CURRENT WORK ON SUNFLOWER BREEDING AT VNIIMK (USSR)

By

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Sunflower is a staple oil-bearing crop in the USSR. Sunflowers are grown on about 5 million hectares in the USSR of total 8 mln hectares sown to this crop in the world.

All the sunflower acreages in the USSR are sown to varietal seeds on account of the license granted by the State Committee of strain testing. During the past year, oil content of commercial seeds (on dry seed basis) averaged 50.3 percent throughout the country.

In the major sunflower producing areas (Ukraine, Moldavia, Krasnodar region, Rostov, Voronezh, and Volgograd districts) mean oil content of commercial sunflower seeds has reached a record of 51 percent, and 52 to 53% in some individual lots.

In the USSR, during the past 2 years (1966-1967) oil yield per hectare averaged 525 kgs.

In 1967, mean sunflower crop was estimated at 16 centners per hectare (about 7 centners of oil per ha) in Moldavia and the Ukraine, at 19.3 centners/ha in Krasnodar region (about 9 centners of oil per ha). On the collective farm "Kuban", Krasnodar region, seed crop from the area of 1170 hectares averaged 30 centners per ha, and the best brigades of the farm harvested as much as 33 centners per ha, or 13 to 16 centners of oil per hectare.

Expansion of sunflower acreages in the world and progress in sunflower breeding abroad are, to a higher extent, conditioned by acheivements of Soviet breeding for high oil percentage.

Such countries as Yugoslavia, Bulgaria, Hungary, Rumania, France have completely turned to sowing Soviet varieties. Recently Turkey, Italy, Spain, Portugal, and Canada have taken a great interest in our varieties as well.

In the Soviet Union, sunflower varieties with maximum possible oil content will be released soon through sunflower breeding.

In 1967, for instance, at state strain trial stations of Krasnodar region and Moldavia, oil content of the variety Peredovik was as high as 56.7 to 57.0 percent.

Individual biotypes in breeding elite of the variety Peredovik, VNIIMK, Krasnodar, have accumulated up to 60.8% of oil in seeds, and 73.0% of oil in kernels approaching apparently ultimate oil percentage in sunflower.

At interval between the two Conferences on sunflower, seven new sunflower varieties were delivered by our Institute (VNIIMK) and its affiliations for state variety testing; 5 of these are medium maturing (90 days growing period) with high oil content, broomrape resistant; 1 variety - early maturing (85 days), and 1 variety of a very short growing season (79-80 days) with 50% oil content on dry seed basis.

All the varieties, at the station variety testing, exceeded the respective controls in oil yield per hectare.

By the same methods, a medium maturing variety was obtained which as shown by the variety testing exceeded control in seed yield by 4.8 centners per hectare (19%).

Sunflower breeding in the USSR has followed different trends in its progress, breeding for 22 characters including. The most important of them are: breeding for high oil content in seeds and for high oil yield per hectare.

The principle trend of sunflower breeding is that of developing varieties-populations with the method of multiple individual selection with estimation of breeding material by progeny in nurseries of purposive and controlled transpollination at open flowering.

As original material for breeding intervarietal sunflower hybrids are also commonly used.

During the past 10 years, large scale research work with method of line hybridization was conducted (by using heterosis controlled genetically).

10 years investigations were aimed to breed interstrain, variety-lineal and intervarietal hybrids of sunflower on the basis of cytoplasmic and genetically controlled male sterility. The material used were high oil, broomrape resistant sunflower varieties bred at VNIIMK.

At present, 114 hybrids obtained on the basis of sterility are being tested; the best ones exceeded control in seed yield by 20 to 50 percent in 1967.

In 1967, twelve varieties were tested at the competitive variety testing. First place was held by interstrain hybrid Pr 30,46 (Simple 30,46) in seed yield and oil yield per hectare; it exceeded the control by 6.8 and 3.0 centners per ha respectively. Interstrain hybrid Pr - 2 during 4-years test exceeded the control VNIIMK 8931 in oil yield by 1.9 centners per ha on the average. Heterosis in the hybrid is shown in seed oil percentage too (+1.8 absolute value).

Line-hybridization method will make it possible to obtain, in the near future, varieties yielding 15 to 25% higher seed yield than current licensed varieties.

In 1937, as a result of research work conducted by Soviet plant-breeders Academician L. A. Zhadanov and Academician V. S. Pustovoit, and others, varieties resistant to broomrape (race "A" and populations of race "B") were created and licensed. As a consequence, high yielding and stable sunflower crops were harvested in the whole country.

Within the 30 years period, broomrape resistant varieties covering over 70 million hectares saved money that could have been spent for controlling the acreages from the disease.

The right place of the crop in the field rotation is the only effective method of controlling downey mildew. Unfortunately, it is prohibited to sow sunflowers to more than one field. (10%).

In connection with this, during the past ten years scientists were confronted with a new urgent problem - to breed sunflowers for group immunity to major pathogenes of the crop.

To breed varieties resistant to sclerotinia, rust and downey mildew was too difficult a task as among cultivated sunflower (H.annuus L.) there were no sources of immunity to a whole range of sunflower diseases.

Studies of the collection of 34 wild species of North American origin represented by a polyploid series have shown that hexaploid group of species possesses an absolute genotypic immunity to major sunflower pathogenes. In preliminary studies, wild species were found to differ in seed and oil biochemical composition between each other and compared with cultivated sunflowers as well.

Wild species have lower oil percentage in achenes (20 to 27 percent on dry seed basis), higher content of linoleic acid in oil because of lower content of oleic acid, and high content of crude protein in seeds (29 to 35%) in the lowest oil species. As found by gas chromotography, some species (H.macrophyllus Willd.and H.tuberosus L.) contain as much as 80 percent of linoleic acid, i.e. 25 to 30% more than cultivated sunflowers do. Oil of some other wild species (H.gigantheus and others) comprises fatty acids not found in oil of cultivated sunflower. These properties of the wild species make it possible to develop interspecific hybrids with a wide range of variability in the characters and with a certain seed and oil composition.

Achenes of wild species are characterized by complete armored layer which accounts for the resistance to sunflower moth, and by much higher volume weight as compared with cultivated sunflower (550 to 750 g/l).

The findings, obtained as a result of investigations on wild species Helianthus, open a new prospect for utilizing the wild species as original forms in breeding for immunity above all.

As intraspecific selections were no success, it made us choose a more difficult method of breeding - interspecific hybridization of wild species Helianthus possessing group immunity to a number of parasitic diseases with the best licensed sunflower varieties bred at VNIIMK.

Starting from 1955-1956, first crosses were made between the high oil broomrape and moth resistant variety N 8931 and the perennial autoallo-hexaploid wild species H. tuberosus v purpurellus L. (topinambur). This species was used as the female parent, and was distinguished by immunity to four diseases: rust, downey mildew, sclerotinia and to the pest sunflower moth. All the work on interspecific hybridization was based on backcrosses with sunflower giving rise to a series of difficulties:

1. Low fertility of the F_1 (allotetraploids $2n = 68$ arose).
2. Total sterility of the F_2 because of the formation of allotriploids ($2n = 51$).
3. Loss of immunity to downey mildew in later generations because of repeated backcrosses with sunflower.
4. High heterozygosis of interspecfic hybrids which makes it difficult to release constant forms on immunity and the like characters.
5. Dominance of nearly all the negative characters of wild species for breeding.

Starting with earlier generations (F_1 and F_2) all estimation of hybrids was done on special plots inoculated with downey mildew, rust, broomrape, and sclerotinia.

Alongside with the field estimation of hybrids, artificial inoculation in greenhouses in winter time was also widely used. It permitted us to do preliminary estimations of breeding elite for resistance to downey mildew in a quantity of 20,000 progenies per season, and to broomrape in a quantity of 2000 numbers.

Later, resistant hybrids were analyzed in laboratories for oil content in kernels, fatty acid composition in oil, and for crude protein content in seeds. Preliminary studies have shown a more complex oil composition in interspecific hybrids of higher generations than in cultivated sunflower (Table 1).

Some hybrids involve up to ten fatty acid components. Most hybrids have a high linoleic acid content (from 42% to 66%).

Protein content has been found to vary from 17.1 to 34.0 percent depending on oil percentage of hybrid. Total protein and oil content in hybrids is very high (from 81.0 to 85.8 percent) (Table 2).

Hybrids of higher generations differ in seed and oil composition. This testifies to the fact that through interspecific hybridization it is possible to obtain hybrids of certain seed and oil compositon.

As a result of 7 years breeding work with the method of inter-hybrid crosses of resistant forms followed by multiple individual selection, we have succeeded in obtaining the material highly resistant to a whole range of sunflower diseases and pests (Table 3).

Due to high heterozygosis of interspecific hybrids, transpollinated plants, it became more complicated to release forms resistant to downey mildew and to maintain the immunity in progeny.

However, as a result of 4 years breeding work by the method of multiple individual selection with artificial inoculation of seedlings, we have succeeded in improving populations of hybrids in immunity to the pathogens. (Table 4).

During the period the number of immune families (0 affection) increased 4-fold, that of resistant families -3-fold (42%). Practically, families with severe infection (from 45 to 100%) nearly disappeared which enabled us to use for further work 70 percent of hybrid population. The latter involved completely immune and resistant hybrids (from 0 to 10% affection).

Of 2000 elite heads, there were released 550 numbers immune to downey mildew as against control with 100 percent affection.

It should be noted that artificial inoculation of seedlings with downey mildew proved to have much more agressive effect than field infestation even under the most severe conditions of infection.

The line with 20% affection by downey mildew under inoculation conditions, proved to be absolutely nonaffected on a heavily infected plot, whereas a susceptible variety-control under the same conditions rated 92% of affection.

Under severe infestation with Brachicandus hilichristi Kalt, in 1966 some wild species and hybrids were found to respond quite differ-

Table 1

Fatty Acid Composition of Oils from Interspecific Hybrids F_{11}
(H. tuberosus x H. annuus No. 8931)

Elite No.	ACIDS Lauric	Myristic	Pentadecanoic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic	Arachidic
175	0.4	0.4	0.5	6.1	0.6	3.8	38.1	46.8	1.6	1.7
822	0	0	0	7.5	1.0	4.0	30.2	43.5	10.8	1.4
765	0	0	0	6.4	0.1	2.8	28.3	62.2	0	0
772	0	0	0	7.8	0.3	2.6	25.2	64.2	0	0
694	0	0	0	5.2	0.4	4.6	46.2	43.5	0	0
746	0	0	0	6.0	0.3	5.1	46.3	42.3	0	0
No.8931	KO	0	0	6.6	0	3.7	35.4	54.4	0	0

Table 2

Mean per cent protein substances (dry seed basis) in seeds kernel of different hybrids F_{11} (H. tuberosus x H. annuus No. 8931) as influenced by oil content, 1967

Elite No.	Oil content in kernel, %	Crude protein content in kernel, %	Total content of oil and protein
338	67.4	18.4	85.8
337	66.2	17.1	83.3
220	62.5	22.9	85.4
379	60.7	23.6	84.3
135	51.9	32.1	84.0
147	50.3	33.0	84.0
70	47.0	34.0	81.0

Table 3

Superior families of interspecific hybrids F_{11} (H.tuberosus x H.annuus 8931) possessing group immunity to major diseases

Plot No.	Plants affected by downey mildew, %	Plants affected by broom-rape, %	Degree of infection with broomrape	Plants affected by rust, %	Intensity of infec-tion with rust	Seed percent with armored layer
419	0	0	0	0	-	100
K-8931[x]	76	40	5	100	10	100
K-A-41[xx]	82	78	12	100	15	96
538	0	0	0	0	-	100
K-8931	71	19	1.2	100	5	100
K-A-41	81	100	10.7	100	25	96
797	0	0	0	0	-	100
K-8931	91	20	1	100	5	100
K-A-41	98	85.7	12.5	100	15	96

[x]Control 8931 - resistant to broomrape

[xx]Control A-41 - susceptible to broomrape

Table 4

Results of hybrids selection for resistance to downey mildew Plasmopara halianthi f. helianthi Novot. by using inoculation method

Groups with percent infection	Infection with downey mildew, %	
	Year 1964 No. 1765	Year 1967 No. 2000
0	7.2	27.5
5-10	15.0	42.0
15-25	28.7	24.0
30-40	21.8	5.2
45-55	16.8	1.1
60-70	7.5	0.2
75-85	2.5	0
90-100	0.5	0

ently to the pest attack.

Hence, there arises a prospect of breeding sunflower varieties for immunity to pests through the method of interspecific hybridization.

Breeding for sclerotinia resistance is of particular importance as the disease refers to widely specialized selective saprophites. In 1966, sclerotinia immunity was found among wild species and their hybrids with sunflower; at present the F_2 immune hybrids have been obtained from crosses of resistant forms in the F_{10} of topinambur-sunflower hybrids (Table 5).

In spite of the fact that nearly all the negative characters of wild species dominate in hybrids, and it takes much time to have them cultivated through interspecific crossings, the ratio of the characters in the population of hybrids has been changed, and closely approached cultivated sunflowers in all these characters. It has been accomplished through the 7 year selection for oil content and huskness by subsequent open and purposive transpollination of the best hybrids.

Selections of breeding elite for productivity (amount and weight of seeds per head) enabled us to use heterosis and transgression occurring as a result of distant hybridization method utilized. In 1964, for instance, 30 percent of heads in the nursery of highly productive breeding elite had from 1900 to 4500 seeds per head. In 1967, over 1,000 heads weighed from 150 to 300 grams each, volume weight being much higher than that of cultivated sunflower.

Comparative studies of the yield of the best numbers in the breeding nursery of the first-year study showed a continuous increase of hybrid productivity as influenced by these selections. (from 1962 to 1966). The most prominent difference in yield between hybrids and control was observed in 1966 when regardless of unfavourable weather conditions hybrids as the most adapted plants maintained high seed yield per hectare exceeding the control by 57 to 70 percent. In some years, hybrid yield was as high as 40 to 42 centners per hectare (Table 6).

In 1966, hybrid oil yield per hectare was also the highest because of high seed yield harvested. The best hybrids gained as much oil as 3.12 centners/ha to 3.43 centners/ha. as compared with control (Table 7).

Though up to 1967 oil percentage of hybrids was much inferior to that of licensed sunflower varieties; however, 20 to 25% of numbers in the first-and second-year study exceeded the control in oil yield per hectare annually by 1.0 to 3.4 centners/ha because of high seed yield.

Low oil percentage and high huskness in achenes of hybrids hindered the best families of the interspecific hybrids to advance further in the breeding process.

However, in 1967 oil percentage of breeding elite of hybrids was equivalent to that of the best current sunflower varieties, ranging from 60 to 69% in absolutely dry kernels, 53.5% at the most in absolutely dry seeds. (Table 8).

Hybrids are studied by the progeny in the first-and second-year study nurseries. For this, the pairing method is used (KNN, KNN) with N8931 as a control-variety. Tests are done in two replications on the plot area of 7 mt^2 with hills 70 x 70 cms apart, and with two plants per hill.

A preliminary evaluation in 1967 on the progenies of 360 lines of the F_{11} hybrids in the first-year study nursery showed that a series of families combined resistance to downey mildew, broomrape, rust and sunflower moth with a superior oil yield up to 2 centners per hectare as against control. The families proved to be as good as the control at a whole range of agronomic characters (oil percentage, huskness, seed yield). (Table 9).

Fair results of two years tests of hybrids with pairing method in the first-and second-year study nurseries permit us to deliver the best families for preliminary and competitive variety testing to obtain first varieties with group immunity. (Table 10).

Interspecific hybrids are characterized by entirely new properties: wide range genotypical immunity to main sunflower diseases and pests; high seed yield and high volume weight up to 500 g/l of seeds; and new seed and oil composition inherited from wild species.

At present we have 15 combinations involving some thousands of numbers. These numbers have been obtained from crosses of 12 different poliploid wild species with cultivated sunflower; 8 combinations of which are in higher generations (F_5 - F_{11}) and of great practical value for breeding.

Thus, "distance hybridization" of cultivated sunflower with wild species Helianthus regardless of great difficulties confronted has opened wider prospects for sunflower breeding. The newly bred hybrid families immune to a whole range of sunflower diseases with high seed yield, and high oil content may be sown to vaster areas, may give higher oil yield per hectare making the sunflower crop more profitable.

(See following pages for Tables 8 - 10.)

Table 5

Results of inoculation of interspecific hybrids population of different combinations and generations with Sclerotinia libertiana Fuck., 1966

Hybrids generation	Number of heads inoculated with sclerotinia	Number of heads not affected with sclerotinia	Heads not affected by sclerotinia,%
F_1	86	86	100
F_2	92	92	100
F_3	81	36	44
F_4	27	14	52
F_5	125	56	45
F_6	388	117	30
F_7	97	30	31
F_9	74	16	22
F_{10}	1360	250	18
H. annuus	2000	0	0

Table 6

Seed yield increase of interspecific hybrids (H. tuberosus x H. annuus 8931) as influenced by selections in nursery of the first year study

Year	No.	Seeds litre weight g/l	1000 seeds weight g	Seed yield, centner/ha	Yield gain, centner/ha	Yield gain in relation to control, %
	26439	459.2	32.2	23.30	+ 3.0	14.7
	K	380.0	31.1	20.30		
1962	26466	465.6	35.5	24.40	+ 3.2	15.1
	K	396.8	32.2	21.20		
	1351	448.4	66.5	27.63	+ 4.7	20.6
	K	408.4	61.1	22.90		
1963	1376	444.8	73.6	27.83	+ 5.84	26.6
	K	407.6	64.0	21.99		
	28899	454.0	71.4	40.8	+11.0	36.9
	K	390.4	80.8	29.8		
1964	28796	441.6	70.7	42.5	+ 9.9	30.4
	K	424.4	78.5	32.6		
	29987	455.2	56.9	40.57	+10.05	32.9
	K	434.8	71.0	30.52		
1965	29981	422.8	54.8	33.99	+ 8.5	33.5
	K	406.8	63.3	25.46		
	31545	462.8	57.1	34.45	+12.5	57.6
	K	404.0	65.1	21.86		
1966	31534	454.2	64.1	35.82	+12.3	60.3
	K	397.6	61.5	20.47		

Table 7

Best numbers of interspecific hybrids F_{10} (H. tuberosus x No. 8931) possessing group immunity to downey mildew, broomrape, rust and sunflower moth, 1966

Elite No.	Seed percent with armored layer	1000 seeds weight, g	Seeds litre weight, g/l	% husk	Oil content in Kernel %	Oil content in seed %	Seed yield cent-ner/ha	Oil yield centner/ ha	Oil gain in relation to control centner/ha
31415	100	71	423	23	63.2	49.8	35.7	15.68	3.43
K-8931	100	69	417	20	63.4	51.9	26.8	12.25	-
31474	100	70	428	25	61.5	47.8	34.2	14.36	3.30
K-8931	100	65	400	21	62.0	50.3	25.0	11.06	-
31480	100	58	447	26	60.0	45.7	35.6	14.36	3.12
K-8931	100	66	409	21	62.0	50.6	25.2	11.24	-

Table 8

NN of interspecific hybrids F_{11} (H. tuberosus x H. annuus x No. 8931) superior in oil content in kernel and seed; tests of 1967

Analysis No.	1000 seeds weight, g	% husk	Oil content (dry seed basis) in kernel %	Oil content (dry seed basis) in seed %	Infection with downey mildew following inoculation, %
337	59	23.2	65.8	52.1	0
423	65	23.6	65.8	51.9	0
567	69	23.2	66.3	52.5	1
541	58	23.2	65.9	52.1	0
829	69	23.0	65.7	52.1	1
855	66	22.6	65.9	52.5	0
861	68	25.6	69.2	58.8	2
K-8931 avg.	54.5	22.6	69.9	49.3	100

Table 9

Superior numbers of hybrids F_{11} (H. tuberosus x H. annuus No. 8931) in nursery of the first year study, 1967

Elite No.	Seeds litre weight, g	% husk	Oil content in kernel %	Oil content in seed %	Seed yield, centner/ha	Oil yield centner/ha
32731	437.8	24.2	62.2	48.7	36.7	15.7
K-8931	412.8	22.5	62.3	49.7	31.3	13.7
32679	435.4	22.0	62.6	50.2	32.2	14.2
K-8931	429.6	22.3	59.8	47.8	32.6	13.7
32799	423.6	23.5	61.0	48.9	33.2	14.0
K-8931	413.2	23.0	60.7	48.13	29.6	12.6

Table 10

Results of 2 years testing of interspecific hybrids F_{11} (H. tuberosus x 8931) in nurseries of the 1st and 2nd year study

Elite No.	Seed percent with armored layer	1000 seeds weight, g	Seeds litre weight g/l	% husk	Oil percentage in absolutely dry		Seed yield, centner/ha	Oil yield, centner/ha	Oil gain in relation to control, centner/ha	Oil gain in relation to control, %
					kernel	seeds				
31415	100	67.4	428.15	23.95	62.38	48.94	34.41	14.83	+2.93	24.1
K-8931	100	64.9	421.2	21.3	62.67	50.65	26.71	11.90		
31616	100	59.0	451.5	25.95	60.79	46.44	35.07	14.34	+2.93	25.6
K-8931	100	68.5	427.0	22.2	62.8	50.28	25.78	11.41		
31534	100	59.75	458.65	32.5	60.33	42.7	35.12	13.30	+2.02	18.0
K-8931	100	67.95	424.2	22.7	61.92	48.95	26.02	11.28		

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DISCUSSION

Kinman: Have any of these advanced generation selections been used as parents of F_1 hybrids using the male sterility from the regular male sterile lines?

Pustovoit: The principle for the method was overcoming male sterility for the first generation and after that she looked through many thousands and she did not find male sterility even once.

Kinman: Have the male sterility plants been used as parents? Those generations which have been developed highly from male sterility, have they been used as parents for crosses? What sort of results did you get?

Pustovoit: Mr. Gundeave is in charge of this section. We do not have that information.

Question: Was the plant breeding achieved through selection or through backcrossing?

Pustovoit: Only in the first two generations. They crossed the cultural sunflower and later on crossed only the selected hybrids. It is very easy to lose the amenity.

Hoes: Did I understand that resistance in later generations disappeared?

Pustovoit: In the first generation they were immune to Sclerotinia. After that, because she did not control, many biotypes appeared to which the lines were susceptible. 20% of the hybrids were found to be resistant to Sclerotinia.

Question: Was this root knot you showed on the slide a nematode?

Pustovoit: No, it was related to the amenity to broomrape.

Hoes: Are there different manifestations of Sclerotinia?

Pustovoit: In the central Black Region of our country there are two forms of Sclerotinia - heads and stems. However, in the Krasnodar region we find Sclerotinia almost entirely on the stems - very rarely on the heads.

Johnson: I was very amazed at the vigor that the F_{11} was showing. Were you using an inbreeding system similar to the pure line system we use in small grains or were these sib-progenies?

(Not answered clearly, but Mr. Kinman suggested that the Pustovoit method does not use line breeding).

Kinman: Has there been any attempt to make inbred lines from selections after these highly desirable characteristics have been isolated?

Pustovoit: I used inbreeding only to get more homozygous material but the productivity of my hybrids was obtained in that the selection method established by Academician Pustovoit has been so successful that the resulting lines compete with the inbred line method.

Hoes: What makes your program so very successful?

Pustovoit: The materials I used for hybridization were the best materials produced and developed by Academician Pustovoit, my father, and the methods applied by him made possible the high oil content which I was able to procure. I have been very successful using my father's methodology, and at least for the immediate future I plan to continue this approach and do not have any intention of following the inbred line system.

Kinman: I do not know of any lines now which have been created by the method of inbreeding which have oil-bearing characteristics surpassing those developed in varieties by Academician Pustovoit. The question that Dr. Hoes raised about why the varieties developed in Russia are higher in oil there than they are on this continent is probably explained by environment. I have a special plea to put out to plant breeders in North and South America - if you have some wild species of sunflowers of which you could send me the seeds, I would be most grateful to put them in the breeding program. They would be very helpful as an addition to materials in the Soviet Union.

Almgard: The fastest results in selection as you have developed varieties seems to be for selection of oil.

Pustovoit: We have found that selecting for the number of seeds or the amount of oil seems to give us about the same result. So you can use either one - oil content or yield of kernel - the result will be the same. At the Krasnodar Institute we determine oil content on a great scale because we want to know immediately this characteristic for all our selections.

Knowles: As you increase kernel yield and oil content do you change in any way fatty acid composition of the oil?

Pustovoit: We have no special program about the composition of the oil. Actually, Academician Pustovoit worked on sunflowers for over 30 years before we looked at the fatty acid content of the high-oil varieties which he developed. As we looked at the varieties, we found that the linoleic acid composition is higher in the high-oil varieties. In the older varieties they were about 50% linoleic acid and in the newer varieties they run about 58% and up as high as 65% in some of the latest varieties.

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