levels of available soil nitrogen, particularly during periods of depressed growth such as caused by moisture stress or cold." ... "May cause nitrate poisoning"  |
| 405 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Toxic to animals? Possible negative effects] "Grazing lactating cows on millet has led to marked butterfat depression, and it has been suggested (Schneider et al., 1970) that high succinic and oxalic acids may be the cause. Under heavy nitrogen fertilization, high nitrate may be recorded. HCN contents are not sufficiently high to be hazardous to stock."  |
| 406 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>         | [Host for recognized pests and pathogens? Potentially] "P. glaucum is host to numerous diseases caused by bacteria, fungi, viruses, and nematodes, parasitised by other plants, and subject to attack by numerous insects and birds, the impact of any one varying from country to country, and region to region. Some of the more important diseases are downy mildew caused by Sclerospora graminicola, smut (Moeszimyces (Tolyposporium) penicillariae), ergot (Claviceps fusiformis), rust (Puccinia substriata) and pyricularia leaf spot (Pyricularia grisea). Stem borer (Coniesta ignefusalis (Lepidoptera: Pyralidae)), millet head miner (Heliocheilus albipunctella (Lepidoptera: Noctuidae)) and millet gall midge (Geromyia penniseti (Diptera: Cecidomyiidae)) are the major insect pests."   |
| 406 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Host for recognized pests and pathogens? Potentially] "The main diseases, among many listed by Ferraris (1973), are smuts (caused by Helminthosporium spp.), downy mildew and top rot. In Queensland, a leaf spot is caused by a fungus, Cercospora." ... "In Africa one of the worst pests is the root parasite, Striga hermonthica, and less commonly S. lutea. The red-billed weaver bird, locusts and Quelea quelea aethiopica take heavy toll. Heliolithis armigera attacks seed-heads, and the stem borer, Coniesta ignefusalis, is also damaging. Ferraris (1973) gives a full list of pests."  |
| 407 | 1999. Galinato, M.I./Moody, K./Piggin, C.M.. Upland rice weeds of south and southeast Asia. International Rice Research Institute, Los Baños, Philippines   | [Causes allergies or is otherwise toxic to humans? No] "The plant is often used as a food and green fodder by people in Africa and India, and as a livestock forage in many areas."   |

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| 407 | 2008. Wagstaff, D.J.. International poisonous plants checklist: an evidence-based reference. CRC Press, Boca Raton, FL  | [Causes allergies or is otherwise toxic to humans? No evidence for humans]   |
| 407 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Causes allergies or is otherwise toxic to humans? No] "Pearl millet is an important grain crop in Africa where the rainfall is not secure enough for sorghum or maize. In the United States and Australia it is a useful, non-toxic forage to replace forage sorghum. The stalks are used in the dry tropics for home building."  |
| 408 | 1999. Galinato, M.I./Moody, K./Piggin, C.M.. Upland rice weeds of south and southeast Asia. International Rice Research Institute, Los Baños, Philippines   | [Creates a fire hazard in natural ecosystems? No evidence] Not listed among negative impacts   |
| 408 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Creates a fire hazard in natural ecosystems? No evidence]   |
| 409 | 1999. Galinato, M.I./Moody, K./Piggin, C.M.. Upland rice weeds of south and southeast Asia. International Rice Research Institute, Los Baños, Philippines   | [Is a shade tolerant plant at some stage of its life cycle? Possibly Yes] "P. glaucum is shade-tolerant and, in one study under 55% shade, grew taller throughout the growing season." [Conflicts with Cook et al 2005. Different races or genotypes may vary in their tolerance to shade]   |
| 409 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>           | [Is a shade tolerant plant at some stage of its life cycle? Possibly No] "Not shade tolerant." [Conflicts with information from Galinato et al. 1999. Different races or genotypes may vary in their tolerance to shade]   |
| 410 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>           | [Tolerates a wide range of soil conditions Yes] "This species is adapted to a range of soil types, but is best on sandy or light loam soils. It will grow on clays, but they must be well drained. P. glaucum is susceptible to waterlogging. Although this species tolerates poor, infertile soils better than most other crop species, it is more productive on fertile soils. The ideal pH range is 5.5 - 7.0, but it will grow in soils with pH as high as 8.3. It can tolerate more acid soil than forage sorghums, growing in soils down to pH 4.5, with subsoils to as low as pH 4 and high in exchangeable aluminium. It is also slightly more salt tolerant than sorghum" |
| 410 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Tolerates a wide range of soil conditions ? Yes] "Bulrush millet grows on a wide range of soils, from sands in the Sudan to clays. It is tolerant of very acid soils. It grows best in a well drained fertile soil." ... "It does not tolerate flooding, especially during the summer. "  |
| 411 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Climbing or smothering growth habit? No] "A robust and free-tillering annual growing to a height of 3 m. Stems 10-20 mm thick; above each node is a shallow groove containing an axillary bud. Nodes slightly swollen; they bear a ring of adventitious root primordia at the basal end."   |
| 412 | 2007. Oppenheimer, H.L.. New plant records from Molokai, Lanai, Maui, and Hawai'i for 2006. Bishop Museum Occasional Papers. 96: 17-34.   | [Forms dense thickets? No evidence] "It is cultivated as a grain in India and Africa and has been reported as an escape from trials in Fiji (as Pennisetum americanum, Smith 1991: 359), and has also been collected from a trial plot at the old Hawai'i Agricultural Experiment Station at Poamoho, O'ahu (Hosaka 2539, 17 Oct 1940, BISH). Material examined. MAUI: West Maui, Lahaina Distr, Māhinahina, 366 m, volunteer in trial plot in former pineapple field, 1 Oct 2004, Oppenheimer, R. Bartlett, & G. Hansen H100402 (BISH); Honokōhau, Kula o Kalālāloa, 134 m, locally common, possibly planted as forage grass trial, 2 Dec 2004, Oppenheimer & G. Hansen H120401." |
| 412 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Forms dense thickets? No evidence outside cultivation] "It is usually grown as a pure stand. In India it has been grown with Cajanus cajan, the mixture providing a useful cover to reduce soil erosion. "  |
| 501 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Aquatic? No] "It does not tolerate flooding, especially during the summer. " [Terrestrial]  |
| 502 | 2012. Tropicos.org. Tropicos [Online Database]. Missouri Botanical Garden, <a href="http://www.tropicos.org/">http://www.tropicos.org/</a>  | [Grass? Yes] Poaceae   |

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| 503 | 2012. Tropicos.org. Tropicos [Online Database]. Missouri Botanical Garden, <a href="http://www.tropicos.org/">http://www.tropicos.org/</a>  | [Nitrogen fixing woody plant? No] Poaceae  |
| 504 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)? No] "A robust and free-tillering annual growing to a height of 3 m. Stems 10-20 mm thick; above each node is a shallow groove containing an axillary bud. Nodes slightly swollen; they bear a ring of adventitious root primordia at the basal end. Leaves flat, dark green and up to 8 cm wide. The inflorescence forms a compact, cylindrical, terminal, spike-like panicle. There are 870-3 000 spikelets on a panicle. Seeds small, 3-4 mm, wedge-shaped of various colours according to variety."  |
| 601 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Evidence of substantial reproductive failure in native habitat? No evidence, but native range poorly known due to long history of domestication] "Originated in central tropical Africa, but cultivated since 1200 BC in India. Now widely distributed in the drier tropics."   |
| 602 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Produces viable seed? Yes] "Seeds are ready to harvest three to four weeks after anthesis. They vary from 3 to 10 mg in weight. Uneven ripening of tillers necessitates multiple harvests where manual methods are used. The seed can be harvested directly by combines, but for tall varieties a roller attached in front of the comb will make the harvesting height easier to handle."   |
| 603 | 1977. Brunken, J./de Wet, J.M.J./Harlan, J.R.. The Morphology and Domestication of Pearl Millet. Economic Botany. 31(2): 163-174.   | [Hybridizes naturally? Possibly] "Pennisetum americanum subsp. Monodii (Maire) Brunken includes all wild plants which are capable of hybridizing with pearl millet to produce fully fertile offspring. Until recently, these plants were divided among two species, Pennisetum violaceum (Lam.) L. Rich. and Pennisetum fallax (Fig. and de- Not.) Stapf and Hubb., both native to the West African sahel. Recent genetic studies by Bilquez and Lecomte (1969) and Brunken (1975) have demonstrated, however, that neither of these two species is reproductively isolated from pearl millet. Hybrids between pearl millet and members of both P. fallax and P. violaceum are uniformly vigorous and fully fertile. The union of these two species into a single subspecies of P. americanum was necessitated in order to reflect the close evolutionary relationship between these taxa and pearl millet." ... "Intraspecific hybridization. Wherever the three subspecies of P. americanum come into contact, the possibility of hybridization is very great." ... "Extensive hybrid swarms have been inspected by us in western Sudan, northern Nigeria and especially western Senegal. They occur most commonly at the margins of actively cultivated fields of pearl millet. Although no data are available, the swarms appear to persist for several years. Owing to the abundance of its pollen, backcrossing is predominantly to the cultivated parent. Hybridization between pearl millet and its wild progenitor has probably been a common occurrence following their divergence during domestication and may have allowed genetic exchange with local races of subsp. monodii as the cultivation of pearl millet spread." |
| 603 | 1977. Brunken, J.N.. A Systematic Study of Pennisetum sect. Pennisetum (Gramineae). American Journal of Botany. 64(2): 161-176.   | [Hybridizes naturally? Possibly] "The hybrid between P. purpureum and P. americanum subsp. americanum has been obtained several times (Burton, 1944; Krishnaswamy, Raman, and Krishnaswami, 1951; Khan and Raman, 1963). In each case, the F1 hybrid was triploid and highly sterile."   |
| 603 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Hybridizes naturally? Potentially] "Interspecific hybridization of P. americanum has usually only been successful with P. purpureum. Bana grass is one such cross and is widely used in south-east Queensland as a wind- break on vegetable farms; it also provides useful fodder. A millet-breeding unit is centred on the EAAFRO, Serere Research Station in Uganda and at Coastal Plains Research Station, Tifton, Georgia, United States."  |
| 604 | 1989. Reger, B.J.. Stigma Surface Secretions of Pennisetum americanum. American Journal of Botany. 76(1): 1-5.  | [Self-compatible or apomictic? Yes] "However, P. americanum does not have a self-incompatibility system; all Pennisetum species are self-compatible."  |
| 605 | 1994. Zomlefer, W.B.. Guide to Flowering Plant Families. The University of North Carolina Press, Chapel Hill & London   | [Requires specialist pollinators? No] Poaceae [anemophilous. Wind-pollinated]  |
| 606 | 2010. gardenguides.com. Pearl Millet (Glaucom). <a href="http://www.gardenguides.com/taxonomy/pearl-millet-pennisetum-glaucom/">http://www.gardenguides.com/taxonomy/pearl-millet-pennisetum-glaucom/</a>   | [Reproduction by vegetative fragmentation? No evidence] "Vegetative Spread - None"   |
| 606 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/dat a/Pf000297.HTM</a> | [Reproduction by vegetative fragmentation? No evidence] "Seeds are ready to harvest three to four weeks after anthesis. They vary from 3 to 10 mg in weight. Uneven ripening of tillers necessitates multiple harvests where manual methods are used."   |

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| 607 | 1977. Brunken, J.N.. A Systematic Study of Pennisetum sect. Pennisetum (Gramineae). American Journal of Botany. 64(2): 161-176.   | [Minimum generative time (years)? 1] "As it is interpreted here, <i>P. americanum</i> encompasses all penicillarias having an annual life cycle"  |
| 607 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Minimum generative time (years)? 1] "A robust and free-tillering annual growing to a height of 3 m." [Annual]  |
| 701 | 1977. Brunken, J./de Wet, J.M.J./Harlan, J.R.. The Morphology and Domestication of Pearl Millet. Economic Botany. 31(2): 163-174.   | [Propagules likely to be dispersed unintentionally? Possibly] "A natural colonizer, it becomes locally common in disturbed sites such as seasonally dry stream beds, roadsides, abandoned fields and human habitations" [May be moved inadvertently because of prevalence along human transportation corridors]   |
| 702 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>         | [Propagules dispersed intentionally by people? Yes] " <i>P. glaucum</i> is mostly grown as a grain crop, being the staple food in those parts of tropical Africa and India that are too hot, dry and sandy for sorghum production. It is also used for grazing, green chop and silage, and, with appropriate management, for hay. Whole grains are fed to poultry and livestock, and the straw is used for bedding, thatching, fencing and fuel."   |
| 702 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Propagules dispersed intentionally by people? Yes] "Pearl millet is an important grain crop in Africa where the rainfall is not secure enough for sorghum or maize. In the United States and Australia it is a useful, non-toxic forage to replace forage sorghum. The stalks are used in the dry tropics for home building. "   |
| 703 | 1999. Galinato, M.I./Moody, K./Piggin, C.M.. Upland rice weeds of south and southeast Asia. International Rice Research Institute, Los Baños, Philippines   | [Propagules likely to disperse as a produce contaminant? Yes] "The species can be a weed in waste places, stubble fields, base places, pastures, crops, and meadows. It often finds its way into fields as an impurity in seed." [Synonym] " <i>P. glaucum</i> ]  |
| 704 | 1983. Barrett, S.C.H.. Crop Mimicry in Weeds. Economic Botany. 37(3): 255-282.  | [Propagules adapted to wind dispersal? No. Predominantly gravity dispersed following shattering of infructescence] "The major features distinguishing the mimetic weed millets and their crop models concerns their respective seed dispersal mechanisms. Infructescences of the weed forms exhibit a shattering habit and most seed is returned to the soil although, because of the synchronous flowering patterns of crop and weed, some seed from late-flowering inflorescences may be harvested and resown with the crop."   |
| 705 | 1977. Brunken, J./de Wet, J.M.J./Harlan, J.R.. The Morphology and Domestication of Pearl Millet. Economic Botany. 31(2): 163-174.   | [Propagules water dispersed? Possibly] "A natural colonizer, it becomes locally common in disturbed sites such as seasonally dry stream beds, roadsides, abandoned fields and human habitations" [Seeds may be moved by water when stream beds flow, but no evidence that water is a primary dispersal vector of this grass]  |
| 706 | 1973. Adesiyun, A.A.. Bird damage to cereals grown in the dry season in some parts of northern Nigeria. Samaru Agricultural Newsletter. 15(1): 34-35.   | [Propagules bird dispersed? No. Birds are seed predators] "In the dry season of 1972 at Samaru, an irrigated plot of sorghum cv. R960 was bordered by 2 plots of irrigated awned wheat and the whole area was attacked by weaver birds ( <i>Plesiositraga cucullatus cucullatus</i> ). Grain yield loss was 100% in the sorghum, but the wheat was virtually undamaged. At Kakawa, grain yield loss from weaver birds in adjacent irrigated plots of millet [ <i>Pennisetum americanum</i> ] and maize was 80% and nil, respectively"   |
| 707 | 1983. Barrett, S.C.H.. Crop Mimicry in Weeds. Economic Botany. 37(3): 255-282.  | [Propagules dispersed by other animals (externally)? Probably No] "The major features distinguishing the mimetic weed millets and their crop models concerns their respective seed dispersal mechanisms. Infructescences of the weed forms exhibit a shattering habit and most seed is returned to the soil although, because of the synchronous flowering patterns of crop and weed, some seed from late-flowering inflorescences may be harvested and resown with the crop." [No evidence, although seeds may possibly adhere to fur or hooves of animals. Not adapted for external dispersal by animals] |
| 708 | 2006. Williams, S.C./Ward, J.S.. Exotic Seed Dispersal by White-tailed Deer in Southern Connecticut. Natural Areas Journal. 26(4): 383-390.   | [Propagules survive passage through the gut? Possibly Yes] "Table 1. Scientific name, common name, life form (Form), life history (Life), frequency of occurrence (Freq), count of seedlings (Count), and dispersal ranking (Rank) for Connecticut exotic species that germinated directly from intact pellet groups (n = 326)." [Included one seed of <i>Pennisetum glaucum</i> that was able to germinate]  |
| 801 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>         | [Prolific seed production (>1000/m <sup>2</sup> )? Yes] "Seed yields of about 250 kg/ha are obtained in the lowest rainfall areas, and (500 -) 670 - 790 (- 1,500) kg/ha in the main production areas in Africa and India. Under optimal conditions, yields may be as high as 5 t/ha, but are often reduced by disease and bird attack."  |

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| 801 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Prolific seed production (>1000/m <sup>2</sup> )? Presumably Yes] "The inflorescence forms a compact, cylindrical, terminal, spike-like panicle. There are 870-3 000 spikelets on a panicle. Seeds small, 3-4 mm, wedge-shaped of various colours according to variety." ... "Number of seeds per kg. About 187 000."  |
| 802 | 2008. Royal Botanic Gardens Kew. Seed Information Database (SID). Version 7.1. <a href="http://data.kew.org/sid/">http://data.kew.org/sid/</a>  | [Evidence that a persistent propagule bank is formed (>1 yr)? Unknown from field conditions] "Storage Conditions: 100 % viability following drying to mc's in equilibrium with 15 % RH and freezing for 10 years at -20°C at RBG Kew, WP."  |
| 802 | 2012. Food and Agriculture Organization of the United Nations. Grassland Species Profiles - Pennisetum americanum. FAO, <a href="http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM">http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000297.HTM</a> | [Evidence that a persistent propagule bank is formed (>1 yr)? Possibly No] "Several reports state that the seed of pearl millet exhibits post harvest dormancy of several weeks. "  |
| 803 | 1999. Galinato, M.I./Moody, K./Piggin, C.M.. Upland rice weeds of south and southeast Asia. International Rice Research Institute, Los Baños, Philippines   | [Well controlled by herbicides? Yes] "Chemical. The weed can be controlled effectively by preemergence application of butachlor or oxadiazon and by postemergence spraying of propanil." [Synonym: <i>P. glaucum</i> ]  |
| 804 | 2005. Cook, B.G./Pengelly, B.C./Brown, S.D. et al.. Tropical Forages: an interactive selection tool., [CD-ROM],. SIRO, DPI&F(Qld), CIAT and ILRI, <a href="http://www.tropicalforages.info/index.htm">http://www.tropicalforages.info/index.htm</a>         | [Tolerates, or benefits from, mutilation, cultivation, or fire? Yes] "Later-maturing varieties are favoured for forage production. Quality is maintained by relatively frequent but lenient defoliation. Crops can be cut initially when they reach 75 cm to 1 m tall, since if plants are allowed to grow taller, quality declines, and there is difficulty in drying the hay. High regrowth yields after defoliation can best be obtained if the cutting height is above the apical meristem, which means adopting a stubble height of 15 - 20 cm. Grazing can start earlier when the stand reaches 30 - 50 cm, but still with the same after-grazing residue to facilitate regrowth. Earlier defoliation encourages tillering. A rotational system favours efficiency of forage utilisation and facilitates better regrowth compared with continuous grazing, particularly when <i>P. glaucum</i> appears susceptible to trampling. The crop should not be allowed to grow above 1 m high before subsequent grazing. The first cut is usually at 60 to 65 days after planting, and successive cuts 30 to 35 days after the preceding cut. Regrowth in successive harvests declines rapidly, the final cut coinciding with early head production. Harvesting for silage is recommended any time from boot to soft dough stage." |
| 805 | 2012. WRA Specialist. Personal Communication.   | [Effective natural enemies present locally (e.g. introduced biocontrol agents)? Unknown]  |

## **Summary of Risk Traits**

### **High Risk / Undesirable Traits**

- Naturalized
- Includes a large number of spontaneously occurring, weedy plants which mimic the crop in their vegetative and floral morphologies
- Thrives in tropical climates
- Grown between sea level and 1,800 m in the tropics (broad elevation range)
- May cause nitrate poisoning
- Possible host of pests & pathogens
- Tolerates many soil conditions (and potentially able to exploit many different habitat types)
- Self-compatible & wind-pollinated
- Annual (reproductive in <1 year)
- Seed contaminant
- Prolific seed production
- Tolerates cutting & grazing by animals

### **Low Risk / Desirable Traits**

- Domesticated forms of this grass valuable for human use (grain & forage)
- Forage & fodder grass
- Not known to spread vegetatively
- Seeds predominantly gravity & human-dispersed
- Herbicides may provide effective control