EFFECT OF ENVIRONMENTAL FACTORS ON THE CONTENTS OF OIL AND PROTEINS AND SOME PARAMETERS OF OIL QUALITY OF SUNFLOWER HYBRIDS

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INTRODUCTION

The sunflower is counted among the principal oil crops; its oil content is as important as its seed yield. Besides a high oil content, sunflower seed contain proteins which may be used for various purposes. More recently, the quality of sunflower oil has started to be paid larger attention.

New sunflower hybrid introduced recently into the commercial production have a higher genetic divergence than the previously grown Soviet varieties.

However, our knowledge of chemical characters of hybrid seed as well as of the effect of environmental factors on the expression of these characters is incomplete.

A number of authors found significant differences in oil contents of different sunflower genotypes (Morozov, 1947; Pustavoit, 1963; Schuster, 1964; etc.). Environmental factors affect considerably the processes of oil accumulation in sunflower seed. Many authors found a correlation between the oil content in sunflower side on one side and soil factors, air temperature, relative air humidity, rainfall, mineral nutrition, and the region of growing on the other. A similar correlation was found between the environmental factors and the protein content in sunflower seed.

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To gain knowledge of the biological values of sunflower oil, it is important to investigate the correlation between oil quality and environmental factors. First studies in this field were conducted by Rushkovski (1957) and Dubljanskaja and Malisheva (1963).

Dubljanskaja and Malisheva (1963) found large differences among sunflower varieties in the values of iodine number. The differences were conditioned by environmental factors. There are numerous literature data on the variability in the composition of higher fatty acids in sunflower oil. Robertson et al. (1978) reported of a high variability in oil content and in the composition of higher fatty acids as affected by environmental factors. Schuster and Škorić (1978) found a correlation between the tocopherol content in oil and environmental factors. Malisheva (1967) announced to have found differences in refraction index, peroxidase number, and the percentage of free fatty acids in oil of different sunflower varieties.

The objective of this investigation was to determine the effect of agroecological conditions of various sunflower-growing regions of Yugoslavia on the formation of oil and protein contents in seed and on some parameters of oil quality of commercially grown sunflower hybrids.

MATERIAL AND METHODS

We tested the hybrids NS-H-26-RM, NS-H-27-RM, NS-H-31-RM, NS-H-62-RM, and NS-H-63-RM as well as a Soviet variety VNIIMK 8931 which had been grown in commercial production before the introduction of NS hybrids.

Large-plot trials were conducted in several sunflower-growing regions of Yugoslavia. The seed from 1979 trials conducted in six localities were used. The network of large-plot trials included three localities in Vojvodina, differing in soil types (Kovilj, Zrenjanin, Subotica), and other three localities in Serbia, Macedonia, and Bosnia and Herzegovina.

Oil content in seed was determined on an NMR analyser manufactured by "J. Štefan", Ljubljana, protein content by Kjeldahl's method, iodine number after Hanush (JUS, E.K. 8.028 x 1962), higher fatty acids on a Hewlett-Packard gas chromatograph. The results include only two most important higher fatty acids-oleic (18:1) and linoleic (18:2). Total phosphorus content in seed was determined by AOCS official method Ca 12-55.

The obtained results were statistically calculated. It should be

pointed out that the selected localities differed in soil type, precipitation level and distribution, temperature, relative air humidity, and other factors. Cultural practices applied in the course of vegetation were similar in all localities, differing only in the levels of mineral fertilization which were intended to secure similar levels of provision by nutrients in all localities.

RESULTS AND DISCUSSION

The average oil contents in seed for the six localities did not differ largely. NS-H-26-RM had the lowest average oil content (46.99%), NS-H-63-RM had the highest (48.98%). The average oil content of the variety VNIIMK 8931 was 47.26%. Differences between the hybrids and the variety in oil content were not significant (Table 1). However, the oil contents of the examined hybrids varied significantly from one locality to the other. Bogatič had the least favorable conditions for oil content formation, which resulted from a number of factors and their interactions. This locality had the poorest soil (sandy and with deep ground water table), high variations of temperatures and relative air humidity, all of which led to a premature ripening. In this locality, four hybrids had the lowest oil contents for the entire experiment.

TABLE 1

Oil content in seed, in %

No.	Hybrid (Variety)	Locality						Average
		Bogatič (Sabac)	Zrenjanin	"Pešćara" (Subotica)	Kovilj (Novi Sad)	Radobor (Bitolj)	Bošnjaci (Brcko)	
1	VNIIMK 8931 con.	45,97	43,09	46,56	48,81	49,74	49,40	47,26
2	NS-H-26-RM	42,51	44,71	47,09	48,72	48,71	50,22	46,99
3	NS-H-27-RM	44,78	46,66	48,59	49,68	52,28	51,59	48,93
4	NS-H-31-RM	44,79	45,40	48,20	47,79	52,79	51,41	48,39
5	NS-H-62-RM	46,08	45,84	48,37	48,65	52,11	48,56	48,26
6	NS-H-63-RM	44,75	46,29	48,41	52,09	49,94	52,44	48,98
	Average of locality	44,81	45,33	48,02	49,29	50,92	50,60	48,13

LSD — 5% = 2,76%
1% = 3,73%

Low oil contents were obtained also in Zrenjanin. The limiting factor there was insufficient rainfall during the larger part of the vegetation. VNIIMK 8931 and NS-H-62-RM had lowest oil contents in this locality.

The localities of Subotica and Kovilj had more favorable environmental conditions for the accumulation of oil in seed. Oil contents were quite similar in these two localities, with the exception of NS-H-63-RM. In these localities unfavorable environmental factors interrupted the vegetation later, at the end of the process of oil synthesis, which is the reason why all hybrids had similar oil contents.

The localities of Bitola and Brčko had the most favorable conditions for oil synthesis —the distributions of rainfall were uniform throughout the vegetation and there were no high temperature variations during the stage of oil accumulation. Three hybrids had highest oil contents in Bitola, two in Brčko.

In general, differences between highest and lowest oil contents caused by specific conditions of the localities were similar with all hybrids.

Protein contents in seed were highly variable from locality to locality. Highest average protein content was found in Bogatić, where the average oil content was lowest. Out of the six examined genotypes, four had the highest protein contents in this locality. The

TABLE 2

Protein content in seed, in %

No.	Hybrid (Variety)	Locality						Average
		Bogatic (Sabac)	Zrenjanin	"Pescara" (Subotica)	Kovilj (Novi Sad)	Radobor (Bitolj)	Bosnjaci (Brcko)	
1	VNIIMK 8931 con.	18,25	17,25	14,81	14,62	17,12	15,06	16,18
2	NS-H-26-RM	15,93	16,62	15,93	14,87	13,45	12,00	14,80
3	NS-H-27-RM	18,06	17,06	14,93	16,25	16,93	16,25	16,58
4	NS-H-31-RM	15,31	16,68	14,56	14,06	14,50	14,37	14,91
5	NS-H-62-RM	17,56	16,81	14,37	13,62	14,43	16,68	15,57
6	NS-H-63-RM	18,93	17,68	14,50	11,81	16,68	14,06	16,61
	Average of locality	17,34	17,01	14,85	14,20	15,51	14,75	15,60

LSD — 5% = 1,40%
1% = 1,89%

other two (NS-H-26-RM and NS-H-31-RM) had the highest protein contents in Zrenjanin, the locality which was also characterized by low oil contents (Table 2).

Three hybrids and VNIIMK 8931 had the lowest protein contents in Kovilj, NS-H-27-RM in Subotica, and NS-H-26-RM in Brčko (only 12%). NS-H-27-RM and NS-H-63-RM had highest protein contents in the same localities in which they had lowest oil contents. The other hybrids had maximum protein contents accompanied by reduced but not minimum oil contents.

In Kovilj, four hybrids had their lowest protein contents while their oil contents were above their averages for all localities and the variety VNIIMK 8931. A more detailed analysis of soil and other factors (temperature, humidity, rainfall) is required to determine which factor limited the expression of proteins in seed.

NS-H-26-RM had the maximum protein and oil contents in the same locality (Bitola).

NS-H-63-RM showed the highest variability in protein content as affected by environmental factors —the maximum content was 18.93 (Bogatić), the minimum 11.81% (Kovilj).

NS-H-27-RM had the highest average protein content (16.58%), NS-H-26-RM the lowest (14.80%). Only these two hybrids had significantly different protein contents at 5%.

The average contents of total phosphorus were similar for all hybrids except NS-H-62-RM which had a somewhat lower content on account of an extremely low phosphorus content in soil in the locality of Brčko (Table 3).

In spite of small differences in average values, there were considerable differences in total phosphorus of individual hybrids grown in different localities. Significant differences were also found among the hybrids in one locality as well as between the localities.

The hybrids and the variety VNIIMK 8931 had highest contents of total phosphorus in seed in the localities in which the oil formation in seed was poorest (Bogatić and Zrenjanin). In these localities, differences in phosphorus contents among the hybrids were smallest. The lowest average phosphorus content was obtained in Bitola, where the oil formation was best. These results show that when conditions are favorable for the expression of oil content the accumulation of phosphorus is low, and vice versa.

In Brčko, NS-H-62-RM had only 0.17% of phosphorus in seed. NS-H-63-RM showed a similar reaction in Subotica, NS-H-26-RM in Bitola. The hybrids showed specific reaction to environmental conditions regarding the processes of phosphorus accumulation in seed.

TABLE 3

Total phosphorus content in seed, in %

No.	Hybrid (Variety)	Locality						Average
		Bogatic (Sabac)	Zre-njanin	"Pesca-ra" (Subotica)	Kovilj (Novi Sad)	Rabodor (Bitolj)	Bo-snjaci	
1	VNIIMK 8931 con.	0,49	0,40	0,48	0,35	0,35	0,41	0,41
2	NS-H-26-RM	0,41	0,48	0,39	0,45	0,25	0,46	0,40
3	NS-H-27-RM	0,43	0,49	0,35	0,36	0,36	0,45	0,40
4	NS-H-31-RM	0,46	0,35	0,44	0,41	0,39	0,44	0,41
5	NS-H-62-RM	0,40	0,39	0,33	0,40	0,30	0,17	0,33
6	NS-H-63-RM	0,45	0,47	0,28	0,39	0,39	0,39	0,39
Average of locality		0,44	0,43	0,37	0,39	0,34	0,38	0,39

LSD — 5%=0,07%
1%=0,10%

TABLE 4

Value of iodine number in oil

No.	Hybrid (Variety)	Locality						Average
		Bogatic (Sabac)	Zre-njanin	Pesca-ra" (Subo-tica)	Kovilj (Novi Sad)	Rado-bor (Bitolj)	Bosnja-ci) (Brcko)	
1	VNIIMK 8931 con.	139,9	128,3	130,3	130,2	131,1	128,0	130,4
2	NS-H-26-RM	134,1	125,9	130,5	132,2	133,2	132,1	131,3
3	NS-H-27-RM	135,5	126,4	131,5	131,8	132,7	130,3	131,3
4	NS-H-31-RM	136,5	130,9	130,2	128,0	132,6	134,4	132,1
5	NS-H-62-RM	135,2	130,5	130,4	133,1	132,1	130,1	131,9
6	NS-H-63-RM	135,2	130,0	132,4	132,4	130,4	129,6	131,6
	Average of locality	135,2	128,6	130,8	131,2	132,0	130,7	131,4

LSD— 5% = 2,9%
1% = 4,0%

The iodine number as an indicator of the non-saturation of fats, i.e., of the present double bonds, affects considerably the quality of oil. The hybrids had similar values of iodine number (Table 4), but their reactions to environmental were specific. All hybrids and VNIIMK 8931 had the highest values of iodine number and smallest differences between the values in Bogatic. In this locality, the interaction among the environmental factors interrupted the oil synthesis but improved the accumulation of proteins and phosphorus in the seed of the majority of the hybrids. The examined parameters of oil quality were expressed specifically —the hybrids had high values of iodine number and the highest values of linoleic acid. The contents of oleic acid (18:1) were low which is understandable in view of a high negative correlation in the contents of these two fatty acids.

Although low oil contents were registered both in Bogatic and in Zrenjanin, all hybrids and VNIIMK 8931 showed significant differences in the values of iodine number in these two localities. It indicates that these localities differed in the environmental factors which affect the expression of iodine number.

In the other localities, there were small differences in the values of iodine number although the localities differed in a number of agroecological factors.

Alpha-tocopherol and the composition of higher fatty acids determine the biological value of oil. Linoleic acid (18:2) is particularly

TABLE 5

Percentage of oleic acid (18:1) in oil

No.	Hybrid (Variety)	Locality: Bogatic (Sabac)	Zrenjanin	"Pescara" (Subotica)	Kovilj (Novi Sad)	Radobor (Bitolj)	Bosnjaci (Brcko)	
1	VNIIMK 8931 con.	*19,4*	20,3	19,9	**23,3**	22,5	20,1	20,9
2	NS-H-26-RM	*19,1*	20,0	21,0	21,4	**22,0**	19,5	20,5
3	NS-H-27-RM	*17,1*	20,0	19,9	**23,0**	21,3	21,6	20,6
4	NS-H-31-RM	*18,7*	18,7	18,7	21,6	**22,8**	21,5	20,3
5	NS-H-62-RM	*19,2*	19,4	19,8	**21,8**	19,5	21,7	20,2
6	NS-H-63-RM	19,1	19,9	19,2	**21,8**	20,2	*18,8*	19,8
	Average of locality	*18,7*	19,7	19,7	**22,3**	21,3	20,5	20,3

LSD — 5% = 3,6%
1% = 4,9%

TABLE 6

Percentage of linoleic acid (18:2) in oil

No.	Hybrid (Variety)	Locality						Average
		Bogatic (Sabac)	Zre-njanin	"Pe-scara" (Subo-tica)	Kovilj (Novi Sad)	Rado-bor (Bitolj)	Bo-snjaci (Brcko)	
1	VNIIMK 8931 con.	**68,3**	66,9	67,6	*64,5*	65,2	68,1	66,7
2	NS-H-26-RM	**68,6**	67,1	66,0	66,5	*65,3*	68,3	66,9
3	NS-H-27-RM	**70,1**	66,9	66,2	63,6	65,2	*63,5*	65,9
4	NS-H-31-RM	**69,7**	68,9	68,9	65,6	*64,8*	66,7	67,4
5	NS-H-62-RM	**68,1**	67,9	67,1	*65,4*	67,7	66,5	67,1
6	NS-H-63-RM	68,6	66,3	67,7	*65,6*	66,7	**69,0**	67,3
	Average of locality	**68,9**	66,3	67,2	*65,2*	65,8	67,0	66,8

LSD — 5% = 1,4%
1% = 1,9%

important. It is desirable to have high alpha-tocopherol and linoleic acid contents in oil. The optimal ratio between the two is 0.7. Numerous studies proved the existence of a negative correlation between the contents of linoleic and oleic acids which, in turn, is positive from the aspect of oil quality.

The hybrids and the variety VNIIMK 8931 did not differ much in the average values of linoleic acid and oleic acid. In some localities, however, the contents of linoleic and oleic acids differed significantly from hybrid to hybrid. Depending on the locality, the contents of linoleic acid were more variable than the contents of oleic acid (Table 6).

Highest contents of linoleic acid and lowest contents of oleic acid were found in Bogatić (Table 5). These results confirm the existence of a negative correlation between these two acids in sunflower oil.

In the agroecological conditions of Kovilj, where the majority of the hybrids had higher oil contents than the average, the average content of oleic acid was highest and the average content of linoleic acid lowest. These results indicate that the expression of linoleic, oleic, and other higher fatty acids is largely affected by certain agroecological factors.

It may be concluded that environmental factors affected considerably the expression of the examined characters. A more detailed

analysis of agroecological conditions is necessary to determine which factors affect the expression of the examined characters and in which period their effects are dominant.

ABSTRACT

Sunflower hybrids were examined in a network of large-plot trials established in different sunflower-growing regions of Yugoslavia. The results showed that environmental factors affected largely the expression of oil, protein, and phosphorus contents in seed as well as some parameters of oil quality.

Commercially grown sunflower hybrids have similar genetic potentials for oil content in seed but the realization of this character varied in different agroecological conditions. The examined hybrids and the control variety had lowest oil contents in two localities in which conditions were unfavorable for a larger part of the vegetation. Water provision (rainfall), air temperature, and relative air humidity contributed significantly to the accumulation of oil.

The hybrids had highest oil contents in the locality with the best distribution of rainfall and lowest temperature variations at the stage of seed filling (Bitola).

The hybrids had similar genetic potentials for protein content in seed. Highest protein contents were obtained in localities in which oil contents were low, indicating differences in the requirements of sunflower plants regarding the accumulation of oil and proteins in seed.

The contents of total phosphorus were variable, as affected by the locality of growing. Similarly to the protein content, maximum phosphorus contents were found in localities which conditioned low oil contents.

The values of iodine number varied significantly, in dependance of the locality of growing. Highest values were found in Bogatic and Zrenjanin although oil contents in these localities were different. The composition of higher fatty acids varied significantly, in dependance of the locality. Largest effects of environmental factors on the contents of oleic (18:1) and linoleic (18:2) acids were observed in Bogatić —the majority of the examined hybrids had the lowest contents of oleic acid and highest contents of linoleic acid in this locality.

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