Effects of Planting Date and Irrigation on Wax Content of Sunflower-Seed Oil

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ABSTRACT

Seed from sunflower grown at Bushland, TX, in 1980 and 1981 and at Florence, SC, in 1982 were evaluated for the influence of date of planting and irrigation on wax production. Wax content of the hull and oil was found to be ca. 10% lower in samples from irrigated than from nonirrigated sunflowers; however, none of the sunflower planted on different dates were under severe moisture stress from bloom to harvest. Although the highest positive correlation was found between the linoleic acid content of the oil and the wax content of the hull, those factors that favored high oil percentage also favored low wax content.

INTRODUCTION

The winterization of sunflower (*Helianthus annus* L.) seed oil is quite difficult because of the low percentage of wax in the oil and the presence of gums that coat the wax and retard filtration (1). These problems have been overcome by using filter aids (2) or solvent winterization (3). Some processors combine the winterization step with either degumming (4) or refining (5).

The majority of the waxes have been shown to be found on the surface of the hull (6). Alternatives to the classical winterization process would include more efficient hull removal or washing the seed with warm hexanes (7) before crushing and extraction.

An earlier report (8) demonstrated a relationship between hull content of the seed (percentage of weight) and wax content (ppm) of the hull, variety and planting location. In this study, effects of date of planting on hull and wax content were evaluated to determine whether adjusting planting date to minimize wax content without reducing oil content might be possible.

MATERIALS AND METHODS

Samples of seed from Bushland, TX and Florence, SC, were used for this study. Seed from Bushland were from hybrid MC (Masters Choice) 894 sunflower from the 1980 and 1981 planting date study. Plants were irrigated to maintain a relatively high soil-water content during the growing season. Seed from Florence, SC, were from hybrids MF (Master Farmer) 700, HySun (Farm Bureau) 101, and DO (Dahlgren) 844. These were from a replicated study involving irrigation and date of planting.

The percentage of hull and kernel in the seed were determined by hand separation. Wax content of the hull and oil were determined by gas liquid chromatography (GLC) (3,8). Total oil was measured by a Newport Mark III wide line nuclear magnetic resonance (NMR) analyzer (9). Fatty acid composition was determined by GLC (10). All samples were analyzed in duplicate and analysis of variance of the data was performed using the Statistical Analysis System (11).

RESULTS AND DISCUSSION

Seed from sunflowers planted on 6 dates from March 23 through July 23 in 1980 and 1981 were evaluated for wax contents of the oil and hull, total oil and hull content.

TABLE I

Variation of Chemical Characteristics of Sunflowerseed with Planting Date

Characteristics and climatic conditions	Planting Dates											
	1980						1981					
	3-23 (140)[a]	4-28 (110)	6-2 (108)	6-17 (106)	7-3 (82)	7-18 (105)	3-23 (137)	4-27 (110)	6-2 (109)	6-18 (93)	7-7 (100)	7-23 (102)
Wax in oil (ppm)	645	687	677	1183	2139	673	765	630	649	1225	1136	861
Hull (%)	27.6	25.6	24.9	29.6	32.9	27.2	24.0	24.8	25.5	25.9	23.4	23.6
Oil (%)	44.1	49.2	34.4	40.0	25.3	44.4	47.6	44.7	44.6	42.8	37.1	39.4
Linoleic acid (%)	40.0	52.8	47.2	58.7	65.2	71.1	42.7	47.8	59.4	65.1	74.2	73.6
Hull wax (ppm)	966	747	969	1020	1184	1198	1299	1090	1216	1073	1514	1420
Rainfall[b]	2.53	3.53	4.80	4.75	1.30	7.52	29.69	26.19	32.66	15.37	16.71	8.84
Temperature[c]	35	34.1	32.4	32.9	31.3	26.9	31.1	30.9	28.3	26.6	26.1	26.4

[a]Number of days from planting to harvest.

[b]Total rainfall (cm) from 50% flowering to harvest.

[c]Mean high temperature (C) from 50% flowering to maturity.

Total rainfall and the mean maximum daily temperature for the period from 50% bloom to harvest were recorded. The results in Table I show a gradual increase in the wax content of the oil to a maximum for the July 3 and June 18 plantings for 1980 and 1981, respectively. The wax content of hull showed different trends. A positive correlation coefficient (r) of +0.72 was found for the relationship between wax content of the oil and hull content, suggesting lower hull content associated with lower wax content. Analysis of variance showed a significant interaction ($P \leq 0.0001$) between years and planting dates within year for wax content of the oil. The mean wax contents of the oils from 1980 and 1981, Table II, were 999 ppm and 864 ppm, respectively, corresponding to mean hull contents of 27.6% and 24.5%. The mean oil content for each year was 41.3% and 43.1% for the respective years, demonstrating the inverse relationship between hull content and oil content.

As can be seen from the data in Table II, the rainfall for 1981 was much higher than for 1980. However, these plantings were irrigated so that sufficient soil moisture was available to minimize moisture stress. The mean high temperature from flowering to harvest was 32.1 C for 1980 and 28.2 C for 1981, suggesting a possible influence of temperature on wax production. The less favorable growing conditions in 1980 are evident in the fluctuation in oil content with an inverse change in the wax content of the oil, which is not as evident in 1981. Wax content of the hull was actually higher for 1981 but because of the larger kernel percentage and corresponding oil content, the wax content of the oil was lower. This inverse relationship between oil content and wax content of the oil is quite evident in 1980.

The effects of planting date and irrigation on wax, hull and oil content are shown in Tables III and IV for 3 hybrids planted on 6 dates from March 12 through August 30, 1982, at Florence, SC. The wax content of the oil for hybrid MF 700 was correlated negatively with rainfall (Table V) and irrigated and nonirrigated plots with correlation coefficients of -0.62 ($P \leq 0.05$) and -0.66 ($P \leq 0.01$), respectively. The same trend was observed for DO 844 with correlation coefficients of -0.83 ($P \leq 0.001$) and -0.80 ($P \leq 0.001$) for irrigated and nonirrigated plot samples. HySun 101 exhibited no significant correlation with rainfall. The wax content of the hull was negatively correlation with both rainfall and mean high temperature for both irrigated and nonirrigated plot samples.

If water stress is a factor in wax production, a negative correlation would be expected between rainfall and wax content and a positive correlation with pan evaporation and wax content with higher correlations for the nonirrigated samples. Pan evaporation was found to be negatively correlated with wax content. Temperature might then be expected to produce a positive correlation. In this study, mean high temperatures from flowering to harvest coincided with high rainfall, largely eliminating drought as a possible source of stress. This was borne out by examining the ratio of rainfall to pan evaporation.

We used the ratio of rainfall to pan evaporation as a rough measure of moisture stress for a plant during oil production (Table V). A value near 1 or greater than 1 1 would indicate good moisture availability. For these 6 dates, all were essentially 1.0-1.2. The wax content of the oil and total oil content of the 8-17 and 8-26 planting, which represent the extremes for the value of this ratio, are similar. The rainfall/evaporation ratios representing the extremes indicate that little or no water stress occurred.

Mean hull and wax content (Table II) for each hybrid and irrigation treatment over all dates show the irrigated plantings containing slightly lower hull and wax content in oil than the nonirrigated samples. Analysis of variance

TABLE II

Means of the Chemical and Physical Characteristics of Sunflowerseed[a]

Hybrid	Planting year	Irrigation[b] treatment	Hull (%)	Oil (%)	Linoleic acid (%)	Wax (ppm) Hull (%)	Wax (ppm) Oil (%)	Rainfall (cm)	Temp (C)
Bushland, TX									
MF 894	80	I	27.6	41.3	55.8	1014	999	4.29	32.1
MF 894	81	I	24.5	43.0	60.5	1218	864	21.56	28.2
Florence, SC									
MF 700	82	I	26.8	39.6	55.0	1197	1140		
		N	27.4	36.3	58.1	1332	1214		
Hysun 101	82	I	26.9	36.4	58.1	1331	1408	14.25	25.3
		N	27.8	35.3	57.0	1530	1715		
DO 842	82	I	27.5	39.4	56.8	1216	1084		
		N	28.2	35.9	56.6	1068	1116		

[a]Average values over all dates of planting.

[b]I = irrigated; N = non-irrigated

TABLE III

Effects of Irrigation and Planting Date on Chemical and Physical Composition of Sunflowerseed

		Planting Dates for 1982																	
		3-12 (102)[a]			4-6 (108)			5-1 (86)			8-17 (116)			8-26 (109)			8-30 (108)		
Hybrids	Irrigation[b] Treatment	Hull (%)	Oil (%)	18:3 (%)	Hull (%)	Oil (%)	18:3 (%)	Hull (%)	Oil (%)	18:3 (%)	Hull (%)	Oil (%)	18:3 (%)	Hull (%)	Oil (%)	18:3 (%)	Hull (%)	Oil (%)	18:3 (%)
MF 700	I	27.0	40.0	43.5	23.7	43.2	44.7	30.2	34.1	47.2	26.5	46.9	68.9	26.8	34.0	70.8	----	----	----
	N	29.3	39.0	47.3	26.3	41.2	49.7	30.6	32.4	46.9	26.5	32.8	72.6	26.0	34.8	69.9	25.9	37.4	62.0
HySun 101	I	27.3	42.3	41.7	26.0	43.2	47.3	31.8	30.0	48.1	26.1	33.4	69.8	23.5	34.1	70.4	26.7	35.4	71.0
	N	28.2	39.3	45.6	26.1	40.9	44.3	30.9	33.9	46.1	26.3	31.7	68.8	29.2	31.0	68.2	25.8	34.7	69.1
DO 844	I	24.3	41.4	45.9	26.0	45.2	42.2	29.2	35.8	44.4	28.7	43.6	68.1	25.8	35.0	73.5	30.8	35.2	66.7
	N	26.1	39.7	42.6	28.0	42.5	41.8	29.7	35.4	40.7	28.9	29.1	76.1	26.9	34.0	67.3	26.6	34.9	71.2

[a] Number of days from planting to harvest.

[b] I = irrigated; n = non-irrigated

TABLE IV

Effects of Irrigation and Planting Date on the Wax Content of Sunflowerseed Hull and Oil

Hybrids	Irrigation Treatment[a]	Planting Dates for 1982											
		3-23		4-6		5-1		8-17		8-26		8-30	
		Hull[b]	Oil[b]	Hull	Oil	Hull	Oil	Hull	Oil	Hull	Oil	Hull	Oil
MF 700	I	813	779	690	684	1109	1436	1689	1313	1683	1491	----	----
	N	777	825	910	843	1175	1364	1787	1460	1849	1522	1495	1273
HySun 101	I	648	735	860	860	1573	1916	1436	1487	1868	1924	1602	1523
	N	670	788	825	1753	942	2220	1893	1654	1848	1999	2999	1877
DO 844	I	628	711	923	567	1355	1197	1258	1394	1590	1329	1539	1303
	N	680	656	742	713	999	941	1239	1786	1140	1191	1576	1411

[a] I = irrigated; N = non-irrigated

[b] Wax content in ppm

TABLE V

Climatological Data from Flowering to Harvest for 1982 Date of Planting Study

Planting Date	Mean High (C)	Total Rainfall (cm)	Total pan Evaporation (cm)
3-23	30.9	15.08	15.16
4-6	31.1	20.42	16.46
5-1	31.7	15.87	12.80
8-17	20.1	10.80	11.10
8-26	19.7	12.47	6.63
8-30	18.1	10.95	5.87

showed a significant interaction ($P \leq 0.001$) for the wax content of the oil with irrigation, variety, planting date, variety by irrigation and variety by date. Analysis of variance showed the same level of interaction for hull content except that no interaction with irrigation occurred.

The characteristic that uniformly gave the highest correlation with the wax content of the hull was the percentage of linoleic acid in the oil. Correlation coefficients ranged from a low of 0.63 ($P \leq 0.1$) in the 1981 planting to 0.94 ($P \leq 0.004$) for the nonirrigated planting of MF 700. At this point, we do not know if this is coincidental or related to a biological process. Indications from this study, however, are that higher linoleic acid content occurred at times of lower oil production. Available data (8) suggests that, as linoleic acid content changes with location, no corresponding change occurs in wax content (12).

Generally, those environmental conditions that favor high oil production, adequate moisture and sunlight during seed filling, also favor low wax content. The mean wax content across planting dates for both irrigation treatments show HySun 101 to have the highest wax content and no correlation of wax content in the oil with either temperature or rainfall.

From our data, fully evaluating the effects of temperature, rainfall or water availability on the wax content of sunflower-seed oil would be difficult because the nonirrigated plantings in this study were not under severe stress. In addition, mean high temperatures occurred during the same periods as high rainfall suggesting high temperature alone, not connected with drough conditions, have little effect on wax content. Slight differences in the 1980 and 1981 plantings would indicate some stress. Water stress appeans to affect oil content to a greater degree than wax; however, the interactions are complex and warrant further investigation.

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