Quantitative and Qualitative Characteristics of Jojoba Seed

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ABSTRACT

Data are presented on the composition of jojoba seed harvested from randomly selected individual plants (175 in 1973, 139 in 1974) of the native population at Aguanga, CA. Except for seed yield per plant, which was 2.7 times higher in 1974, wax, protein, and hull content of the seed, as well as fatty acid and alcohol composition of the wax, were not very different in the 2 years. A significant ($P<0.01$) positive correlation was found between seed wt and wax content of the seed. Highly significant ($P<0.01$) correlations were found in pairs of fatty acids and alcohols except where fatty acid 20:1 was included. Comparison of data from 22 plants of known identity for the 2 years also showed no significant change in wax content and composition of the seed. By contrast, correlations for seed wt, protein, hull percent, and yield per plant for the same period were all nonsignificant.

INTRODUCTION

Jojoba seed differs from other oilseeds in that it contains a liquid wax rather than triglycerides (1,2). Several disjunct natural populations of jojoba have been identified in California, Arizona, and Mexico, occupying a wide range of ecological niches (3). Thus, an opportunity is available to investigate the amount and types of genetic and environmental variability in wax composition, as well as in other seed characteristics, present in this species among and within the existing natural populations. With the advent of efficient analytical techniques, a great deal of information has been developed on the quantity and quality of oil extracted from cultivated oil crops. By contrast, little information of this type is available on the oil and wax of wild species. This report presents data on seed collected from a natural population of jojoba growing in the vicinity of Aguanga, CA.

MATERIALS AND METHODS

The population studied lies at about 33° N. latitude to

TABLE I

Mean, Range, and Coefficient of Variation of Quantitative and Qualitative Jojoba Seed Components in 1973 and 1974[a]

	Mean		Range		Coefficient of Variation	
	1973	1974	1973	1974	1973	1974
Wax (%)	51.0	49.0	41.5-56.6	42.4-55.7	5.0	5.5
Protein (%)	32.5	29.9	25.8-37.8	20.6-34.6	6.5	9.3
Seed wt (g/seed)	0.41	0.35	0.17-0.83	0.17-0.59	24.7	25.8
Seed yield (g/plant)	453	1219	30-4330	16-6910	108.6	94.6
Seed moisture (%)	55.4	53.2	33.6-80.3	34.1-73.7	8.0	12.6
Hull (%)	45	46	12.6-94.8	14.8-64.0	16.6	20.7
Fatty acid 18:1 (%)	13.8	14.2	10.1-20.7	10.1-18.6	13.6	12.2
Fatty acid 20:1 (%)	73.0	71.5	67.5-77.0	67.8-75.6	1.6	1.9
Fatty acid 22:1 (%)	10.6	11.3	6.2-12.8	9.2-13.8	10.6	9.0
Alcohol 20:1 (%)	53.9	53.7	46.6-63.3	26.1-61.4	5.7	5.7
Alcohol 22:1 (%)	34.8	36.4	27.2-41.8	30.7-42.0	6.9	6.7
Alcohol 24:1 (%)	4.0	4.5	1.4-7.5	1.0-8.0	23.4	24.5
Wax (g/seed)	0.21	0.17	0.08-0.43	0.08-0.30	25.6	27.5
Wax (g/plant)	230	590	22-2130	8-3234	107	93.8
Protein (g/seed)	0.13	0.10	0.05-0.25	0.04-0.16	24.7	25.9
Protein (g/plant)	150	362	10-1508	4-2041	112.6	94.1

[a]175 plants were studied in 1973, 139 in 1974. Data based on 25 g single plant seed samples.
[b]Data of % wax and % protein are given on a moisture free basis.

TABLE II

Simple Correlation Coefficients Between Quantitative and Qualitative Jojoba Seed Components (1974)[a]

	Wax (%)	Protein (%)	Wt (g/seed)	Seed yield (g/seed)	Hull (%)	Fatty acids 18:1	Fatty acids 20:1	Fatty acids 22:1	Alcohols 20:1	Alcohols 22:1
Protein (%)	-.03									
Seed wt (g/seed)	.30[b]	-.11								
Seed yield (g/plant)	-.14	-.07	-.10							
Hull (%)	-.20	.02	-.29[b]	.02						
Fatty acid 18:1 (%)	-.21[c]	-.03	-.01	.10	.00					
Fatty acid 20:1 (%)	.20[c]	.06	.05	-.07	-.08	-.73[b]				
Fatty acid 22:1 (%)	-.18	.08	.03	-.12	-.11	-.63[b]	-.13			
Alcohol 20:1 (%)	.19[c]	-.12	-.02	.08	-.01	.76[b]	-.17	-.92[b]		
Alcohol 22:1 (%)	-.12	.10	.08	-.06	-.01	-.73[b]	.15	.94[b]	-.94[b]	
Alcohol 24:1 (%)	.14	.11	.06	-.09	-.04	-.56[b]	.16	.64[b]	-.73[b]	.64[b]

[a]Based on 139 plants.
[b]Significant, $P<0.01$.
[c]Significant, $P<0.05$.

TABLE III

Means, Coefficients of Variation, and Simple Correlation Coefficients Between Qualitative and Quantitative Components of Jojoba Seed Harvested from the Same 22 Plants in 1973 and 1974

	Mean		Coefficient variation		Correlation coefficient
	1973	1974	1973	1974	
Wax (%)	50.4	50.0	4.8	5.4	0.7[a]
Protein (%)	32.7	29.6	5.1	8.4	0.2
Seed wt (g/seed)	0.45	0.38	21.6	17.5	0.7[a]
Seed yield (g/plant)	460	1991	74.4	89.7	0.1
Hull (%)	44	40	15.1	32.5	0.2
Fatty acid 18:1 (%)	15.2	14.8	15.5	13.6	0.8[a]
Fatty acid 20:1 (%)	72.3	71.0	2.0	2.3	0.7[a]
Fatty acid 22:1 (%)	10.0	11.2	13.6	7.5	0.8[a]
Alcohol 20:1 (%)	55.5	54.4	6.3	4.8	0.8[a]
Alcohol 22:1 (%)	34.0	36.0	7.5	5.4	0.7[a]
Alcohol 24:1 (%)	3.6	4.5	26.2	18.6	0.3

[a]Significant, $P < 0.01$.

the north, and east of Aguanga, CA, in an area which receives about 360 mm of rainfall annually with 29 year average maximum and minimum temperatures ranging from 40 C to -9 C (4). Jojoba plants were harvested individually in the summers of 1973 and 1974. The seed was picked by hand prior to dehiscence but at an advanced stage of development indicated by the brown color and wrinkling of the pericarp. Little, if any, change in seed wax content and composition takes place from that stage of development until maturity (2). Duplicate 25 g seed samples were taken from each of these plants. Wax content of dried seed samples was determined by wideline nuclear magnetic resonance (NMR). Protein content of the meal (N x 6.25%) from each seed sample was determined by Kjeldahl analysis. Wax was obtained by pressure and solvent extraction from each seed sample and was analyzed for its chemical composition as previously described (4).

RESULTS

The mean, range, and coefficient of variation of the seed components studied are shown in Table I. Because of the large variability among plants in both size and botanical characteristics, yield of seed, wax, and protein per plant exhibited extremely large coefficients of variation. By contrast, data on wax quality were much less variable. The most striking difference between the 2 year data was in seed yield per plant, which in 1974 was 2.7 times greater than in 1973. Higher seed yield in 1974 was entirely due to the larger number of seeds produced per plant in that year. Major fluctuations in seed yield of jojoba plants from year to year are not uncommon. The precise reasons for these fluctuations, however, have not been explained adequately. Simple correlations between qualitative and quantitative components of the seed followed the same pattern in both years; thus, correlations for 1974 only are given in Table II. Of considerable interest is the highly significant ($P<0.01$) positive correlation between seed wt and wax content. Thus, selection for large seeded jojoba strains would not only contribute to easier harvesting but also to seed types with higher wax content. Contrary to what has been found in some other oil crops, the correlation between wax and protein content of the seed was not significant. The lack of correlation between seed yield per plant and any of the other characteristics is viewed with skepticism because it could result from the excessive variability found for seed yield among plants in both years. The significant ($P<0.01$) negative correlation between seed wt and hull percent could probably be attributed to the presence of seeds at different stages of development, with seeds at later stages of development having a lower hull to seed ratio. The highly signifi-

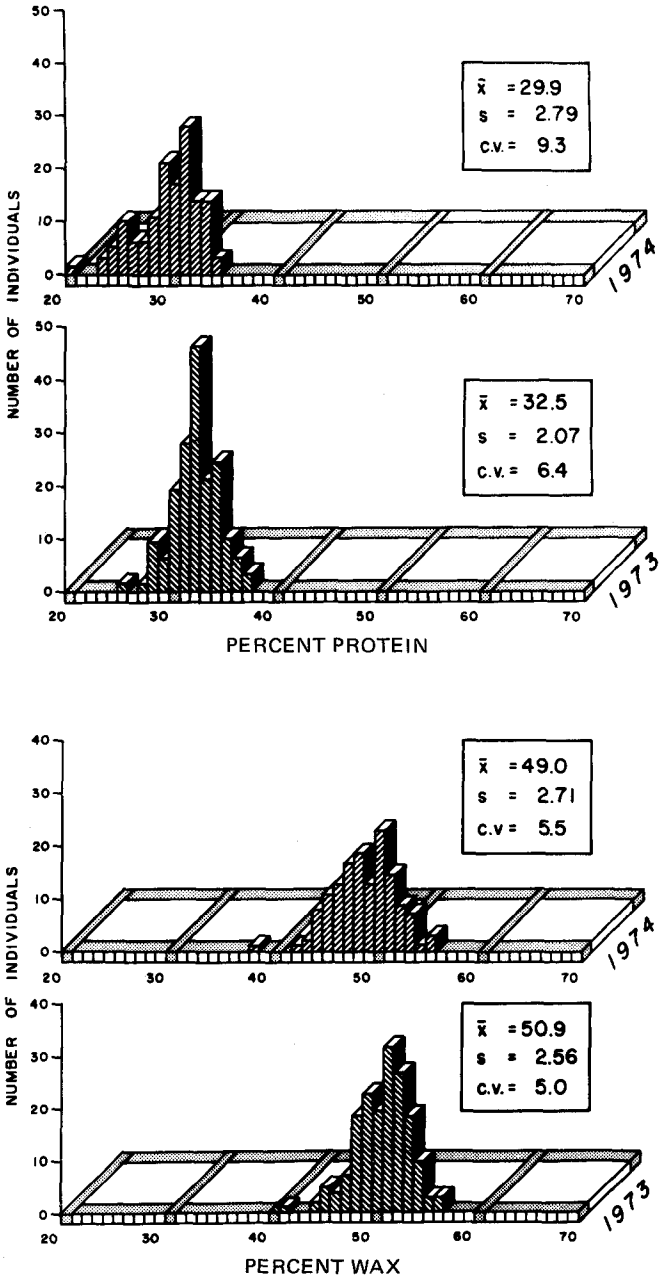

FIG. 1. Variability in percent wax and protein in single jojoba seed samples harvested in 1973 and 1974. $\bar{x}$ = mean; s = standard deviation; cv = coefficient of variation.

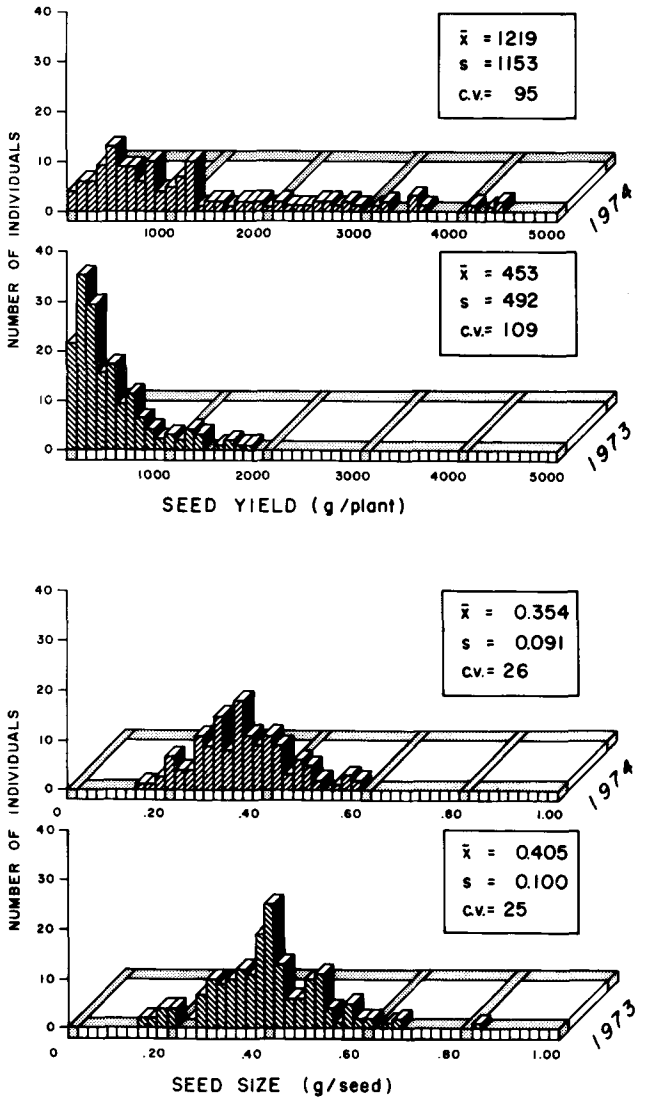

FIG. 2. Variability in seed yield and wt in single plant jojoba seed samples harvested in 1973 and 1974. $\bar{x}$ = mean; s = standard deviation; cv = coefficient of variation.

cant ($P<0.01$) correlation among fatty acids and alcohols and the absence of significant correlations between fatty acid 20:1 and most of the other fatty acids and alcohols will be better understood when the biochemical pathways for their synthesis are established.

Figures 1-3 were constructed to provide a visual measure of the amount of variability available for characteristics under selection, which is of paramount importance in plant improvement projects. In general, the amount of variability for seed wt, yield, wax, and protein content tended to be greater in 1974 when the mean seed yield per plant was higher. No such trend was detected in the fatty acid and

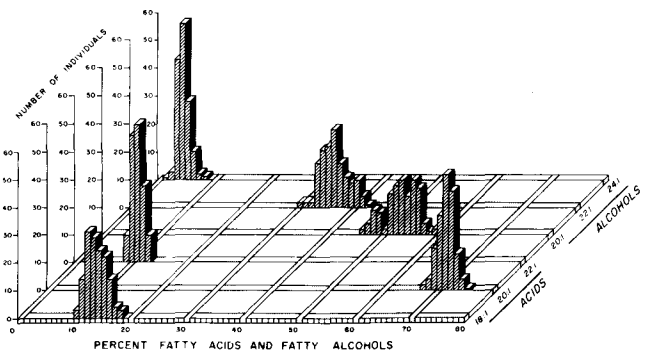

FIG. 3. Variability in fatty acid and alcohol composition in single plant jojoba seed samples harvested in 1974.

alcohol content.

Several hundred plants were tagged in this population so as to survey and evaluate the performance of individual plants over a period of several years. Unfortunately, most of the metal tags used were removed by passersby, and data for only 22 plants of known identity could be compared over this 2 year period. Correlation coefficients were calculated for each of the seed characteristics studied to determine how consistent the performance of those 22 plants was over the 2 year period. Consistent expression of a given characteristic would indicate that the genotypic composition of plants overrides the effects of the environment in that case. Significant ($P<0.01$) correlation coefficients were obtained for wax content, seed wt, and composition, except in the case of alcohol 24:1 (Table II). Because alcohol 24:1 is significantly ($P<0.01$) correlated with the other two alcohols plus fatty acids 18:1 and 22:1 (Table II), and because each of these is in turn significantly ($P<0.01$) correlated with individual plants (Table III), alcohol 24:1 and individual plants should have exhibited a significant ($P<0.05$), higher than $r = 0.3$, correlation coefficient. The lack of significance in this case could not be explained. Stability in wax content and composition from year to year would be a major asset in marketing and utilization of jojoba wax. By contrast, variable expression would indicate that environmental effects determine to a greater extent the degree to which a given characteristic expresses itself. Correlations for protein, hull percentage, and yield per plant were all nonsignificant. Optimum expression of these characteristics will depend on the development of appropriate cultural practices.

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