JOJOBA YIELD VARIABLES IN RELATION TO DIFFERENT ENVIRONMENTAL FACTORS.

F.A.G. ALMEIDA *
L. HOGAN **
W. V. ASDALL ***

RESUMO

PRODUÇÃO DA JOJOBA EM RELAÇÃO A DIFERENTES FATORES AMBIENTAIS

Jojoba — *Simmondsia chinesis* (Link) Scheider — um arbusto do deserto, da família Buxaceae, e nativa do México e Estados Unidos foi estudado durante um ano de investigação em três diferentes áreas no Estado do Arizona, considerando-se as variáveis de produção da planta em relação às temperaturas do solo e do ar, precipitação, água disponível no solo, potencial de evapotranspiração e ao estágio de desenvolvimento e características químicas do solo.

As áreas 1 e 2 estão localizadas nas faces Leste e Oeste, respectivamente, das montanhas de Tucson e a área 3 ao Sudeste das montanhas de Santa Catalina.

A produtividade dos frutos foi estimada com base no peso seco dos mesmos. Para se estimar a produtividade potencial de cada área, levou-se em consideração, além do número de frutos maduros, o número de frutos imaturos e/ou abortados. O peso médio da semente bem como das cascas dos frutos foram determinados. A percentagem de frutos com duas e três sementes foi, também, determinado.

Os valores de precipitação foram registrados semanalmente e os de temperatura continuamente. A evapotranspiração potencial foi calculada com base em métodos descritos por THORNTHWAITE[9] e THORNTWAITE &MATHER[10]. De acordo com ANDERSON[1], calculou-se a capacidade de retenção d'água do solo. Determinou-se ainda o seu estágio de desenvolvimento e algumas de suas características químicas.

A extensão de desenvolvimento do solo, sua capacidade de retenção d'água e seu pH influenciaram a produtividade bem como o tamanho e o peso do fruto. Quanto maior a precipitação ocorrida no inverno, maior foi a produtividade do fruto. Houve uma relação inversa entre a produtividade e a temperatura anual do solo.

PALAVRAS-CHAVE: Jojoba, Produção, Ambiente, Temperatura, Precipitação, Evapotranspiração, Solo, Características Químicas.

SUMMARY

Jojoba — *Simmondsia chinensis* (Link) Schneider, a desert shrub from the

* Associate Professor of Biology Department of Federal University of Ceará.
** Full Professor of Agronomy Department of the University of Arizona.
*** Associate Professor of General Biology Department of the University of Arizona.

Buxaceae family, and native to Mexico and United States, was investigated during an intensive one year studing at three different sites in Arizona considering the plant yield variables in relation to air and soil temperatures, precipitation, available water capacity, potencial evapotranspiration, development of the soil, and some chemical characteristics of the soil.

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.

The fruit productivity of each area was estimated based on the dry weight of the fruits. Also the number of mature and immature and/or aborted fruit on randomly selected plants was counted to estimate the potential productivity of each site. The average seed weight from the selected plants was determined and the hulls were separated from the seed and hull weights determined. Percentages of double and triple-seeded fruit were, also, determined.

The values of precipitation were recorded weekly and soil temperatures were recorded continuowsly. The potential evapotranspiration was calculated using a technique described by THORNTHWAITE[9] and THORNTWHAITE & MATHER[10]. According to ANDERSON[1] calculation of available water capacity was made. The development and some chemical characteristics of the site soils were determined.

The extent of development of the soil its available water capacity, and its pH influenced yield as well as the size and weight of the fruit. The higher the winter precipitation, the higher was the fruit yield. There was an inverse relationship between yield and the annual soil temperature.

INTRODUCTION

Simmondsia chinensis (Jojoba) is a dioecius desert shrub, Buxaceae family, native to southwestern United States and northwestern Mexico. The pistillate (female) plants produces a capsule with a single seed, frequently improperly referred to as a nut.

Studies with jojoba indicate that, if brought into successful cultivation, it has great potential for a large variety of useful products. These products are derived from the seeds and can be used as lubricants, cosmetics, pharmaceutical preparations, adhesives, plastics, polishes, candles, and animal feed supplement, etc. Additionally, soil-mulch amendments can be derived from the dry capsules (NATIONAL ACADEMY OF SCIENCES[8] and HOGAN[7]).

According to HAASE[6], in 1973, in one area near the San Carlos Reservoir at San Carlos Apache Indian Reservations with annual precipitation of 569 millimeters, seed production from 794 plants was 172.6 kilograms. In 1974, when annual precipitation was 157 millimeters, only 5 kilograms was produced. The seed weight decreased from 47 grams to 32 grams from 1973 to 1974 but the average liquid wax content increased from 46.8% to 49.8%.

YERMANOS & DUNCAN[11] comparing the yields of individual native jojoba plants at Aguanga, California, found that the seed production per plant in 1974 was 2.7 times that of 1973.

GENTRY[5] reported 1957 to be a poor year for seed set of jojoba, in both Arizona or California, because of the absence of fall rains in 1956. He concluded this because spring precipitation was near the long term average in many parts of these states, and two locations receiving 2.5 to 5 millimeters of rain in late November and early December, produced a satisfactory crop. Additional evidence came from two plants in Aguanga, California, having heavy sets of capsules which were not benefitted by three irrigations of 190 liters (50 gallons) each, during April, May, and June. He assumed that for maximum seed development, soil moisture must be provided deeply and either early in the season or in the fall.

BURDEN[2], reporting on the microclimatic requirements for the germination and establishment of **Simmondsia chinensis**, in Arizona, concluded that sites with elevations above 730 meters are more conducive to growth than at lower elevation habitats. He says that although the importance of temperature and light cannot be minimized, the available soil moisture during the early phases of development appears to be the key factor. GENTRY[5] stated a combination of low winter temperature and soil moisture buildup appear to be necessary for jojoba reproduction.

FELDMAN[4] working mostly in Arizona, found that the average wax percentage of the seeds harvested in 1974 varied directly with January 1974 mean temperature. It was positively correlated with increasing site elevation. It was also directly correlated witch percent silt and inversely correlated with percent gravel and total soluble salts. The average seed weight varied inversely with October 1973 mean temperature and directly with December 1973 mean temperature, and varied directly wity November 1973 raifall.

Staminate plants according to GENTRY[5], are taller or larger with less dieback and knobbiness than female plants.

Much of the early work on jojoba has focused on establishing its economic potential. Now that many commercial uses for its liquid wax have been demonstrated, additional studies are needed to maximize this potencial. In order to understand the plant better, its ecological characteristics require investigation. These phenomena have been studied by a few workers using broad regional climatic data instead of with local microlimatic measurements. The objective of this research was to study the jojoba yield variables in relation to the environ mental factors air and soil temperatures, precipitation, available water capacity, potential of evapotranspiration, and the development and some chemical charecteristics of the soil.

MATERIAL AND METHODS

During an intensive one year (March 23, 1978 to March 26, 1979) investigation of jojoba, 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[2]), and (5) areas with ease of accessibility.

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 790m and its topography is undulating.

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.

Site 3, in the southern 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.

The sites were 40 m long and 25 m wide.

The fruit productivity of each site 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 used because one plant was badly demaged by pests. All fruit were harvested when more than 50% were completely mature.

The number of mature and immature and/or aborted fruit on randomly selected plants was counted to estimate the potentialproductivityofeachsite. Although the potential productivity would be more realistically determined by counting the number of flowers borne by the plants, it was decided to determine the total number of fruits, both mature and aborted since jojoba plants may produce flowers more than once a year.

Based on the number of the mature fruits and their respective weight, the average fruit weight in each area of study was estimated. To determine the average seed weight, 100 fruits from the ten selected plants were separated and weighed. The hulls were separated from the seed and hull weights determined. As the fruit weight was previously known, the seed weight was determined by subtraction. Percentages of double and triple-seeded fruit were determined.

Routine and mechanical analysis of the soil of each study site were determined by the soil, water, and plant tissue testing laboratory of the Department of Soils, Water and Engineering of the University of Arizona. Routine analysis included the determination of nitrate, phosphate, potassium, sodium, soluble salts content, exchangeable sodium percentage (ESP), and pH. Mechanical analysis involved the determination of both small and large fractions of the soil such as gravel, sand, silt, and clay. Gravel was comprised of all particles over two millimeters in diameter. The soil samples were taken from the "A" and "B" horizons. Since site number 1 had mostly "B" and "C" horizons, a sample of the "B" horizon was collected at a depth of thirty centimeters. Since the soil appeared homogeneous, only one sample was taken. Site 2 had only "A" and "C" horizons. Samples of the "A" horizon at 30 cm were collected. As this soil appeared heterogeneous, three samples at different locations were taken. Site number 3 had a well developed and homogeneous soil with "A", "B", and "C" horizons. One sample from the "A" and one from the "B" horizons were collected separately. The upper two centimeters were avoided in taking the "A" horizon sample. The "B" horizon sample was collected at 30 cm.

Mechanical analysis of the soil yielded percentages of various particle classes permitting soil texture description. This coupled with gravel percentages allowed the calculation of available water capacity (ANDERSON[1]).

A weather station consisting of a tru-check rain gauge made by Edwards Mfg. Co. and two point thermograph made by Weather Measure Corporation was used at each study site. The thermograph measured air temperature and soil temperatures at a depth of 30 centimeters where the roots of jojoba are presumably most active. Standard procedures were used to eliminate evaporation of water caught by the rain gauge (DAUBENMIRE[3]). The values of precipitation were recorded weekly and air and soil temperatures were recorded continously. All instruments were read and serviced weekly. Temperature data were compiled into thirty-day, season, and yearly periods. The amount of precipitation was compiled biweekly and by season. Also, the total amount of rainfall registered during the period of study was totalled. The biweekly precipitation was compiled to show the distribution of rainfall during the period of study and to try to relate it to the biweekly vegetative growth. Seasonal and yearly precipitation were related to plant yield variables.

Based on the monthly mean temperatures and the latitude of the areas, the montly and annual potential evapotranspiration were calculated using a technique described by THORNTHWAITE[9] and THORNTHWAITE & MATHER[10].

RESULTS AND DISCUSSIONS

Although sites 1 and 3 showed similar productivity (plant yield per area), fruit yield per plant was higher at site three. Site number 2 was the least productive (see Table 1). Site 3, with 190.5 g per plant, was 4.2 times more productive than site 1 with 45.4 g per plant, and 5.2 times more productive than site

TABLE 1

Jojoba yield variables at final harvest

Plant Characteristic	Site 1	Site 2	Site 3
Fruit production per site (kg/ha)	63.6	14.9	62.9
Female plants per hectare	1400	410	330
Fruit yield per plant (g)	45.4	36.4	190.5
Fruit yield per plant[1] (g)	111.4 a	51.7 a	287.56
Male plants per hectare	1380	340	280
Male to female ratio	0.99	0.83	0.85
Fruit weight average	0.69	0.69 a	1.04 b
Weight per seed[1] (g)	0.50	0.53	0.84
Number of mature fruits[1]	156.1 ab	69.4 a	269.7 b
Number of immature fruits[1]	31.8 a	67.4 a	107.6 a
Mature to aborted fruit ratio	4.9 a	1.03 b	2.51 b
Male plant height (m)	0.72	0.85	1.05 b
Female plant height (m)	0.76	0.88	0.97
Double seeded fruit (%)[2]	14.0	6.0	24.0[3]

[1] Average of ten plants

[2] Average of 100 fruits — ten seed from each selected plant

[3] Includes triple seeded fruits.

Means followed by the same letter in each row are not different at the 5% level of significance.

2, with 36.4 g per plant. Based on the ten plants studied, sites 1 and 2 were not statistically different at the 5% level of significance. At site 1 the plant fruit yield ranged from 24.75 to 352.88 g with a mean of 11.4 g. At site 2 yields ranged from 6.0 to 221.35 with a mean of 51.7 g, and at site 3 yields ranged from 101.5 to 979.6g with a mean of 287.5 g. The number of mature fruits from the ten plants at site 3 was 1.7 times higher than the number found at site 1, and 3.9 times higher than that of site 2. Sites 1 and 3, in terms of number of mature fruits, constitute statistically, a similar population of jojoba, but they are significantly different in terms of fruit yield per plant. The number of immature and/or aborted fruits increased from site 1 to site 3. Fruit weight was also higher in site 3. It ranged from 0.79 to 1.61 g with a mean of 1.04 g. Sites 1 and 2 showed the same fruit weight mean, 0,69g. The fruit weight, at site 1 ranged from 0.53 to 0,90 g, and from 0.41 to 0.94 at site 2. Seed weight, determined from a composite sample, was similar to the fruit weights at all sites. At site 1 27.5% of the fruit was hull, at site 2 23.2%, and at site 3 only 19.2% was hull. The mean potential yield determined from the total number of fruits mature and immature and/or aborted, multiplied by the mean fruit weight, was 134.0 g per plant at site 1, 102.3 g at site 2, and 402.6 g per plant at site 3. The potential yield at sites 1 and 2 are not statiscally different at the 5% level of significance where the potential yield was compared to the real yield per plant at each site, it was determined that a reduction of at least 16.9% at site 1, 49.5% at site 2, and 28.6% at site 3 was caused by immaturity of the fruits caused by unknown factors.

Fruit yield per plant was related to exchangeable sodium percentage (ESP) and to the extent of development of the soil. The higher the ESP and the more developed the soil the higher was the yield per plant (see Tables 1 and 2). A pH between 6.8 and 7.0 appeared to be more conducive to higher vigor and productivity parameters. The yield per plant was higher when the available water capacity (AWC) of the soil was higher.

TABLE 2

Chemical characteristics and available water capacity of the soils at the three sites of study.

Data	Site 1[1]	Site 2[2]	Site 3 Horizon A	Site 3 Horizon B
Soluble salts (ppm)	413	296	189	266
Sodium (meq/1)	1.63	1.20	0.86	1.56
Potassium (meq/1)	0.17	0.18	0.16	0.12
Exchangeable sodium percentage (ESP)	0.41	0.23	0.11	0.96
Nitrate (ppm)	23.10	14.00	17.60	14.10
Phosphate (ppm)	1.86	5.94	2.33	1.60
pH	6.65	7.20	7.0	6.8
Available water capacity[3] (AWC)	0.80	0.80	1.0	1.0

1 "B" horizon
2 "A" horizon
3 Inch of water/foot of soil

TABELA 3

A comparison of monthly, seasonal and annual potential evapotranspiration (PE) and the precipitation at the three sites of study.

	Site #1		Site #2		Site #3	
Date	PE (mm)	Precip. (mm)	PE (mm)	Precip. (mm)	PE (mm)	Precip. (mm)
Mar 24/Apr 23, 1978	71,0	1.3	58.0			7.6
Apr 24/May 23	93.0	20.8	107.0			21.6
May 24/Jun 23	173.0	0.0	177.0			0.0
Jun 24/Jul 23	207.0	43.4	200.0			38.2
Jul 24/ Aug 23	183.0	52.0	173.0			86.8
Aug 24/Sep 23	151.0	18.4	148.0			6.8
Set 24/Oct 23	123.0	49.0	129.0			63.8
Oct 24/Nov 23	34.0	46.9	48.0			62.9
Nov 24/Dec 23	8.0	24.2	16.0			45.8
Dec 24/Jan 23, 1979	8.0	82.6	19.0			91.4
Jan 24/Feb 23	8.0	45.7	18.0			44.6
Feb 24/Mar 23	22.0	25.4	40.0			24.1
Spring 78	337.0	22.1	342.0			29.2
Summer	541.0	113.8	521.0			131.8
Fall	165.0	120.1	193.0			172.5
Winter 78/79	38.0	153.7	77.0			160.1
Total	1,081.0	409.7	1,133.0			493,6

When the AWC was the same, potential evapotranspiration and winter precipitation contributed to site productivity (see Table 3). Although, site 1 had less fall precipitation, its potential evapotranspiration was lower, allowing moistures from short-term rainfalls to penetrate to deeper levels. Water use was, therefore, more efficient than expected. Additionally, in winter, site 1 received more rainfall than site 2. These conditions should make the plants at site 1 more productive than plants at site 2. Although plant yield does not show a definite relation to air temperatures, it did reveal an relationship to annual soil temperature (see Table 4). The average of the soil maximum temperatures (see Table 5) in the spring was related to the fruit yield per plant. Site 3, with an average of 27.6.^{o}C,

TABLE 4

Air and soil temperature extremes observed at the three sites of study; values expressed in degreee Celsius (°C).

			Site #1				Site #2				Site #3	
		Air			Soil		Air		Soil		Air	Soil
Date	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Marc 24/Apr 23, 1978	2.0	34.0	18.0	27.0	3.0	32.0	15.0	28.0	1.0	29.0	10.0	25.0
Apr 24/May 23	8.0	43.0	21.0	36.0	8.0	41.0	16.0	35.0	4.0	38.0	8.0	31.0
May 24/Jun 23	10.0	44.0	27.0	38.0	12.0	41.0	27.0	39.0	11.0	41.0	23.0	37.0
Jun 24/Jul 23	17.0	44.0	27.0	39.0	18.0	42.0	26.0	41.0	17.0	41.0	24.0	38.0
Jul 24/Aug 23	17.0	41.0	27.0	37.0	19.0	38.0	27.0	39.0	17.0	37.0	25.0	36.0
Aug 24/Sep 23	11.0	39.0	24.0	36.0	12.0	37.0	26.0	37.0	12.0	37.0	24.0	36.0
Set 24/Oct 23	11.0	38.0	20.0	31.0	12.0	37.0	20.0	34.0	12.0	36.0	15.0	32.0
Oct 24/Nov 23	–1.0	29.0	11.0	22.0	2.0	29.0	7.0	25.0	1.0	27.0	7.0	22.0
Nov 24/Dec 23	–11.0	23.0	3.0	14.0	–2.0	24.0	–1.0	13.0	–8.0	22.0	–1.0	11.0
Dec 24/Jan 23, 1979	–4.0	22.0	6.0	11.0	–3.0	22.0	4.0	13.0	–4.0	21.0	2.0	9.0
Jan 24/Feb 23	–8.0	28.0	4.0	14.0	–5.0	27.0	2.0	16.0	–7.0	27.0	0.0	15.0
Feb 24/Mar 23	–3.0	27.0	9.0	19.0	1.0	28.0	8.0	21.0	0.0	26.0	6.0	19.0
Year Range	–8.0	44.0	3.0	39.0	–5.0	42.0	–1.0	41.0	–8.0	41.0	–1.0	38.0

TABLE 5.

Maximum and minimum average air and soil temperatures by month, season, and year at the three sites of study.

	Site #1				Site #2				Site #3			
	Air		Soil		Air		Soil		Air		Soil	
Date	Max (°C)	Min (°C)	Max (°C)	Min (°C)	Max (°C)	Min (°C)	Max (°C)	Min (°C)	Max (°C)	Min (°C)	Max (°C)	Min (oC)
Mar 24/Apr, 23, 1978	29.0	9.7	24.2	21.3	26.4	9.2	24.9	19.7	24.4	8.8	22.2	16.0
Apr 24/May 23	33,3	12.3	29.0	25.0	30.5	13.6	30.2	24.0	28.8	12.6	26.5	19.8
May 24/Jun 23	39.5	16.1	35.6	30.6	37.6	18.6	36.3	30.2	36.1	18.5	34.1	27.9
Jun 24/Jul 23	40.1	23.1	36.7	32.4	37.8	23.4	38.3	32.2	36.9	22.3	35.2	29.2
Jul 24/Aug 23	37.5	21.8	34.3	30.4	34.5	22.1	36.7	30.2	34.7	20.5	33.4	26.9
Aug 24/Sep 23	35.8	19.9	32.3	29.1	34.5	20.4	35.1	29.7	32.7	19.7	32.4	27.1
Sep 24/Oct 23	33.6	17.6	28.3	25.8	33.0	19.4	30.9	26.2	31.6	17.1	28.8	23.9
Oct 24/Nov 23	21.7	8.6	17.7	16.3	22.5	13.2	19.9	15.2	20.3	8.7	16.6	13.2
Nov 24/Dec 23	14.1	1.2	10.0	8.9	15.9	7.3	11.4	7.7	13.0	1.8	7.6	4.8
Dec 24/Jan 23, 1979	14.2	2.3	9.3	8.3	15.6	7.9	10.9	7.6	13.1	3.3	7.3	4.7
Jan 24/Feb 23	16,0	0.2	9.9	8.1	16.6	7.4	11.9	7.2	14.6	1.9	9.2	5.0
Feb 24/Mar 23	19.9	3.8	15.2	12.6	20.2	10.8	16.9	11.8	18.2	5.0	14.9	10.0
Spring 78	33.9	12.7	29.6	25.6	31.5	13.8	30.5	24.6	29.8	13.3	27.6	21.2
Summer	37.8	21.6	34.4	30.6	35.6	22.0	36.7	30.7	34.8	20.8	33.7	27.
Fall	23.1	9.1	18.7	17.0	23.8	13.3	20.7	16.4	21.6	9.2	17.7	15.7
Winter · 78/79	16.7	2.1	11.5	9.7	17.5	8.7	13.2	8.9	15.3	3.4	10.5	6.6
Annual Mean	27.9	11.4	23.5	20.7	27.1	14.4	25.3	20.1	25.4	11.7	22.4	17.4

may have optimum conditions for root respiration at favoring higher levels of water and ion uptake. Site 2, with an average temperature of 30.5.°C, may have inhibited the water and ion uptake activity by root system. As noted above, particularly at site 2, a large proportion of the real production was reduced by the immaturity of many fruits.

Two conditions could be explained as follows:

2) A mild, warm fall with an average minimum temperature above 13.° C and an average maximum temperature slightly below 30.°C (see Table 5). This is best understood by considering the sequence of developmental events for male jojoba plants starting the preceding spring. At that time most primordia are initiated and undergo partial development. High air temperature apparently causes male reproductive dormancy, which may continue into the autumm during certain years. When, weather conditions are similar to those described above, dormancy is broken and anthesis is favored. This leads to pollination, fertilization, and fruit formation. When fruits are formed near end of fall, they do not have sufficient time to reach full development before the onset of freezing temperatures in winter.

Fruit yield per plant was related to exchangeable sodium percentage (ESP) and to the extent of development of the soil. The higher the ESP and the more developed the soil the higher was the yield per plant (see Tables 1 and 2). A pH between 6.8 and 7.0 appeared to be more conducive to higher vigor and productivity parameters. The yield per plant was higher when the available water capacity (AWC) of the soil was higher. When the AWC was the same, potential evapotranspiration and winter precipitation contributed to site productivity (see Table 3). Although, site 1 had less fall precipitation, its potential evapotranspiration was lower, allowing moistures from short-term rainfalls to penetrate to deeper levels. Water use was, therefore, more efficient than expected. Additionally, in winter, site 1 received more rainfall than site 2. These conditions should make the plants at site 1 more productive than the plants at site 2. Although plant yield does not show a definite relation to air temperatures, it did reveal an relationship to annual soil temperature (see Table 4). The average of the soil maximum temperatures (see Table 5) in the spring was related to the fruit yield per plant. Site 3, with an average of 27.6.°C, may have optimum conditions for root respiration at favoring higher levels of water and ion uptake. Site 2, with an average temperature of 30.5.°C, may have inhibited the water and ion uptake activity by root system. As noted above, particularly at site 2, a large proportion of the real production was reduced by the immaturity of many fruits.

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2) the late fertilization (end of April and beginning of May) of some flowers formed in the spring produce fruits which are subjected to high temperatures at the end of spring and the beginning of summer. This causes them to be dried before they reach their full development and, consequently, they do not mature.

Both of these conditions occurred with site 2 plants, and only the second condition happened with plants at the other two sites.

The incidence of double-seeded fruits was related to winter precipitations as well as to the AWC of the soil. A higher percentage of double-seeded fruits was found on plants growing in the best developed soils.

On late March, 1978, when this research started, the fruits were at the beginning stage of development in all sites but less advanced at the third site. On April 17 most of the fruits initiated in March were near full development. At site 1, thirty fruits collected from five plants averaged 18.3 millimeters long and 9.9 millimeters wide; at site 2, fruits measured 17.6 millimeters long and 11.0 millimeters wide. On April 12 at site 3, fruits were 14.1 millimeters long and 8.2 millimeters wide. At sites 3 and 1, the growth of fruits continued until 24 May, when they all started to mature. But at the other site it was only on the 5th of June that the fruits started to mature. On the 26th of June most of the fruits from all selected plant at all sites were at the dehiscent stage and were fully mature. High temperature at all sites appeared to have accelerated maturation of the fruits. This final stage of maturation occurs during a three to four week period, from approximately 24 May to 26 June, when daily maximum air temperatures start to increase abruptly. High temperatures tend to cause water stress and concomitant stomatal closure. Stomatal closure restricts metabolism, and fruits immediately begin maturation.

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