Maclura pomifera (Raf.) Schneid. Osage-Orange

Moraceae Mulberry family

J. D. Burton

Osage-orange *(Maclura **pomifera**)* produces no sawtimber, pulpwood, or utility poles, but it has been planted in greater numbers than almost any other tree species in North America. Known also as hedge, hedge-apple, bodark, bois-d'art, bowwood, and naranjo chino, it made agricultural settlement of the prairies possible (though not profitable), led directly to the invention of barbed wire, and then provided most of the posts for the wire that fenced the West. The heartwood, bark, and roots contain many extractives of actual and potential value in food processing, pesticide manufacturing, and dyemaking. Osage-orange is used in landscape design, being picturesque rather than beautiful, and possessing strong form, texture, and character.

Habitat

Native Range

The natural range of Osage-orange (fig. 1) is in the Red River drainage of Oklahoma, Texas, and Arkansas; and in the Blackland Prairies, Post Oak Savannas, and Chisos Mountains of Texas *(28)*. According to some authors the original range included most of eastern Oklahoma *(34)*, portions of Missouri *(49,54)*, and perhaps northwestern Louisiana (28,491.

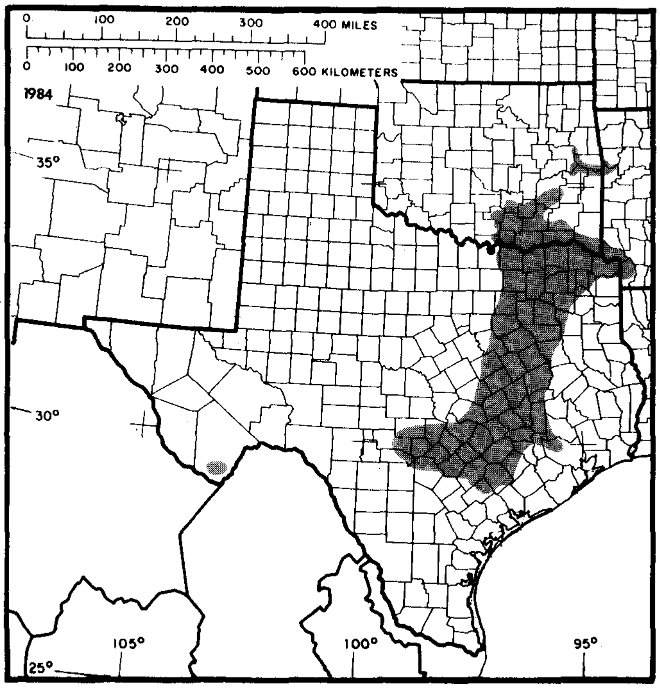

Figure ***l-The native range*** *of* Osage-orange.

Osage-orange has been planted as a hedge in all the 48 conterminous States and in southeastern Canada. The commercial range includes most of the country east of the Rocky Mountains, south of the Platte River and the Great Lakes, excluding the Appalachian Mountains.

Climate

Within the natural range of Osage-orange, average annual temperature ranges from about 18" to 21" C (65" to 70" F), July temperature averages 27" C (80° F) and January temperature ranges from 6" to 7" C (43" to 45" F) with an extreme of -23" C (–10° F). The frost-free period averages 240 days. Average annual precipitation ranges from 1020 to 1140 mm (40 to 45 in>, and April to September rainfall from 430 to 630 mm (17 to 25 in).

Osage-orange is hardy as far north as Massachusetts but succumbs to winter-kill in northeastern Colorado and the northern parts of Nebraska, Iowa, and Illinois *(34,36)*.

Soils and Topography

Even within the limited native range, growth of Osage-orange before agricultural settlement was restricted to about 26 000 km^2 (10,000 mi^2), and probably half that area produced no trees of merchantable size *(17,32)*. Some pure stands covered as much as 40 ha (100 acres), but most were much smaller. Pure stands appeared on rich bottom-land soils and were called "bodark swamps" (colloquialism for bois-d'arc). Though not true swamps, these areas frequently became inundated. Over much of its natural range, particularly south of the Red River, Osage-orange grew in isolated small stands, either pure or mixed with other hardwoods, interspersed with prairie. The largest trees and those of the best quality grew on bottom lands of the Red River tributaries in Oklahoma. Most bodark swamps have been converted to fields, and within the Red River system today Osage-orange grows most commonly on sandy terraces not yet occupied by other vegetation and on Blackland Prairie soils underlain by chalk or marl. Distribution and abundance of natural

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regeneration seem to depend more on lack of competition than on kind, quality, or condition of soil.

Osage-orange readily escapes from cultivation and invades exposed, eroding soil, particularly in overgrazed pastures. Thickets are characteristically found along fence rows, ditch banks, ravines, and around abandoned farmsteads.

Most observers report that Osage-orange grows vigorously on all soils *(32,34)*. Some state, however, that hedges planted on soil from which the Al horizon is removed do not thrive as well as those on less eroded sites (48). On sandy soils where the topsoil has blown away, growth of Osage-orange (and other species) in the Prairie States Forestry Project is strongly retarded (33). Natural regeneration is abundant and vigorous on many soils (Alfisols, Ultisols, Vertisols, and Mollisols), including those too alkaline for most forest trees. The species is sensitive to soil compaction. It thrives best on moist soils but tolerates extreme drought. It is resistant to heat, road salt *(22)*, and urban air pollution (42).

Associated Forest Cover

Osage-orange is not included in any of the forest types recognized by the Society of American Foresters (13). In moist, well-drained minor bottom lands in northwestern Louisiana and nearby parts of Oklahoma, Arkansas, and Texas, it is found with white oak *(Quercus alba)*, hickories *(Carya* spp.), white ash *(Fraxinus americana)*, and red mulberry *(Morus rubra)* (37). In Nebraska and Kansas, it invades overgrazed pastures, accompanied by honeylocust *(Gleditsia triacanthos)* and is succeeded by black walnut *(Juglans nigra)*, oaks *(Quercus* spp.), hackberry *(Celtis* spp.), hickories, and elms *(Ulmus* spp.) *(18)*. Among the most common associates on limestone-derived soils in middle Tennessee and neighboring portions of Kentucky and Alabama are eastern redcedar *(Juniperus virginiana)*, black walnut, hickories, and elms (45).

Life History

Reproduction and Early Growth

Flowering and Fruiting-Osage-orange is dioecious. The simple, green, four-part flowers appear soon after the leaves on the same spurs, opening from April through June, and are wind pollinated. Male flowers are long peduncled axillary racemes 2.5 to 3.8 cm (1 to 1.5 in) long on the terminal leaf spur of the previous season; female flowers are in dense globose heads, axillary to the leaves, about 2.5 cm (1 in) in diameter (2). The female flower in ripening becomes very fleshy, forming a large multiple fruit or syncarp (fig. 2) composed of l-seeded drupelets. The fruit ripens from September through October. The ripe fruit, 7.6 to 15 cm (3 to 6 in) in diameter, yellowish-green, resembles an orange, often weighing more than a kilogram (2.2 lb). Fruits average 23/dkl (80 to the bu) (53). When bruised, the fruit exudes a bitter milky juice which may cause a skin rash and which will blacken the fruit on drying.

Figure 2—*Ripe fruit of Osage-orange (scale in cm).*

Female trees often produce abundant fruit when no male trees exist nearby, but such fruit contains no seeds.

Seed Production and Dissemination-Female trees bear good seed crops nearly every year, beginning about the 10th year. Commercial seed-bearing age is optimum from 25 to 65 years, and 75 to 100 years may be the maximum (53). Germinative capacity averages 58 percent. Seeds are nearly 1 cm (0.4 in) in length. The number of clean seeds ranges from 15,400 to 35,300, averaging 30,900/kg (7,000 to 16,000, averaging 14,000/lb). Livestock, wild mammals, and birds feed on the fruit and disseminate the seed. The seeds have a slight dormancy that is easily overcome by soaking in water for 48 hours or by stratifying in sand or peat for 30 days. Fruit stored over winter in piles outdoors is easily cleaned in the spring, and the seed germinates promptly. Viability can be maintained for at least 3 years by storing cleaned, air-dried seeds in sealed containers at 5” C (41” F) (56). Recommended sowing depth is about 6 to 13 mm (0.25 to 0.5 in); soil should be firmed.

Seedling Development-Germination is epigeal. Natural regeneration apparently requires exposed mineral soil and full light. A study of survival and growth in the Prairie States Forestry Project windbreaks indicated average survival of Osage-orange at age 7 years to be 68 percent, ranking seventh of 16 "shrubs"; total height was 2.4 m (8 ft), ranking fifth of 16; and crown spread was 1.8 m (6 ft). Osage-orange was usually planted in the shrub (outer) rows and sometimes in the tree (inner) rows. It grows too fast, however, to be considered a shrub and often overtops slower growing conifers *(33)*.

Vegetative Reproduction-Osage-orange may be vegetatively propagated using root cuttings or with greenwood cuttings under glass. To propagate thornless male (nonfruiting) clones for ornamental use, scions or cuttings should be taken only from the mature part of the crown of a tree past the juvenile stage. Perhaps the easiest way to grow selected stock is by grafting chip buds onto nursery-run seedlings and plastic-wrapping the graft area *(30,31)*.

Sapling and Pole Stages to Maturity

Growth and Yield-Osage-orange is a small tree or large shrub averaging 9 m (30 ft) in height at maturity (fig. 3). Isolated trees on good sites may reach heights of as much as 21 m (70 ft); crowded trees usually do not grow so tall. In windbreak plantings on the Great Plains, Osage-orange grew 6 m (20 ft) tall on average sites during a 20-year period; on some sites it grew 12 m (40 ft) tall (39).

Branchlets growing in full sunlight bear sharp, stout thorns. Slow-growing twigs in the shaded portions of the crown of mature trees are thornless. The thorns, 1.3 to 2.5 cm (0.5 to 1 in) long, are modified twigs. They form in leaf axils on l-year-old twigs (fig. 4). Shade-killed lower branches remain on the tree many years. Regional estimates, based on the 1964-1966 Forest Surveys, indicated virtually no Osage-orange of commercial size and quality on forest land in Oklahoma, Texas, and Louisiana. There are two reasons for this: the species usually grows on non-forest land, and merchantability standards for forest trees do not apply to Osage-orange. Mature trees have short, curved boles and low, wide, deliquescent crowns. Even in closed stands on good sites, less than half the stems contain a straight log, 3 m (10 ft) long, sound and free of shake.

Figure *3-Mature Osage-orange tree 66 cm (26 in) in d.b.h. and 14.6 m (48 ft) in total height, near Bastrop, LA.*

Rooting Habit-Osage-orange is characteristically deep rooted, but because it has been planted so widely, the species is usually off-site, where its rooting habit is variable. When the tree grows on shallow, fertile soils over limestone, the lateral rootspread is tremendous (32).

Excavation of root systems in 7-year-old or older shelterbelts revealed a lateral radius of 4.3 m (14 ft) and a depth of more than 8.2 m (27 ft) for Osage-orange near Goodwell, OK *(9)*. The soil was Richfield silt loam. Most of the lateral roots were in the uppermost 0.3 m (1 ft) of soil. Excavations in Nebraska revealed a lateral radius of 2.1 m (7 ft) and a depth of 1.5 m (5 ft) for 3-year-old Osage-orange in Wabash silt loam; for 23-year-old Osage-orange in Sogn silty clay loam, lateral radius was 4.9 m (16 ft) and depth was 2.4 m (8 ft) (47). At both ages, there was a well-developed taproot, and most of the long laterals

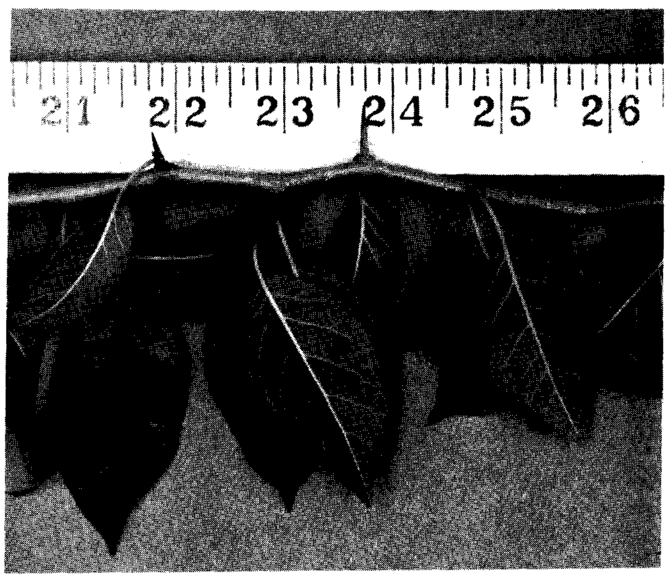

Figure *4-Thorns in leaf axils on fast-growing l-year-old shoots of Osage-orange in full sunlight (scale in inches).*

originated within the first 0.3 m (1 ft) of soil. At 3 years, most of the long laterals were within the first 0.6 m (2 ft) of soil; at 23 years, laterals were as abundant in the eighth as in the first foot of soil.

Reaction to Competition-Osage-orange is tolerant according to some authors *(6,37)* and very intolerant according to others *(3)*. Overall, it is most accurately classed as intolerant of shade. The occurrence and circumstances of natural regeneration suggest intolerance, but the growth of planted Osage-orange in hedges and shelterbelts, under strong competition, indicates tolerance. How vigorously and at how advanced an age the species responds to release has not been determined. Severe competition does not prevent abundant seed production. Osage-orange sprouts vigorously, even following cutting of interior rows in windbreaks.

No literature on the silviculture of naturally regenerated forest stands of Osage-orange is known.

Damaging Agents-Although Osage-orange is one of the healthiest tree species in North America, it is attacked by some parasites. Cotton root rot, caused by ***Phymatotrichum omnivorum,*** attacks Osage-orange and most other windbreak species in Texas, Oklahoma, and Arizona *(59)*. Losses are greatest in plantings on dry soil where rainfall is scant. Cotton root rot is the only serious disease.

Two species of mistletoe, ***Phoradendron serotinum*** and ***P. tomentosum,*** grow in the branches and cause witches' brooms. Osage-orange ornamentals in the Northeast have occasionally succumbed to Verticillium wilt, caused by *Verticillium albo-atrum*. Leaf-spot diseases are caused by *Ovularia maclurae, **Phyllosticta maclurae, Sporodesmium maclurae, Septoria angustissima, Cercospora maclurae,*** and ***Cerotelium fici***. Seedlings in a Nebraska nursery have been killed by damping-off and root rot caused by ***Phythium ultimum*** and ***Rhizoctonia solani (21). Phellinus ribis*** attacks stemwood exposed in wounds. ***Poria ferruginosa*** and ***l? punctata*** are the only two wood-destroying basidiomycetes reported on Osage-orange; they occur only on dead wood, mainly in tropical and subtropical parts of the western hemisphere (21). Maclura mosaic virus and cucumber mosaic virus have been identified in leaf tissue of Osage-orange in Yugoslavia (35).

Osage-orange trees are attacked by at least four stem borers: the mulberry borers ***(Doraschema wildii*** and ***D. alternatum)*** *(4)*, the painted hickory borer ***(Megacyllene caryae),*** and the red-shouldered hickory borer ***(Xylobiops basilaris)*** *(8)*. The twigs are parasitized by several scale insects including the European fruit lecanium ***(Parthenolecanium corni)***, the walnut scale ***(Quadraspidiotus juglansregiae),*** the cottony maple scale ***(Pulvinaria innumerabilis),*** the terrapin scale ***(Mesolecanium nigrofasciatum),*** and the San Jose scale ***(Quadraspidiotus perniciosus)*** *(25,46)*. The fruit-tree leafroller *(Archips argyrospilus)* feeds on opening buds and unfolding leaves.

Osage-orange is attacked by, but is not a principal host of, the fall webworm ***(Hyphantria cunea)*** *(55)*, an Eriophyid mite, ***Tegolophus spongiosus*** *(51)*, and the fourspotted spider mite, ***Tetranychus canadensis*** *(4)*.

Osage-orange trees and several other species in 1- to 5-year-old plantations on old fields in the prairie region of Illinois were partially or completely girdled by mice. Severity of damage was greatest where weeds were most abundant (26).

Windbreaks on the Great Plains, unless given cultivation during their early years, are invaded by herbaceous vegetation, become sod bound, and are permanently damaged *(33,38,39)*. This vegetation may harbor rodents. Grazing is not satisfactory for herbage control; multiple-row windbreaks should be fenced to exclude livestock.

Osage-orange sustained less damage by insects, diseases, drought, hail, and glaze than any other species planted in the Prairie States Forestry Project. Along with bur oak ***(Quercus macrocarpa)*** it survived better than any other deciduous species on uplands of the Southern Plains (7,381.

Special Uses

Osage-orange has been planted in great numbers, first as a field hedge, before barbed wire became available, secondly as a windbreak and component of shelterbelts, and thirdly to stabilize soils and control erosion.

The single-row field hedge proved to be a valuable windbreak on the prairie; evidence of this was the raised ground level under 15-year-old hedges, caused by accumulation of windborne soil material. Hedges around every quarter-section were common, especially in areas of deep sand *(20,38)*. These hedges were a source of durable posts. Prairie farmers customarily clearcut hedges on a 10- to 16-year cycle, obtaining about 2,500 fence posts per kilometer (4,000 per mi) of single-row hedge. The slash was piled over the stumps to protect the new sprouts from browsing livestock. Pole-sized and larger Osage-orange trees are practically immune to browsing, but seedlings and tender sprouts are highly susceptible. Recommended practice is to thin the new sprout stands to 240 vigorous stems per 100 m (73/100 ft), 3 to 5 years after the clearcut, and to protect the sprouts from fire. If inadvertently burned, the sprouts should be cut back immediately to encourage new, vigorous growth (20).

Osage-orange heartwood is the most decay-resistant of all North American timbers and is immune to termites. The outer layer of sapwood is very thin; consequently, even small-diameter stems give long service as stakes and posts (40,431. About 3 million posts were sold annually in Kansas during the early 1970's. The branch wood was used by the Osage Indians for making bows and is still recommended by some archers today.

The chemical properties of the fruit, seed, roots, bark, and wood may be more important than the structural qualities of the wood. A number of extractives have been identified by researchers, but they have not yet been employed by industry *(11,12,23, 24,44,58)*. Numerous organic compounds have also been obtained from various parts of the tree *(16,44,57)*. An antifungal agent and a nontoxic antibiotic useful as a food preservative have been extracted from the heartwood (5,241.

Osage-orange in prairie regions provides valuable cover and nesting sites for quail, pheasant, other birds, and animals *(20,33)*, but the bitter-tasting fruit is little eaten by wildlife. Reports that fruit causes the death of livestock have been proven wrong by feeding experiments in several States.

Osage-orange has been successfully used in strip mine reclamation. Its ease of planting, tolerance of alkaline soil, and resistance to drought are desirable qualities *(1,14,29)*. These qualities plus growth, long life, and resistance to injury by ice, wind, insects, and diseases make Osage-orange a valued landscape plant *(15,30,31)*.

Genetics

There is no known literature on the genetics of Osage-orange, and no information on geographic races is available. A thornless cultivar, ***Maclura pomifera*** var. ***inermis*** (Andre) Schneid., can be propagated by cuttings or scions taken from high in the crowns of old trees, where the twigs are thornless *(30,31)*. The only known hybrid, ***x Macludrania hybrida*** Andre, is an intergeneric cross: x ***Macludrania = Cudrania x Maclura. Cudrania tricuspidata*** (Carr.) Bureau is a spiny shrub or small tree, native to China, Japan, and Korea. The ***Maclura*** parent is variety ***inermis.*** The hybrid is a small tree with yellowish furrowed bark and short, woody spines *(2,41)*. Some authorities believe that the tropical dye-wood, fustic &*Chlorophora* ***tinctoria*** (L.) Gaud.é belongs in the genus ***Maclura;*** however, the majority opinion is that there is only one species of Osage-orange (28).

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