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# Hackberry Seed Sources for Planting in the Southern Great Plains

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*Seedlings of 60 families from 24 seed zones of common hackberry* (Celtis occidentalis L.) *were planted on a southwest Oklahoma site. Two-year height and survival data suggest that sources from the southwestern part of the hackberry's range are the best sources for use in Oklahoma. For growing hackberry for windbreaks and shelterbelts in western and central Oklahoma, using local seed sources is best.* Tree Planters' Notes 44(2):78-82; 1993.

Common hackberry *(Celtis occidentalis* L.) is receiving increased interest among people planting trees in the Great Plains. This interest is prompted by disease problems that developed in several of the tall-tree species that are commonly planted in the Great Plains. American elm *(Ulmus americana* L.) is in danger of being completely exterminated by Dutch elm disease. Siberian elm *(Ulmus pumila* L.) has suffered high rates of mortality caused by stem canker diseases, insect defoliators, and herbicide drift. Hackberry has the potential to replace or supplement these species in both windbreak and ornamental plantings (Read 1958, Bagley 1979). Also a member of the elm family, hackberry has several desirable traits: a pleasing upright crown with a spreading to rounded head; a straight, clear bole with lower branches occurring 8 to 10 feet from the ground; considerable drought hardiness (Albertson and Weaver 1945); and a lack of any serious diseases (figure 1).

As part of a cooperative regionwide effort in the Great Plains, hackberry seeds were collected from 219 different sites during 1982 to 1988. Provenances were sampled in 9 States: North Dakota, South Da kota, Minnesota, Nebraska, Iowa, Missouri, Kansas, Oklahoma, and Arkansas. Provenance trials were then established in sites across the Great Plains. The objectives of the study were to (1) identify the extent and pattern of genetic variability within hackberry, (2) identify hackberry seed sources best adapted for windbreak and ornamental plantings in the Great Plains and (3) provide a highly variable gene pool that could be utilized for future selection and breeding.

In Oklahoma, Oklahoma State University (OSU) in cooperation with the USDA Soil Conservation Service, established one of the 14 Great Plains trial plantings on the OSU Sandylands Research Station near Mangum, Oklahoma. The objectives of the study at this site were in accord with the region wide objectives but also with the intent to evaluate the best seed sources for central and western Oklahoma and to provide the Oklahoma Depart ment of Agriculture-Forestry Services these data and materials for seed production and breeding purposes.

## Materials and Methods

Hackberry seed was collected from native trees on 219 sites from across its natural range (figure 2) in the Great Plains during 1982 to 1988. These col lections included samples from 57 seed zones throughout the Great Plains portion of hackberry's range. The seed zones were originally defined by

**Figure 1**—*Outplanted hackberry seedlings.*

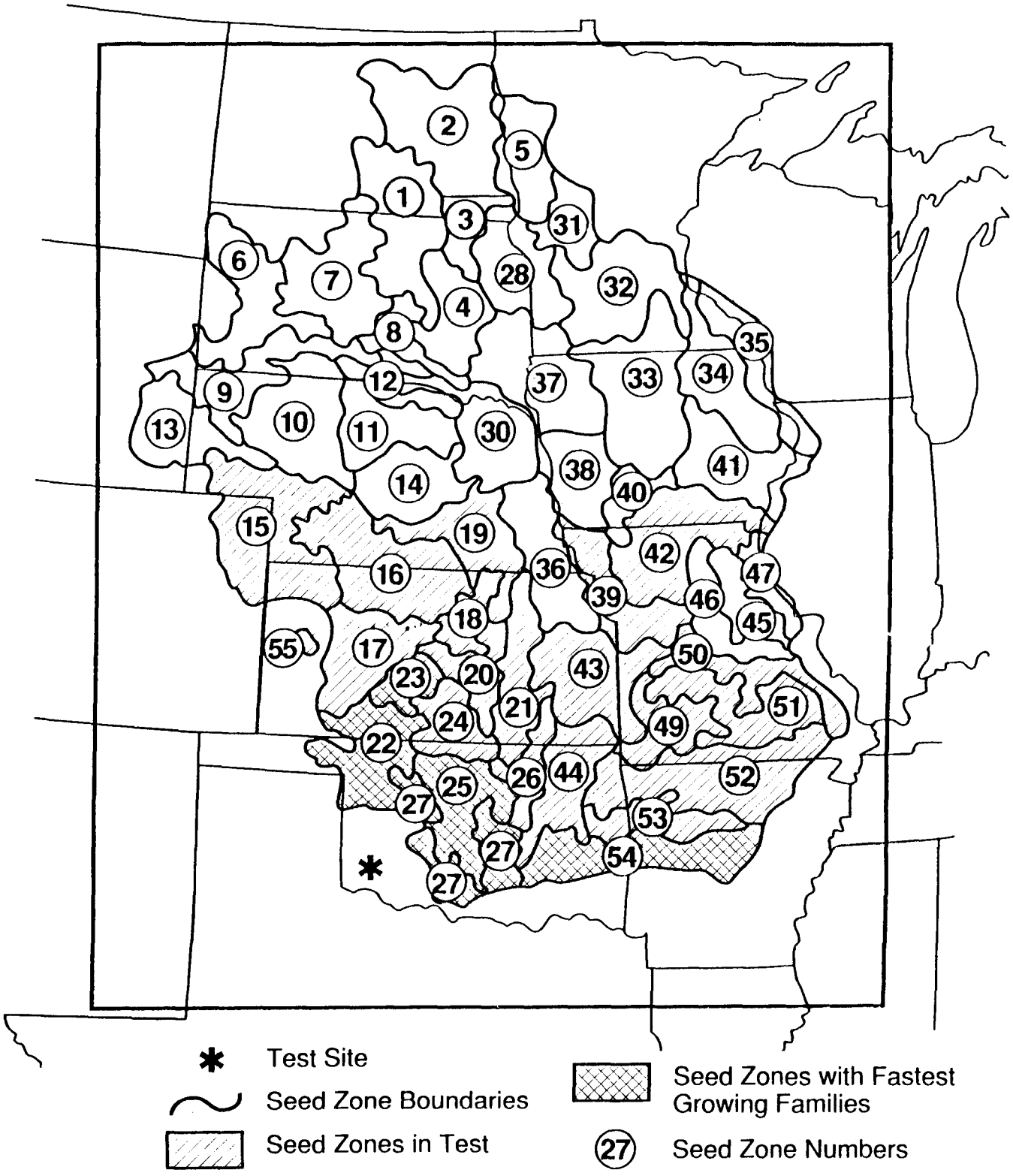


**Figure 2**—*A regional map of the hackberry seed zones sampled in the Great Plains study, the seed zones represented in this test, and the seed zones with the fastest growing families at age 2.*

Cunningham (1975) and were based on climatic and soil data. Additions and modifications to these seed zones have been made by Cunningham (1982) and Cunningham and Jacobson (1981), resulting in the zones shown in figure 2.

Planting stock was grown by the North Dakota Association of Soil Conservation Districts at their Lincoln-Oakes Nursery in southeastern North Dakota. Seeds were sown in October of 1988 and they germinated in May 1989. Seedlings were lifted in October 1989 as 1+0 stock and held in cold storage at 28 /F (-2 /C) until shipping. Planting stock was shipped in March 1990 to Oklahoma State University where it was put back in cold storage until outplanting in April 1990. Total cold storage time following shipping was about 2 weeks. Seedlings were stored in 5-gallon (18.9-liter) buckets with water and peat moss during the planting operation.

The site, a Meno loamy-sand soil, was previously growing wheat. Several fertilizer applications were made to the study site in anticipation of planting no-till alfalfa, which never was planted. These fertilizer applications included 1 ton per acre (2.24 metric tons/ha) of 50% effective calcium carbonate equivalent lime (September 9, 1989), 209 pounds per acre (516 kg/ha) of 17-0-38 N-P-K (October 4, 1989), and 120 pounds per acre (134.5 kg/ha) of 34-0-0 (December 18, 1989). Site preparation included application of 1 pound active ingrediem per acre (1.12 kg/ha) of glyphosate (Roundup®) before planting, followed by 2 pounds per acre (2.24 kg/ha) active ingredient oryzalin (Surflan®) broadcast immediately after planting.

The study at the Sandylands Research Station contains five blocks, each having 60 families from the 24 seed zones representing the southern half of the Great Plains collection (figure 2). The planting is in a randomized complete block design with each family represented by one 4-tree family rowplot per block in 5 blocks. The 4-tree family rowplots were planted on a 10- x 15-foot spacing with 15 feet (4.6 m) between rows and 10 feet (3.0 m) within rows. A border row of Oklahoma origin (1+0 seedlings) hackberry was planted around the entire plantation.

Weed control during the growing season ineluded mowing, light disking, and hand weeding as needed. Following several weeks of severe drought, the trees were irrigated once in July 1990. In September 1990, winter wheat was interplanted in the plantation for erosion control. The wheat was shredded in April 1991. In May 1991, all weeds were removed around the tree bases. Weed control in July 1991 included bush hogging and blade plowing between rows.

A survival count was made in late August 1990. In May 1991, replacement seedlings were planted for those accessions for which seedlings were still available. Blocks 1, 2, 3, 4, and 5 had 36, 26, 10, 13, and 9 seedlings replaced, respectively. Replacement seedlings were 1+1 stock, which had been transplanted their second growing season at the USDA Forest Service's Bessey Nursery at Halsey, Nebraska.

Survival and height measurements were taken after the second growing season. Trees were considered alive if they exhibited any green foliage. Height measurements were taken from ground level to the tallest point on the tree without moving the tree. Data were analyzed on a plot-mean basis using the SAS GLM procedure. Family and seed zone means were compared using Duncan's multiple range test. The format of the analysis of variance is given in table 1.

**Results and Discussion**

First-year plantation survival was 89%, with 132 dead trees among the original 1,200 planted. In the spring of the second year, 94 of these trees were replanted. At the end of the second growing season, survival based on total number of trees planted (now 1,294) was 86`%>. Ninety-four trees, or 8%of the planting positions, were empty after the second growing season, and 52 of the replacement trees were alive. The height data analysis includes these trees, as their removal did not significantly change the results.

Variation in survival among families and among seed zones was significant (table 1). Family survival, including replacement, ranged from 35%, (seed zone 52, table 2) for a north central Arkansas family to 100//, for 13 families from across the seed zones represented. Six of these families were found to be in collections from the three seed zones (22, 23, and 54) with the fastest growing trees. Survival by seed zone (table 2) ranged from 68 to 100% with the poorest survivors from seed zone 52 located in northern Arkansas. Sources and families from this seed zone showed the greatest variation in survival and extreme variation in growth. Survival in seed zones 21, 22, and 55 was 100% and survival exceeded 90% in 5 additional zones (table 2). Individual families in 20 of the 24 seed zones sampled exceeded 90%> survival. There was

Table *1-Analysis of variance to test for seed zone and family differences for second-year height and survival of an Oklahoma planting of hackberry.*

| | | Survival | | Height | |
|---|---|---|---|---|---|
| Source | df | Mean squares | Pr>F | Mean square | Pr>F |
| Block | 4 | 0.0424 | | 0.8189 | |
| Zone | 23 | 0.0558 | 0.025 | 0.5958 | 0.005 |
| Block x zone | 92 | 0.0241 | | 0.0845 | |
| Family (zone) | 59 | 0.0521 | 0.025 | 0.1637 | 0.005 |
| Error | 143 (140)* | 0.0296 | | 0.0746 | |

*'There were 140 df for the height analysis. These df are corrected for missing cells.

Table *2-Mean height and survival by seed zone for hrrckHerrtl fnrvilies in nn Oklnlrorrro seed source test*

| Seed zone | No. of families | X ht (m) | % Survival with replacement | X ht (m) | Family range % survival |
|---|---|---|---|---|---|
| 54 | 2 | 1.48 a | 98 | 1.45-1.50 | 95-100 |
| 22 | 3 | 1.18 b | 100 | 0.95-1.43 | 100 |
| 23 | 4 | 1.10 bc | 93 | 0.63-1.47 | 78-100 |
| 27 | 1 | 1.09 bcd | 87 | 1.09 | 87 |
| 25 | 1 | 0.97 bcde | 82 | 0.97 | 82 |
| 52 | 5 | 0.94 bcdef | 68 | 0.60-1.15 | 35-95 |
| 26 | 2 | 0.94 bcdef | 87 | 0.85-1.01 | 78-95 |
| 44 | 2 | 0.93 bcdef | 83 | 0.68-1.17 | 76-90 |
| 24 | 3 | 0.90 bcdefg | 88 | 0.78-0.99 | 78-95 |
| 43 | 2 | 0.85 cdefgh | 88 | 0.71-0.98 | 50-100 |
| 17 | 2 | 0.84 cdefgh | 88 | 0.64-1.03 | 82-95 |
| 49 | 2 | 0.82 cdefgh | 84 | 0.70-0.94 | 71-100 |
| 51 | 2 | 0.80 defgh | 98 | 0.79-0.81 | 95-100 |
| 50 | 2 | 0.79 efgh | 86 | 0.78-0.80 | 82-90 |
| 53 | 1 | 0.78 efgh | 95 | 0.78 | 95 |
| 18 | 2 | 0.72 efgh | 84 | 0.71-0.72 | 82-86 |
| 39 | 4 | 0.72 efgh | 92 | 0.60-0.80 | 77-100 |
| 21 | 1 | 0.71 efgh | 100 | 0.71 | 100 |
| 42 | 2 | 0.69 efgh | 84 | 0.58-0.81 | 79-90 |
| 55 | 1 | 0.66 fgh | 100 | 0.66 | 100 |
| 16 | 3 | 0.64 fgh | 87 | 0.44-0.95 | 81-95 |
| 20 | 4 | 0.61 gh | 78 | 0.53-0.69 | 74-86 |
| 19 | 5 | 0.59 h | 89 | 0.50-0.71 | 79-95 |
| 15 | 4 | 0.56 h | 74 | 0.53-0.60 | 63-90 |

*Mean heights with the same letter in common are not significantly different.

no apparent geographic trend in survival. It is also worth noting that the three seed zones with the fastest growing seedlings also all exceeded 90% survival.

Average tree height for the plantation for surviving trees was 0.83 m. Average family heights varied from 0.44 to 1.50 m (table 2), and an analysis of variance showed the family contribution to height variance to be statistically significant (table 1). After 2 years in the field, the fastest growing families also generally showed high survival, with eight of the ten fastest growing families exceeding 95% survival. Thus, preliminary 2-year results sug-Best selection of the fastest growing families for windbreak and conservation planting should also insure high survivability. Survival and early growth are the most important traits for initial selection of genotypes for such plantings.

Analysis of variance showed the seed zone contribution to total variance for height to be significant (table 1). Examination of average height by seed zone showed that the trees in the four high est ranked seed zones exceeded a meter in height by the end of the second growing season (table 2). This can be considered an excellent growth rate for any hardwood species planted in the relatively harsh environment of the southern Great Plains. The families from seed zone 54 grew significantly

aster than all other families averaged by seed one (table 2), based on a Duncan's multiple range est. On a family basis (family analysis not pre-ented), the two families in seed zone 54, plus one amily from seed zone 23 and one from seed zone 2, were significantly faster growing than all other amilies, except for one additional family in seed one 23.

The five best seed zones, based on average tree eight, were zones 54, 22, 23, 27, and 25 (table 2). When plotted on the seed zone collection map figure 2), it becomes apparent that the best seed

ones to collect from for windbreak plantings in outhwest Oklahoma are the extreme southern and outhwestern sources of hackberry. The recommen-lation to use local or near-local seed sources of

Bagley (1979), who found local or near-local Kansas ackberry sources best for Kansas. In the absence f further tests or data, it is reasonable to recom-nend the use of local or near-local sources of ackberry for plantings in the southern Great Plains.

data are the best available at this time. Fifth-year data from all 14 Great Plains plantings will be available in late 1994. However, this particular planting test was the southernmost of the 14, and located just southwest of the contiguous natural range of hackberry (about 20 miles west and 50 miles south of the range).

## Literature Cited

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