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JAPANESE MILLET
(Echinochloa crusgalli var. frumentacea)

Section 7.16, US ARMY CORPS OF ENGINEERS
WILDLIFE RESOURCES MANAGEMENT MANUAL

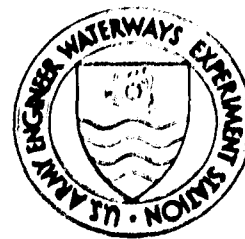
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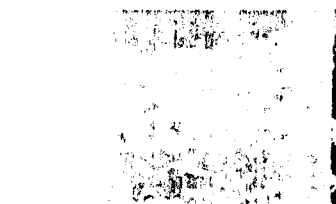
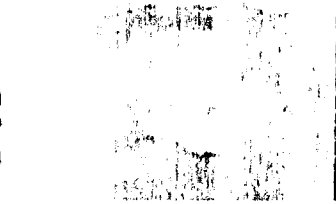
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<p>A plant materials report on Japanese millet (<i>Echinochloa crusgalli</i> var. <i>frumentacea</i>) is provided as Section 7.1.6 of the US Army Corps of Engineers Wildlife Resources Management Manual. The report was prepared as a guide to assist the project biologist with the selection, cultivation, and management of suitable plant materials for wildlife and habitat development programs. Major topics discussed are description, distribution, habitat requirements, wildlife value, establishment, management, and cautions and limitations.</p> <p>Japanese millet is an introduced, annual, warm season grass that is an improved variety of wild millet (<i>E. crusgalli</i>). It can be grown throughout the United States and has been widely planted to develop waterfowl feeding areas. The characteristics, distribution, and habitat requirements of this species are described, and its value to wildlife is discussed. Guidelines for the establishment of Japanese millet include specifications for site</p>					
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selection, plot design, and seeding. Criteria are provided for the management of water levels consistent with maximum plant growth and seed production.

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PREFACE

This work was sponsored by the Department of Defense (DOD) military branches under the DOD Natural Resources Program. Technical Monitors for the study were representatives of the Fish and Wildlife Committee of the Defense Natural Resources Council, DOD. The report serves as a section of the US Army Corps of Engineers Wildlife Resources Management Manual, as developed by the Headquarters, US Army Corps of Engineers, under the Environmental Impact Research Program.

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NOTE TO READER

This report is designated as Section 7.1.6 in Chapter 7 -- PLANT MATERIALS, Part 7.1 -- GRASSES, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 7.

JAPANESE MILLET
(*Echinochloa crusgalli* var. *frumentacea*)

Section 7.1.6, US ARMY CORPS OF ENGINEERS
WILDLIFE RESOURCES MANAGEMENT MANUAL

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Japanese millet, an improved variety of *Echinochloa crusgalli*, is widely distributed in North America (Neely and Davison 1971). It has several common names, including black millet and alkali millet (Miller and Arend 1959), as well as those frequently used for the species, such as wild millet, barnyard grass, water grass, and duck millet (Neely and Davison 1971, SCS 1971). It was once exploited under the name billion-dollar grass (Hitchcock 1950) and is sometimes erroneously called wild rice in Louisiana and the Gulf coast states (Kester and Kester 1983).

This species may be cultivated for forage (Bailey 1949), but it is most frequently employed in the management of waterfowl food resources. It has been planted extensively throughout the United States to develop waterfowl feeding areas and is one of the better food plants to use in shallow-water field developments (Denton 1987), such as beaver ponds, duck field impoundments, and waterfowl food patches around lakes and ponds. Although Japanese millet is readily eaten by songbirds (Martin et al. 1951), the emphasis of this report is its establishment and management for waterfowl.

DESCRIPTION

Japanese millet is an erect, warm season, annual grass that is usually 2 to 5 ft (0.6 to 1.5 m) in height at maturity (Kester and Kester 1983, Denton 1987). However, depending upon the seed source and site conditions, this species may grow as tall as 8 ft (2.5 m) or no taller than 1 ft (0.3 m) (SCS 1967).

The glabrous leaves are 4 to 20 in. (10 to 50 cm) long; the leaf sheath is smooth, and a ligule is absent at the leaf base (Elmore et al. 1986). The purplish-brown inflorescence is a terminal panicle 4 to 16 in. (10 to 40 cm) long that consists of numerous incurved 1-in. (2.5-cm) spikes (Hitchcock 1921, Elmore et al. 1986) (Fig. 1). Each spike is crowded with many ovoid, awnless spikelets that contain the reddish-purple seeds (Miller and Arend 1959, SCS 1972).

Japanese millet is similar in appearance to barnyard grass (*E. crusgalli*) but exhibits several characteristic differences. The plants are taller and more robust and have denser, more compact seedheads than those of barnyard grass (Miller and Arend 1959, Coastal Zone Resources Division 1978, SCS 1984). The seeds of barnyard grass are whitish in color (Radford et al. 1968) and have awns that are several times as long as the spikelets (Hitchcock 1921, Bailey 1949) (Fig. 1d).

The seeds of Japanese millet mature in approximately 60 days (Denton 1987) but may require more time in northern climates (Linde 1969) and less time in the South (Wesley 1975). High seed production is characteristic of this grass, and average yields of 1500 to 2000 lb/acre (1680 to 2240 kg/ha) may be expected (Johnson et al. 1976, SCS 1984). Single yields of 3000 lb/acre (3360 kg/ha) have been produced behind diked impoundments in California; this is equivalent to 30 to 60 bushels of seed per acre (Green et al. 1964).

DISTRIBUTION

Japanese millet originated in Africa and Asia (Bailey 1949) and is well adapted to temperate climates. It is distributed throughout the United States, its range extending northward into New Brunswick, Canada, and southward into northern Mexico (Elmore et al. 1986) (Fig. 1). It grows at low and medium altitudes (Hitchcock 1950) in cultivated fields and wet areas planted



Figure 1. Distribution and distinguishing characteristics of Japanese millet (*E. crusgalli* var. *frumentacea*): (a) entire plant with terminal panicle, (b) seed, and (c) spikelet. A spikelet of barnyard grass (*E. crusgalli*) is shown for comparison (d). The map shows the overall species distribution (diagonal lines) and the region of greatest management use (cross-hatching)

for waterfowl, but occasionally escapes to roadsides, ditches, and other waste places (Coastal Zone Resources Division 1978, Elmore et al. 1986).

HABITAT REQUIREMENTS

Japanese millet is better adapted to wetland conditions than most species planted for waterfowl food (Linde 1969). It will grow on a wide variety of moist to wet soils such as humus-rich sands, peat, sandy loam, and sandy clay (Coastal Zone Resources Division 1978). This species will tolerate shallow flooding during growth in the Southeast (SCS 1984) and is adapted to irrigated fields in arid western states (SCS 1971). Japanese millet requires drier conditions than barnyard grass (Miller and Arend 1959) but grows well on soils too wet for browntop millet (*Panicum ramosum*) and corn (*Zea mays*) (Neely and Davison 1971). Although a wetland plant, it can be grown successfully on well-drained upland soils in high rainfall regions (SCS 1967).

Suitable soils may have pH values ranging from 4.6 to 7.4 (Coastal Zone Resources Division 1978). Although Japanese millet has been grown successfully in acid soils (Denton 1987), its growth and development are enhanced when soil pH is greater than 5.4 (McLain 1957). This species has greater salt tolerance than other cereal grains (Coastal Zone Resources Division 1978) and can withstand salinities of 3000 ppm (SCS 1972).

Full sun is required for maximum seed production (Coastal Zone Resources Division 1978). Preferred natural habitats include roadsides, fields, waste ground, ditches, moist open places, damp lowlands, mud flats, stream and lake banks, river bottoms subject to overflow, and lakes or ponds that are intermittently dry in summer and flooded in winter (Hitchcock 1950, Coastal Zone Resources Division 1978, Kester and Kester 1983). Japanese millet may also volunteer and grow as a weed in rice fields (Neely and Davison 1971).

WILDLIFE VALUE

Japanese millet is extensively used by waterfowl, upland game birds, and songbirds (Table 1). It has been evaluated as a choice food for ducks (Davison and Neely 1959, SCS 1984), mourning dove (Davison and Sullivan 1963), California quail, geese, and seed-eating songbirds and is considered a fair food for the ring-necked pheasant (SCS 1971). Although most birds feed on the millet seeds, geese also use the leaves and stems (Stanton 1957).

Table 1. Birds known to use Japanese millet as food*

Common Name	Scientific Name
<u>Waterfowl</u>	
Northern pintail	<i>Anas acuta</i>
American wigeon	<i>A. americana</i>
Northern shoveler	<i>A. clypeata</i>
Green-winged teal	<i>A. crecca</i>
Blue-winged teal	<i>A. discors</i>
Mottled duck	<i>A. fulvigula</i>
Mallard	<i>A. platyrhynchos</i>
American black duck	<i>A. rubripes</i>
Gadwall	<i>A. strepera</i>
Wood duck	<i>Aix sponsa</i>
Redhead	<i>Aythya americana</i>
Ring-necked duck	<i>A. collaris</i>
Greater scaup	<i>A. marila</i>
Common goldeneye	<i>Bucephala clangula</i>
Greater white-fronted goose	<i>Anser albifrons</i>
<u>Upland game birds</u>	
California quail	<i>Callipepla californica</i>
Northern bobwhite	<i>Colinus virginianus</i>
Ring-necked pheasant	<i>Phasianus colchicus</i>
Mourning dove	<i>Zenaida macroura</i>
<u>Songbirds</u>	
Northern cardinal	<i>Cardinalis cardinalis</i>
American goldfinch	<i>Carduelis tristis</i>
Bobolink	<i>Dolichonyx oryzivorus</i>
Blue grosbeak	<i>Guiraca caerulea</i>
Indigo bunting	<i>Passerina cyanea</i>
Dickcissel	<i>Spiza americana</i>
Smith's longspur	<i>Calcarius pictus</i>
Dark-eyed junco	<i>Junco hyemalis</i>
Lincoln's sparrow	<i>Melospiza lincolni</i>
Song sparrow	<i>M. melodia</i>
Savannah sparrow	<i>Passerculus sandwichensis</i>
Field sparrow	<i>Spizella pusilla</i>
White-throated sparrow	<i>Zonotrichia albicollis</i>
Red-winged blackbird	<i>Agelaius phoeniceus</i>
Tricolored blackbird	<i>A. tricolor</i>
Brown-headed cowbird	<i>Molothrus ater</i>
House sparrow	<i>Passer domesticus</i>
<u>Marsh and shore birds</u>	
Common snipe	<i>Gallinago gallinago</i>
Purple gallinule	<i>Porphyrula martinica</i>
Sora	<i>Porzana carolina</i>

* Table compiled from major references cited in the text.

Japanese millet is one of the major species planted throughout the United States to provide food for waterfowl. In the Southeast, ducks (especially mallards) are attracted in large numbers to managed beaver ponds seeded with this grass (Arner 1963). It is also planted in openings of bottomland hardwood forests (Merz and Brakhage 1964), in farm ponds and duck field impoundments, and around lake and pond edges (SCS 1979). Because of its abundant seed production, this species has special advantages as a waterfowl food. Plants grow densely and produce large seedheads that can withstand the intensive feeding of hundreds of ducks per acre for several days (Hopkins 1962). A large number of seeds remain available into January (Arner 1963) and are especially important when there is a poor mast crop on bottomland hardwood sites (Merz and Brakhage 1964).

ESTABLISHMENT

Site Selection

Japanese millet can be successfully grown on a variety of sites managed for waterfowl. Ideal locations include duck field impoundments (Neely and Davison 1971), drained marshland (Hopkins 1962), pond and lake edges (SCS 1979), openings in bottomland hardwood stands (Merz and Brakhage 1964), and beaver ponds, especially those with minimal coverage of aquatic vegetation (Arner and Hepp, in press) (Fig. 2).

The primary consideration in selecting a site is that it will be dry enough for planting in midsummer but wet enough for shallow flooding in fall, thus making seeds available to migrating or wintering waterfowl. Since rainfall is unreliable for timely flooding, sites should have the potential to support water control systems that allow dewatering and reflooding at the appropriate times. Therefore, it is desirable for a site to contain a live stream or be located near a dependable source of water (SCS 1979).

Plot Design

Size. Plot size may range from a few acres in small developments (SCS 1979) to several hundred acres in large areas such as marshes (Hopkins 1962) and bottomland hardwood forests (Merz and Brakhage 1964). A minimum of 1 to 2 acres is required for plots in beaver ponds, duck field impoundments, or pond and lake edges; however, 5- to 10-acre plots yield the best results and can accommodate larger numbers of waterfowl (SCS 1979). Japanese millet has



Figure 2. Japanese millet growing in a beaver pond with little aquatic vegetation

been planted in marshes in units up to 200 acres (Hopkins 1962) and has been seeded in bottomland clearings of 400-acre tracts to supplement pin oak (*Quercus palustris*) mast (Merz and Brakhage 1964). Plots of several acres may be sowed in solid blocks, but those in large open tracts are more effective if planted in wide strips separated by bare ground. Large units can be laid out in a patchwork of strips 50 to 100 ft wide so that areas of open water will be available for approaching waterfowl (Hopkins 1962).

Water level control. Water levels must be controlled to provide proper water regimes for the maximum production and utilization of Japanese millet. Water control structures will be required to dewater sites that are not dry enough to plant by midsummer and to contain water for reflooding the plots before ducks arrive in the fall. These structures will also be employed in maintaining the shallow water levels needed to make millet seeds available to waterfowl throughout the winter. Water management is discussed under a separate heading later in the report.

Site Preparation

Although plots may be sown while still flooded, the more common practice is to seed sites after water removal. Water may recede naturally in time for planting around lake and pond edges; however, impoundments usually require drawdown, and beaver ponds will need to be drained. Dewatering may be done in either spring or summer. Davison and Neely (1959) recommended water removal in March or early April for southern states, soon after waterfowl have migrated, and Green et al. (1964) found that the best plant growth and seed production in Ohio resulted from drawdown in May. However, waiting until mid-summer to drain beaver ponds will help maintain habitat for late-hatching wood ducks (Teaford 1986).

Mud flats should be sown immediately upon exposure (Wesley 1975); therefore, drawdown should be rapid and decisive so that plots can be seeded before drying occurs and perennials become established (Linde 1969). In arid climates, dry sites may be flooded until the area is saturated; water can then be removed rapidly to produce mud flats ready for planting (Miller and Arend 1959). Dry sites in more humid climates may be disked to prepare seedbeds, as mechanical preparation and subsequent covering of seeds will retain moisture and increase natural seed production (Givens et al. 1964). Soil amendments are generally not required on Japanese millet plots.

Propagules

Japanese millet is established from seed, which is usually available from commercial seed dealers. The seed should be relatively clean and should test 80% to 85% purity and 70% to 85% germination (SCS 1967). Pretreatment is needed only for seeds to be planted in flooded fields. To ensure sinking, these should be soaked overnight and drained for 1 to 2 hours, but not allowed to dry, before sowing (SCS 1972).

It should be noted that the variety *E. c. chiwapa* may also be sold under the name Japanese millet. Although it is a high-yield producer, the seeds require 90 to 120 days for maturation (Wesley 1975, SCS 1984). However, this variety may be useful on areas where drawdown conditions are favorable for planting in late spring or early summer (SCS 1984).

Planting Methods

Time of seeding. Japanese millet should be planted so that maturation coincides with the time seeds are required for waterfowl use. Seeds mature in

approximately 60 days, and target dates for seed availability are early September in northern areas and mid-October in the South (Givens et al. 1964). The following regional planting dates are recommended:

Southeast	Mid-July to mid-August (Teaford 1986)
Northeast	Mid-June (McLain 1957)
North-central	Mid- to late-June (Linde 1969)
Northwest	May-June (SCS 1971)
California	May-July (SCS 1972)

A crop needs ample time to mature before the first frost, but seeding too early may result in several problems. For example, excessive competition from aquatic plants may reduce the growth and yield of Japanese millet (Wesley 1975), and seeds that mature too early for waterfowl may be consumed or damaged by other wildlife species (Linde 1969). Therefore, the time of planting may be critical for abundant seed production and effective utilization by target species.

Seeding. Japanese millet seeds may be sown by broadcasting or drilling. Seeds may be broadcast onto flooded ground (Green et al. 1964), disked dry land (SCS 1984), or moist exposed mud flats (Anderson-Tully Company 1987, Denton 1987). If broadcast onto a prepared seedbed or land dry enough to work, seed should be covered with less than 1 in. of soil by harrow (SCS 1967) or drag (Neely and Davison 1971), whereas seed broadcast onto mud flats or partly drained ponds and lakes should remain uncovered (SCS 1967).

Broadcasting may be accomplished by hand, cyclone seeder, crawler tractor (on mud flats), or airplane (Linde 1969). Aerial seeding is especially effective for sowing flooded fields, mud flats, or extensive drained areas that might otherwise dry out before seeding has been completed (Hopkins 1962). All dewatered sites should be seeded as soon as possible after exposure, as the soft moist soil is necessary for optimum germination (Wesley 1975, SCS 1979).

Drilling is the most effective method to use in arid climates on soils that sustain rapid evaporation, but seeds should be placed no deeper than 1/4 in. (SCS 1972). Linde (1969) recommended drilling seeds 1 to 2 in. deep in Midwestern soils, whereas Neely and Davison (1971) suggested placing seeds only 1/2 to 1 in. deep in soils of the Southeast. To ensure germination of millet planted in rice fields, seeds should be drilled no deeper than 1/4 in. (SCS 1972).

The suggested seeding rate is approximately 20 lb seed/acre (Denton 1987). Rates in the more humid Southeast may range up to 25 lb/acre, whereas

those in the arid Southwest may require only 10 to 15 lb/acre (Coastal Zone Resources Division 1978). Linde (1969) suggested the following seeding rates based on the method of seeding: cyclone seeder, 20 to 25 lb/acre; drilling, 28 to 30 lb/acre; aerial broadcasting, up to 30 lb/acre; and hand broadcasting, approximately 35 lb/acre. Seeding at 20 lb/acre is sufficient in drained beaver ponds (Arner 1963, Wesley 1975).

WATER MANAGEMENT

Flooding

Timing. Flooding the crop of Japanese millet is required for waterfowl utilization of the seeds. Plots are usually reflooded after seed maturity, just before the arrival of waterfowl in the fall (Green et al. 1964, Neely and Davison 1971) or 2 weeks prior to the opening of hunting season (SCS 1984).

Depth. Plots to be used by dabbling ducks should be flooded to a depth of 15 in. (Neely and Davison 1971, SCS 1972) to 18 in. (Florida Game and Freshwater Fish Commission 1969, Linde 1969), whereas those prepared for diving ducks require several feet of water. If the high point of a field is more than 15 in. above the low point, progressive (incremental) flooding may be used to provide a constant source of fresh food with the advancement of winter (Neely and Davison 1971). Drains should be removed from beaver ponds to allow beavers to rebuild dams and impound water to its original shallow depth, which is usually appropriate for seed utilization by waterfowl (Wesley 1975).

Progressive flooding. Progressive, or incremental, seeding and flooding may be employed to provide food for longer periods into the winter (Linde 1969). Japanese millet is seeded at intervals to produce several stages of seed maturation, and plots are flooded as the seeds mature. This modification should extend seed availability, especially for early migrants. However, care must be taken not to plant so late that heavy frost will prevent maturation of later seedings or so early that blackbird flocks can destroy the millet before arrival of large numbers of ducks.

Incremental flooding may be used in beaver ponds to reduce damage from army worms (larvae of Family Noctuidae) by creating a movement barrier for young caterpillars (Teaford 1986). After plants have reached an average height of 1 ft, ponds may be partially flooded and water levels maintained at one quarter to one half the average height of the growing millet. When seeds

have matured, beavers may be allowed to repair dams and finish flooding the pond.

Control Structures

Water level control structures commonly consist of culvert drains and stop logs, or boards, that can be removed to dewater a site or be individually replaced to effect incremental flooding. Impoundments in large, open agricultural fields may require only one such structure in a single levee (Fig. 3). In regions of moderate to heavy rainfall, this system will allow water to be collected and maintained at a maximum depth during the seasons of waterfowl use. Pumping systems for both flooding and dewatering planted sites may be required for diked impoundments built on flat areas or for those constructed in regions of unreliable autumn rainfall (Neely and Davison 1971).

Control structures for beaver ponds may be made of 3 logs or PVC pipes bound together and placed in the dam at the main stream channel to dewater the site and maintain stream flow throughout summer (Teaford 1986). The drain can be removed in fall so beavers can repair the dam and reflood the site to its former shallow depth. Construction details for several types of drains used to manipulate water levels where beavers constitute a problem are given in Wesley (1975), SCS (1979), Buech (1985), Teaford (1986), and Frentress (1989).

CAUTIONS AND LIMITATIONS

Timing Considerations

The timing of seeding and reflooding can be critical to the successful use of Japanese millet in waterfowl food plots. Flocks of small birds are attracted to the seedheads and can cause heavy damage to millet that matures too early (Givens et al. 1964, Linde 1969, Neely and Davison 1971, SCS 1972). Blackbirds have been known to take as much as 40% of a crop before the autumn arrival of ducks (Stanton 1957). This problem is more likely to occur on plots that have been sown so that seeds mature in advance of waterfowl; one solution is to flood plots as soon as possible after seed maturity if large flocks of birds appear (Neely and Davison 1971).

The usefulness of this species to waterfowl, however, can be decreased by flooding plots too early. Investigation of the length of time that seeds last underwater showed 90-day deterioration rates of 43% in Washington (Shearer et al. 1969) and 57% in South Carolina (Neely 1956). Preacher (1978) found



Figure 3. A waterfowl impoundment planted with Japanese millet in a large agricultural field. Note the water control structure in the single levee (photo courtesy of Charles Allred, Soil and Water Conservation District, Warren County, Mississippi)

that Japanese millet seeds deteriorated only 24% in 120 days in upland plots; this suggests that use of progressive flooding may reduce the time that seeds remain underwater before waterfowl consumption. Therefore, if premature flooding is required, it could be applied incrementally to protect seeds and yet extend usefulness of the millet to waterfowl.

Native Plants

Recent studies have shown that many species of native moist-soil plants increase the diversity of a wetland community yet satisfy nutritional requirements and provide suitable habitat for waterfowl and other wildlife throughout the year (Fredrickson and Taylor 1982). Although artificially propagated grains such as Japanese and browntop millet benefit waterfowl, these species are not always dependable food sources unless carefully managed. Their most efficient use is in potential waterfowl habitats that have a minimal coverage of desirable aquatic vegetation. Thus, the manager should evaluate the existing vegetation at a site before proceeding with a program to modify water

levels for the introduction of Japanese millet. Whenever conditions allow, millets can be interspersed within stands of native species to ensure a sustained food supply and increase the habitat quality for a variety of wildlife species.

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