

ASSOCIATED PERENNIAL SPECIES INFLUENCING NATIVE JOJOBA —  
*Simmondsia chinensis* (Link) Schneider - YELD VARIABLES IN ARIZONA  
STATE, U.S.A.

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RESUMO

PRODUÇÃO DE JOJOBA NATIVA NO  
ARIZONA, USA, INFLUENCIADA POR  
ESPÉCIES PERENES

Jojoba — *Simmondsia chinensis* (Link) Schneider — arbusto nativo do Deserto de Sonora, Sudoeste dos Estados Unidos e Noroeste do México, foi estudado em três diferentes áreas no estado do Arizona, levando-se em consideração, principalmente, as espécies perenes associadas com ele. As áreas 1 e 2 estão localizadas nos lados Este e Oeste das montanhas de Tucson, respectivamente. A área 3, por outro lado, encontra-se situada na face Sudoeste das montanhas de Santa Catalina.

Em cada área de estudo, levando-se todas espécies perenes. Usando-se a técnica do quadrado, todas espécies foram contadas separadamente, sem levar em consideração seus estratos, e a seguir ordenadas em termos de densidade absoluta. A cobertura absoluta de cada espécie foi estimada usando-se a técnica de interseção de linhas para, em seguida, calcular-se a cobertura relativa.

O vigor das plantas de jojoba foi determinado com base em sua altura média. Também, a relação de plantas masculinas e femininas da espécie em estudo foi determinada. A produção de seus frutos foi estimada com base no peso seco de todos os frutos colhidos em cada área de estudo e com base em dez plantas previamente selecionadas ao acaso.

*Franseria dumosa*, *Cercidium microphyllum*, *Opuntia Spinosior* e *Opuntia Bigelovii* foram as únicas espécies presentes em todas as áreas de estudo. A primeira espécie foi mais alta em densidade e em cobertura nas áreas 1 e 2. Já na área 3, *Encelia farinosa* foi a que apresentou maior densidade e cobertura. O vigor da planta de jojoba foi mais alto na área 3 e a relação de plantas masculinas para femininas foi mais alta na área 1. Quanto mais alta a densidade e a cobertura de *Franseria dumosa*, mais baixa a produção de frutos por planta de jojoba.

KEY WORDS: Perennial, Native, Jojoba, Associated, Yield, Arizona, Density, Coverage, Vigor.

SUMMARY

Jojoba — *Simmondsia chinensis* (Link) Schneider — a shrub from the Sonora Desert, native to south-western United States and north-western Mexico, was studied at three different sites in

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Arizona considering the perennial species associated with it. Site 1 is located on the eastern slope of the Tucson Mountains, site 2 is on the west side of the Tucson Mountains, and site 3 is in the southern foothills of the Santa Catalina Mountains.

A species list was compiled in each area of study. All species, using the quadrat technique, were counted separately, regardless of their strata and ranked in terms of absolute density. The absolute coverage of each species was estimated using the line intercept technique and, then, the relative coverage was calculated. Height of jojoba plants was measured to determine their vigor. Also, the ratio of male to female jojoba plants was determined. The fruit productivity was estimated based on the dry weight of all fruits harvested and, also, based on ten plants previously selected.

*Franseria dumosa*, *Cercidium microphyllum*, *Opuntia Spinosior*, and *O. Bigelovii* were the only species common to all sites. *Franseria dumosa* was higher in density and in coverage in both Sites 1 and 2. But, at site 3, *Encelia farinosa* was higher in both density and coverage.

Jojoba plant vigor was higher at site 3 and male to female jojoba ratio was higher at site 1. Higher the density and coverage of *Franseria dumosa*, the lower the jojoba fruit yield per plant.

## INTRODUCTION

Very few individuals have studied synecological subject in jojoba communities. The knowledge of some synecological and autoecological parameters of natural communities are very important to characterize the ecological response of one species to a specific environment. GENTRY<sup>7</sup> noted that in drier environments jojoba is usually short and dieback common. This is reflected in short internodes and prolific lateral branching, forming through the years a very twiggy bush with dense, intricate branches. Jo-

joba, depending upon its environment, may grow three meters or will mature at 0.2 to 0.5 meters.

BURDEN<sup>3</sup> found jojoba growing in shallow mountains soils overlying granites and schists and on alluvial soils developed from acid, igneous materials. Density of jojoba was positively correlated with densities of *Cercidium microphyllum*, *Eriogonum fasciculatum*, and with aspect and slope angle.

ANI *et alii*<sup>1</sup> noted sharp differences between California and Arizona jojoba populations. In Tucson, where most precipitation occurs in Summer, the jojoba coverage was 1.7% while in San Diego, where precipitation occurs mostly in winter, its coverage was 9.1%. From these observations, they concluded that jojoba coverage is greater on those sites where the precipitation occurs mostly in the winter.

GENTRY<sup>7</sup> indicated that male jojoba plants are taller or larger with less dieback and knobiness than female plants.

The main objective of this research was to study the species associated with jojoba in three different sites in Arizona, U.S.A., to investigate some yield variables in relation to synecology.

## MATERIALS AND METHODS

Several approaches were followed to better understand its ecological relationships at three study sites.

Criteria for the selection of the sites were: (1) areas with abundance of jojoba; (2) areas with slopes not exceeding 15 percent; (3) areas topographically suitable for machine operation; (4) areas with elevations above 730 meters more conducive to growth, in Arizona, BURDEN<sup>3</sup>, and (5) areas with ease of accessibility.

Site 1, on the eastern slope of the Tucson Mountains is located on Speedway Blvd. close to the Painted Hills Road, 10 km west of the University of Arizona Campus. The elevation of the site is 790 m and its topography is undu-

lating. This site has mostly "B" and "C" horizons.

Site 2, on the westside of the Tucson Mountains, is located at an elevation of 820 m in the Tucson Mountain Park, west of Tucson, 24 km from the University of Arizona Campus. Its topography is almost level with 1 to 3 percent slope. This site has only "A" and "C" horizons.

Site 3, in the souther foothills of the Santa Catalina Mountains, north of Tucson, is located 14 km from the University of Arizona Campus. The elevation of this site is 850 m and its topography is almost level with a slope of 1 to 3 percent. This site has a well developed and homogeneous soil with "A", "B", and "C" horizons.

An intensive survey of the perennial flora at each site was conducted (JOHNS-TON<sup>8</sup>, KEARNEY & PEEBLES<sup>9</sup>). A species list was compiled to determine the species associated with jojoba in each area of study. All species in three different quadrats (40 m long and 25 m wide) were counted separately, regardless of their strata and ranked in terms of absolute density<sup>1</sup>. The absolute coverage<sup>2</sup> of each species was estimated using the line intercept technique described by COX<sup>4</sup>. The relative coverage was calculated to evaluate the level of competition between jojoba and associated plant species. The average height of both male and female jojoba was measured to determine their vigor (DAUBENMIRE<sup>5</sup>). The ratio of male to female jojoba plants was determined based on absolute coverage data.

The fruit productivity of each area was estimated based on the dry weight of all fruits harvested in the quadrat. The fruit yield per plant was obtained by using two approaches, based on: (1) the entire female population and (2) random samples of 10 females, except at site 3, nine plants were used because one plant was badly damaged by pests. All fruit were harvested when more than 50% were completely mature.

## RESULTS AND DISCUSSIONS

The plants associated with jojoba at site 1 in decreasing order of density were: *Franseria dumosa*, *Acacia constricta*, *Janusia gracilis*, *Larrea divaricata*, *Condalia spathulata*, *Carnegiea gigantea*, *Cercidium microphyllum*, *Lycium fremontii*, *Opuntia spinosior*, *Baileya* sp. *Condalia lycioides*, *Celtis pallida*, *Opuntia leptocaulis*, *Ferocactus Wislizeni*, *Prosopis glandulosa*, *Anisacanthus Thurberi*, *Opuntia Bigelovii*, *Acacia Greggii*, *Psilostrophe Cooperi*, and *Calliandra eriophylla*. The last five species showed the same density values. Absolute and relative coverage of these species are shown in Table 1.

The plants associated with jojoba at site 2 in decreasing order of density were: *Franseria dumosa*, *Opuntia Engelmannii*, *Jatropha cardiophylla*, *Opuntia Bigelovii*, *Opuntia spinosior*, *Calliandra eriophylla*, *Fouquieria splendens*, *Carnegiea gigantea*, *Encelia farinosa*, *Cercidium Microphyllum*, *Ferocactus Wislizeni*, *Janusia gracilis*, and *Mammillaria* sp. The last five species showed the same density values. Absolute and relative coverages are shown in Table 1.

At site 3 the plants associated with jojoba were (in decreasing order of density): *Encelia farinosa*, *Jatropha cardiophylla*, *Calliandra Schottii*, *Franseria dumosa*, *Opuntia phaeacantha*, *Psilostrophe Cooperi*, *Cercidium microphyllum*, *Opuntia acanthocarpa*, *Opuntia spinosior*, *Porophyllum gracile*, *Fouquieria splendens*, *Acacia constricta*, *Ferocactus Wislizeni*, *Prosopis glandulosa*, *Opuntia fulgida*, *Acacia Greggii*, *Mammillaria* sp., *Ephedra trifurca*, *Janusia gracilis*, *Opuntia Bigelovii*, *Celtis pallida*. The last five species presented the same density values. Coverage values are reported in Table 1.

Jojoba yield variables in relation to its density, ratio of male to female, and vigor are shown in Table 2. The results were estimated partly from all jojoba plants in the quadrat and partly from only the ten selected female plants.

Table 1

Absolute and Relative Coverages of the Percentual Flora in the Three Sites of Study.

Species Name	Coverage (%)					
	Absolute		Relative			
<i>Simmondsia chinensis</i> (Female)	5.2	9.7	5.9	11.7	20.1	12.6
<i>Simmondsia chinensis</i> (Male)	3.7	4.6	5.2	8.3	9.5	11.1
<i>Franseria dumosa</i>	12.5	25.0	7.6	28.1	51.9	16.3
<i>Larrea divaricata</i>	11.2	—	—	25.2	—	—
<i>Acacia constricta</i>	5.5	—	1.4	12.4	—	3.0
<i>Janusia gracilis</i>	2.2	—	—	4.9	—	—
<i>Condalia spathulata</i>	1.7	—	—	3.8	—	—
<i>Cercidium microphyllum</i>	0.9	—	—	2.0	—	—
<i>Baileya</i> sp.	0.9	—	—	2.0	—	—
<i>Calliandra eriophylla</i>	0.4	0.7	—	0.9	1.5	—
<i>Calliandra Schottii</i>	—	—	4.8	—	—	10.3
<i>Opuntia leptocaulis</i>	0.1	—	—	0.2	—	—
<i>Anisacanthus Thurberi</i>	0.1	—	—	0.2	—	—
<i>Lycium Fremontii</i>	0.1	—	—	0.2	—	—
<i>Jatropha cardiophylla</i>	—	4.5	2.7	—	9.3	5.8
<i>Opuntia Bigelovii</i>	—	1.6	—	—	3.3	—
<i>Opuntia spinosior</i>	—	1.1	—	—	2.3	—
<i>Ferocactus Wislizeni</i>	—	0.8	—	—	1.7	—
<i>Opuntia Engelmannii</i>	—	0.2	—	—	0.4	—
<i>Encelia farinosa</i>	—	—	9.9	—	—	21.2
<i>Prosopis glandulosa</i>	—	—	3.3	—	—	7.1
<i>Fouquieria splendens</i>	—	—	2.4	—	—	5.1
<i>Opuntia phaeacantha</i>	—	—	2.3	—	—	4.9
<i>Porophyllum gracile</i>	—	—	1.2	—	—	2.6
<b>Total</b>	<b>44.5</b>	<b>48.2</b>		<b>100.00</b>	<b>100.00</b>	

Table 2

Jojoba Variables in Relation to Selected Synecological Characteristics.

Plant characteristic	Site 1	Site 2	Site 3
Female plants per hectare	1400	410	330
Male plants per hectare	1380	340	280
Male to female ratio	0.99	0.88	0.85
Male plant vigor (m)	0.72	0.85	1.05
Female plant vigor (m)	0.76	0.88	0.97
Fruit production per site (kg/ha)	63.6	14.9	62.9
Fruit yield per plant (g)	45. Y	36.4	190.5
Fruit yield per plant <sup>6</sup> (g)	111 Y	51.7	287.56

<sup>6</sup> Average of ten plants.

The soil at site 1 can be described as a very gravelly sand clay loam. This characterization applies mostly to the "B" horizon since the "A" horizon was only approximately 2.0 cm deep. The soil was more shallow than at the other two sites.

The soil at site 2, lacking a "B" horizon, was relatively undeveloped and can be described as a very gravelly sand loam.

The soil of site 3 is well developed and has well defined "A", "B", and "C" horizons. It is the deepest of the three soils studied. The "A" horizon, about 8 cm deep, has a very gravelly sand loam texture, similar to that of site 2. The "B" horizon has a very gravelly sand clay loam texture similar to that found in site 1 soil.

*Franseria dumosa*, *Cercidium micro-*  
*m*, *Opuntia spinosior*, and *O. Bi-*  
*i* were the only species common to  
 sites. Density of *Franseria dumosa* in  
 number 2 was 3.6 times as much as  
 of site 1 and 8.3 times more than  
 Coverage of *Franseria* showed al-  
 the same trend as that presented for  
 y. From Table 1, it is seen that the  
 age of this species in the second si-  
 s 1.85 times greater than the cove-  
 of the first site and 3.2 times of the  
 site. No species showed any kind of  
 onship to jojoba in terms of density  
 orted by BURDEN<sup>3</sup> or in terms of  
 age. It was observed, however, that  
 higher the density and coverage of  
*Franseria dumosa*, the lower the jojoba  
 yield per plant (see plant fruit  
 listed in Table 2). *Franseria* grows  
 ly during the spring when jojoba  
 are in the process of enlargement.  
 g this period of study spring was  
 season with the lowest precipitation  
 (Table 5). Presumably, *Franseria*, ha-  
 shallower root system, would have  
 vantage over jojoba during periods  
 w precipitation because it would  
 e the water before it penetrated to  
 r soil levels. The density of male jo-  
 plants at site 1 was 4.1 times that of  
 and 4.9 times that of site 3. Fema-  
 nt density at site 1 was 3.4 times  
 t site 2 and 4.2 times that at site 3.  
 igher the density of male plants in  
 on to females the lower was the  
 er of aborted and/or immature  
 The ratio of male to female jojo-  
 ants calculated from the absolute  
 y showed values less than 1.0, but  
 not coincide with the mean ratio  
 to 1 reported by SHERBROOKE  
 AASE<sup>10</sup> for Arizona (see Table 2).  
 to female ratio coverage closer to  
 as more conducive to higher fruit  
 per plant (see also Table 1). When

male plants were taller than females, as  
 observed at site 3, plant fruit yield was  
 significantly higher. Since no agent other  
 than wind has been observed to pollinate  
 jojoba plants (GENTRY<sup>7</sup>, GAIL<sup>6</sup>), slight-  
 ly taller male plants should increase  
 pollination.

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