

## ABSTRACT

*Anemopsis californica* (Nutt.) Hook. & Arn. was cultivated in upland irrigated fields and in a riparian area using techniques typical to small-scale growers in the American Southwest. Research was carried out in the high-altitude, semi-arid environment of northern New Mexico at the Sustainable Agriculture Science Center of New Mexico State University in Alcalde, New Mexico, during the 1998–2000 growing seasons. Dormant crowns were obtained from native stands in late March of 1998 and 1999 and transplanted into prepared, furrowed, pre-irrigated seedbeds at two locations, a sandy loam upland soil and a clay loam riparian soil, and at two planting arrangements, bed tops (BT) and furrow bottoms (FB). The experimental design was a Randomized Complete Block Design (RCBD). Both sites were furrow irrigated. Crowns and roots were harvested after two growing seasons, dried, weighed and counted to determine plant survival. Survival for both 1998 and 1999 plantings was consistently higher for FB treatments at both riparian and upland sites, though survival overall was considerably higher in the 1999 planting. Survival rates by site were not consistent between planting years. Root dry matter weight (DMW) means after adjusting for survival rates were greater in FB treatments at both sites for both planting years, and greater for both treatments in the upland site for both 1998 and 1999. These results indicate that *Anemopsis californica* can be established under irrigated upland conditions, using a preferred planting position in furrow bottoms.

*Anemopsis californica* (Nutt.) Hook. & Arn. in the family Saururaceae (Benson, 1959) is an herba-

ceous perennial with reputed medicinal properties native to riparian habitats of northern Mexico and the southwestern United States. Called by various names including *yerba del manso*, *manso*, *yerba mansa*, lizard-tail, and swamp root (Kress, 2006), it has traditionally been and continues to be used for medicinal and antiseptic purposes by indigenous and Hispanic cultures in its geographic range. Ethnobotanical sources report it being used for the treatment of colds, chest congestion, stomach ulcers, and as a wash for open sores (Bean & Saubel, 1972; Swank, 1932). Manso extract is also a traditional treatment for uterine cancer (Artschwager-Kay, 1996). Recent studies validate the *in vitro* antimicrobial and anti-cancer properties of *Anemopsis* essential oil (Medina et al., 2005; Medina, 2006). *Anemopsis* typically grows in wet, especially somewhat alkaline or saline marshy places, lowlands, and riparian habitats (Plants For a Future, 2006), but can also be found in open areas such as alkali seeps that indicate high water tables.

*Anemopsis* has the potential to become a widely used herbal cold remedy in the rapidly-growing medicinal herb industry in North America, but because native plant populations are located mostly in sensitive riparian habitats, its availability for mass marketing remains limited unless it can be brought under cultivation. No mention of it being cultivated as a crop appears in the ethnobotanical literature (Medicinal Plants of the Southwest, 2006). Estimates of the productive capacity from native *Anemopsis* stands have not been determined since the area of distribution of manso in riparian communities currently has not been quantified. In any case, native stands could be depleted or the species

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could even become endangered if over-harvested, so it is important that methods be developed to make *Anemopsis* a cultivable crop. The National Center for the Preservation of Medicinal Herbs has placed *Anemopsis californica* on a list of herbs at risk of being lost due to overharvesting, claiming that as “a possible substitute for Goldenseal, Yerba Mansa could experience skyrocketing demand.” (National Center for the Preservation of Medicinal Herbs, 2006). In New Mexico, acreage in riparian areas and subsequently all riparian species, including *Anemopsis*, continue to be reduced as a result of urban development and other activities.

Farmers typically create furrows and raised row beds with a lister plow or cultivator in order to direct and control irrigation flow down the row, but planting manso on the tops of such beds may reduce the accessibility of this wetland species to moisture needed to survive, establish and grow. Planting manso in the furrow allows the crown direct access to irrigation water but then obstructs machinery traffic down the row, limiting weed control options. Plant placement on bed tops or furrow bottoms therefore becomes an important consideration in determining optimal stand establishment methods for this new crop. Site selection is another important factor to be studied since most agricultural lands in New Mexico are irrigated upland areas.

Research was conducted at the New Mexico State University Sustainable Agriculture Science Center in Alcalde, New Mexico, with the aim of determining the feasibility of cultivating this native species under small-scale farming conditions typical of this region. Since most growers in this area use flood or furrow irrigation, this trial compared the survival and root production of manso plantings on furrowed bed tops (BT) versus plantings on the furrow bottoms (FB) at two different sites, one a riparian area and the other an upland irrigated field.

## MATERIALS AND METHODS

This trial was conducted from the spring of 1998 through the fall of 2000 at the New Mexico State University Sustainable Agriculture Science Center at Alcalde in north central New Mexico, USA. Two sites were chosen, one in a riparian area with soil made up of clay loam (Abiquiu–Peralta complex, 25.6% sand, 34.8% silt, 39.6% clay, in the 0–15 cm [0–6 inch] layer) at an altitude of 1,738 m (5,716 feet), the other in a previously fallow

**Table 1. Soil test results of riparian and upland sites, at 0–15 cm (0–6 inch) and 15–30 cm (6–12 inch) depths, NMSU Agricultural Experiment Station, Alcalde, NM. Report provided by Laboratory Consultants, Ltd., 211 Shakespeare, Lordsburg, NM 88045**

	Riparian site		Upland site	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Bicarbonate	6	3	4	5
Nitrate-N, ppm	34	10	5	4
OM, %	2.4	1.6	1.1	0.5
pH, S. U.	7.2	7.3	7.6	7.7
Sand, %	25.6	39.6	79.6	89.6
Silt, %	34.8	28.8	10.8	2.8
Clay, %	39.6	31.6	9.6	7.6
Classification	Clay Loam	Clay Loam	Sandy Loam	Loamy Sand
Water holding capacity, cm/dm	1.92	1.92	1.1	0.83

upland field consisting of a Fruitland sandy loam [coarse-loamy, mixed (calcareous), mesic Typic Torriorthent], consisting of 79.6% sand, 10.8% silt, and 9.6% clay in the 0–15 cm (0–6 inch) layer, at an altitude of 1741 m (5726 feet) (Table 1). Both sites were prepared identically before planting by disk harrowing, rototilling, and bed shaping using a rolling-tine cultivator, then pre-irrigated before transplanting. The cultivator was set to form beds approximately 36 inches from bed top to bed top, and each plot consisted of four rows 12 feet in length. Dormant *Anemopsis* crowns were obtained from a native population in a riparian area of San Juan Pueblo approximately 2 km (1 1/4 mile) from the experiment station. Roots and crowns (hereafter referred to as roots) were dug up in late March of 1998 and 1999 by hand, washed to remove soil, and planted one foot apart in the plots at two planting treatments, bed tops (BT) and furrow bottoms (FB). Planting dates were March 22, 1998 and March 24, 1999. Each treatment was replicated three times at both sites. Irrigation requirements have not been established for *Anemopsis*, so irrigation timing and duration were based upon a practical soil “feel test” of the upland site BT treatment (Herrera, 2000). Weed growth was controlled by hand and by machine mowing to just above the heights of the manso leaf rosettes. Each set of plants was allowed to grow two seasons before being dug up in mid-October of the second growing season, after the plants became dormant. Digging area averaged 30 cm (one foot) in depth and radius from the crown. Roots from 3.05 m

(10 feet) of two interior rows of each plot were removed, washed, dried in a precision laboratory dryer at 65°C for forty-eight hours, then weighed. Plant survival was determined by subtracting dead plant numbers within the sample area at the time of harvest from the initial plant count at the time of transplanting and then converting the ratio to a percentage. The experimental design was a randomized complete block (RCBD) with a two-level factorial structure—site (upland or riparian) and plant placement (BT or FB) being the two factors. One-way and two-way analysis of variance was performed using Minitab Release 13 for Windows™ and SAS 9.1.3 (SAS Institute Inc., 2000–2004).

## RESULTS

*Anemopsis* response varied considerably between the two planting cycles, so data from the two years are treated separately. Due to different variances in data between the riparian and upland sites, SAS Proc mixed was applied to the analysis of root DMW means.

### 1998 Planting

**Survival.** Plant survival is an indicator of relative success of establishment method. Plant survival means for 1998 ranged from 55% to 98%, with significantly higher rates of survival in the riparian site and in FB treatments at both sites (Table 2).

**Root DMW.** Survival differences resulted in varying plant densities and different sample sizes per sample area. Statistical analyses of root DMW for both 1998 and 1999 data were therefore adjusted using survival as a covariate to account for differences in sample sizes (Table 3). Root DMW means in 1998 ranged from 118.3 kg/ha (105.6 lb/A) to 197.1 kg/ha (176 lb/A), with greatest yields at both sites occurring in FB treatments. Combined root DMW means between the riparian and upland sites were not statistically significant at  $p \leq .05$ .

### 1999 Planting

**Survival.** All treatments from the 1999 planting showed high rates of survival (>80%), with mean survival percentages ranging from 82% to 98%. Plant survival means between the riparian and upland sites were not statistically significant at  $p \leq .05$ . Survival means between the FB and BT treatments also were not statistically significant.

**Table 2.** *Anemopsis* plant survival after two seasons of growth. Survival is given as percent initial plant density per 6 m (20 feet) of row.

	Site			
	Riparian		Upland	
	FB	BT	FB	BT
1998	98 <sup>ab</sup>	73 <sup>b</sup>	82 <sup>ab</sup>	55 <sup>b</sup>
1999	87	82	98	93

Means with same letter designations indicate significant treatment differences at  $p \leq .05$

**Table 3.** *Anemopsis* root DMW, kg/ha (lb/A), after two seasons of growth, adjusted for plant survival.

	Site			
	Riparian		Upland	
	FB	BT	FB	BT
1998	139.8 <sup>a</sup> (124.8)	118.3 <sup>b</sup> (105.6)	197.1 <sup>a</sup> (176.0)	166.6 <sup>b</sup> (148.8)
1999	211.4 <sup>c</sup> (188.8)	181.0 <sup>c</sup> (161.6)	379.9 <sup>c</sup> (339.2)	290.3 <sup>c</sup> (259.2)

Means with same letter designations indicate significant treatment differences at  $p \leq .05$

There were no site-by-treatment interactions in the 1999 planting.

**Root DMW.** Root yields from the 1999 planting were considerably greater than those from 1998. Climatic, precipitation, or mean temperature differences between years may account for this variability in *Anemopsis* production. Root DMW means from the 1999 planting ranged from 181.0 kg/ha (161.6 lb/A) to 379.9 kg/ha (339.2 lb/A) and were statistically significant both between treatments within each site and between sites. Root yields were greatest in the upland FB treatments.

Overall, the initial findings of this study indicate that *Anemopsis californica* can be successfully established under upland irrigated agricultural conditions. While this trial showed consistently greater survival and root DMW yields of *Anemopsis* when planted on furrow bottoms, practical consideration of other factors such as tillage equipment, weed control methods, or grade and levelness of the field will also affect individual growers' choice of planting arrangement in furrowed, surface-irrigated field situations like the one in this trial. Because the creeping nature of this stolon-producing species results in a solid stand of *Anemopsis* over time, the findings of this study are relevant primarily for the initial establishment phase of this crop. Further study is recommended to establish other cultivation

parameters such as irrigation, fertilization, and light requirements; to document the response of *Anemopsis* to soils, fertilizer types, and weed competition; to determine crop coefficients; and to identify other factors that may affect *Anemopsis* survival, growth, and yield.

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