VARIABILITY OF SUNFLOWER OIL YIELD IN EUROPE AS INFLUENCED BY CULTIVAR OIL CONTENT

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INTRODUCTION

The experimentation of sunflower cultivars in international trials conducted co-operatively within the F.A.O. Research Network on Sunflower provided a large amount of data regarding the interaction of the most important agronomic traits with the various environmental conditions existing in Europe. In this paper, we tried to explore the results concerning a staple trait — the oil content — and its contribution to oil yield formation.

Data were published in the Scientific Bulletin "Helia", Numbers 1/1978, 3/1980, 5/1982 and 7/1984, under the co-ordination of the Research Institute for Cereals and Industrial Crops of Fundulea, Romania, as Co-ordination Centre of Sunflower Network.

MATERIALS AND METHODS

Source of results. Experiments were carried out in four biennial experimental cycles including the years 1976—1977, 1978—1979, 1980—1981 and 1982—1983. Certain changes occurred in each cycle as to the number of entries as well as of localities ; the experimental set of genotypes was changed every two-years corresponding to the intensive development of sunflower hybrid breeding. The number of localities and hybrids or cultivars in each experimental cycle was as follows (Table 1).

Table 1

Number of localities and hybrids or cultivars

Years	Maximum number of localities	Number of genotypes
1976—1977	14	19
1978—1979	12	32
1980—1981	14	58
1982—1983	16	25

Evaluated traits. The evaluated traits were oil yield per area unit and its two single components : yield of achenes per area unit and achene oil content. These traits are in a mutual relation leading to the development of a three-trait system, representing a close entity. In addition, both components can be compensated to a considerable degree ; thus they form a pair of traits designated as "traits on balance". If the system of three traits (the complex and its two components) fulfils the two given assumptions, i.e. integrity and compensability of the components, relatively simple numerical and graphical methods can be used for evaluation of the relation between these traits. The system of three traits defined in this way can be illustrated as in *figure 1,* where 1 represents the complex trait, 2 and 3 are components, $\times$ is a residual factor, P_{ij} are path coefficient, and r_{ijk}, partial correlation coefficient.

Evaluated localities. The condition for the inclusion of any locality was its participation in at least 4 years, i.e. half of the experimental years (*Table 2*).

The total span of 37.6 — 52.3° north latitude makes almost 15° north latitude span and represents a somewhat larger extent than the actual one in what sunflower for oil is grown in Europe. The optimum interval for growing sunflower in Europe can be considered between 41 and 48° north latitude, but the best conditions are between 43 and 46° north latitude. Within this span there occur 12 and 8 localities, respectively, included in this evaluation.

RESULTS

Among the studied parameters, the relation factor (ratio of directional coefficient) was evaluated. At the same time, we tried to determine the variability of achene oil content under the geographic conditions of Europe and the share of this trait in the total oil yield. Average oil content reached in single localities and its variation span in single years are given in *Table 3.*

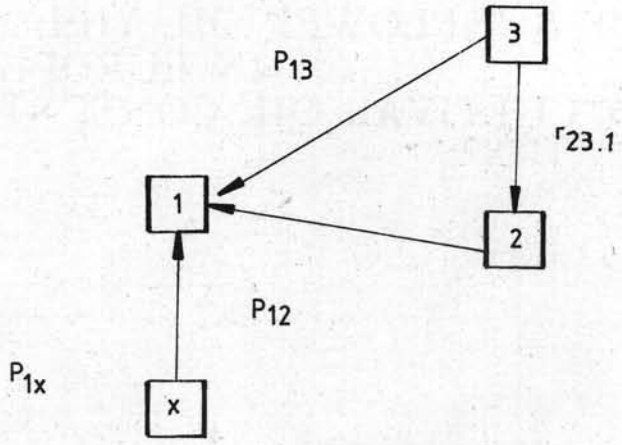

Fig. 1. — The system of three traits illustrated graphically

The variation span of the whole set of average oil contents varies between 40.6—53.3, i.e. within the limits of 12.7 %. The variation span between localities is 44.7—51.4, i.e. 6.7 % and between years 46.9—49.1, i.e. 2.2 %. The variability of oil yield within single years is not very expressive. Within single experimental cycles, the difference between two years was often larger than the mutual difference between cycles. From this finding, the rank of experimental factors as for their effect on the variability of oil content can be at least approximately estimated. The largest variation is caused by localities, a substantially smaller variation by years and the smallest one by changes in the set of cultivars or hybrids. In the majority of localities, the minimum oil content reaches at least 43 % and the maximum one 50—53 %. Most often the variation span varies between 5—8 %. Average oil content is low in the most northern and in the most southern areas not reaching 46 % in either case. Average path coefficient P_{12} (achene yield — oil yield) reaches

Table 3

Variation of oil content by countries and years

Country	Average oil content (%)	Variation span
Spain	45.7	43.6—48.7
Portugal	47.8	43.1—51.4
Turkey	46.0	42.3—50.4
France (1)	50.1	48.7—52.7
France (2)	51.4	49.6—53.3
Bulgaria	46.7	43.8—49.6
Italy	44.7	40.6—48.3
Romania (1)	50.0	47.8—51.3
Yugoslavia	46.0	42.0—51.3
France (3)	49.1	45.8—50.7
Hungary (1)	47.7	45.2—51.7
Hungary (2)	47.6	44.4—51.0
Romania (2)	50.4	48.8—52.4
Czechoslovakia	47.8	42.7—50.7
Germany F. R.	45.9	45.0—46.7
Poland	45.5	43.8—48.9

Table 2

Countries and localities

Country	Locality	Experimental years	North latitude (degrees)
Spain	Cordoba and Sevilla	4	37.6
Portugal	Elvas	5	38.7
Turkey	Yesilköy	5	41.1
France (1)	Aude	5	43.1
France (2)	Montpellier	4	43.6
Bulgaria	General Toshevo	6	43.9
Italy	Pisa	5	44.0
Romania (1)	Fundulea	8	44.5
Yugoslavia	Novi Sad	8	45.4
France (3)	Clermont Ferrand	4	45.9
Hungary (1)	Szeged	5	46.1
Hungary (2)	Iregszemcse	8	46.6
Romania (2)	Podu-Iloaie	6	46.8
Czechoslovakia	Bratislava and Topolcany	4	48.2
Germany F. R.	Giessen	4	50.6
Poland	Poznan	5	52.3

Table 4

Values of directional coefficients

Country	Share in % on $P_{12}+P_{13}$	
	P_{12}	P_{13}
Spain	58.6	41.4
Portugal	80.9	19.1
Turkey	67.5	32.5
France (1)	78.7	21.3
France (2)	55.3	44.7
Bulgaria	68.2	31.8
Italy	70.9	29.1
Romania (1)	59.3	40.7
Yugoslavia	71.2	28.8
France (3)	68.2	31.8
Hungary (1)	67.8	32.2
Hungary (2)	66.1	33.9
Romania (2)	67.8	32.2
Czechoslovakia	63.7	36.3
Germany F. R.	72.8	27.2
Poland	76.9	23.1

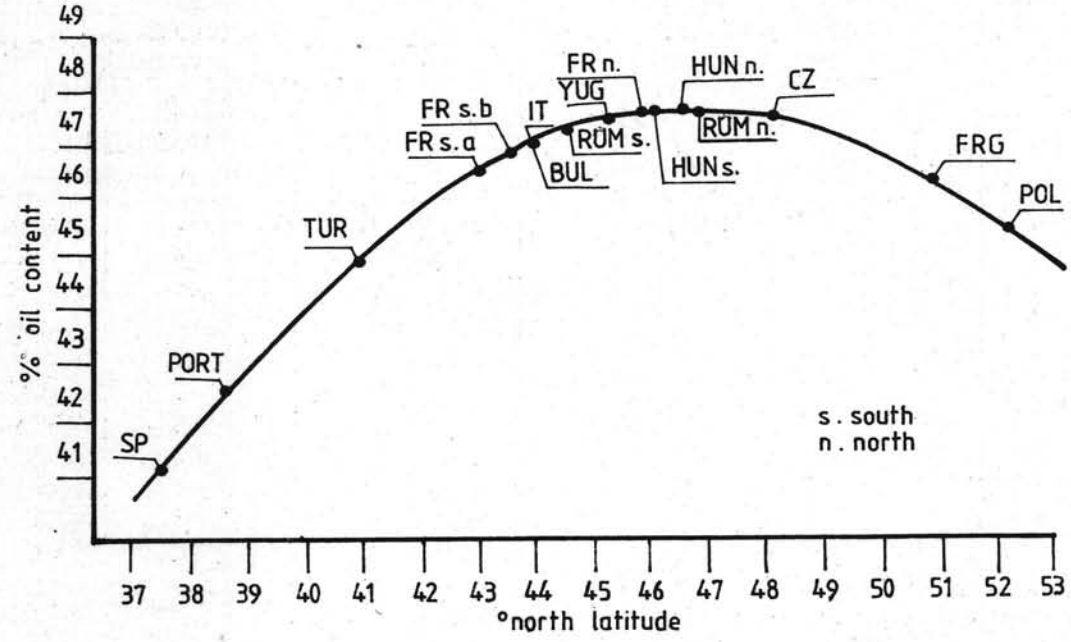

Fig. 2. — Relation north latitude — oil content
($y = -115.65 + 6.957\ x - 0.0741\ x^2$)

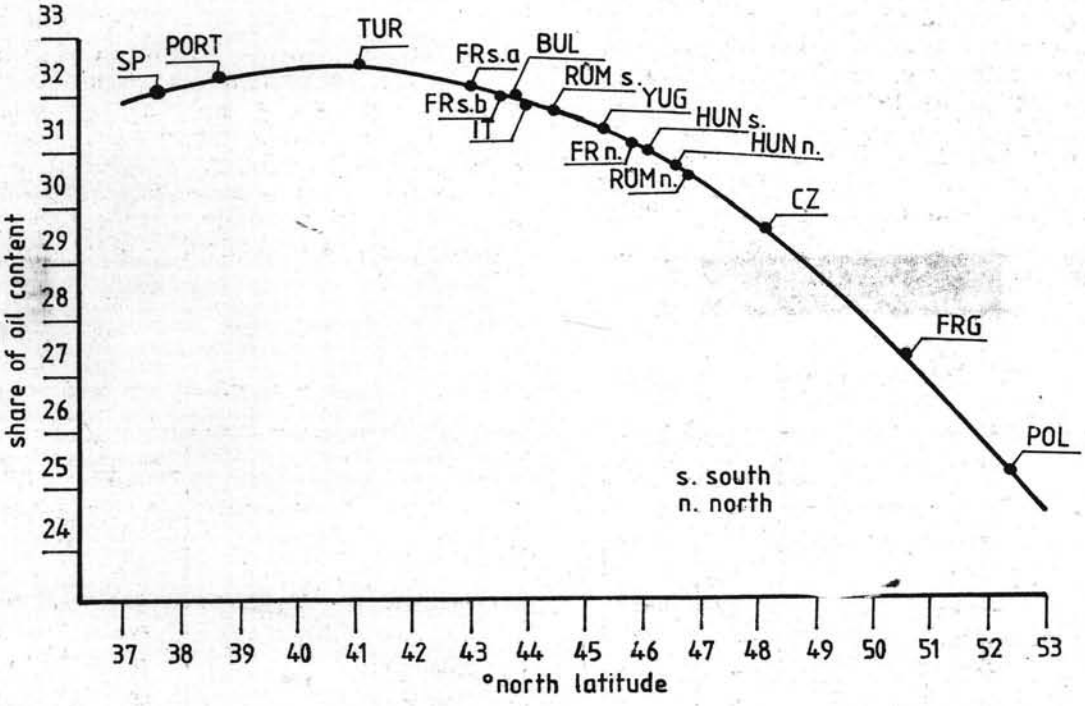

Fig. 3. — Relation north latitude — share of oil content
($y = -22.0 + 2.0\ x - 0.0004\ x^3$)

the value 0.887 and P_{13} (achene oil content — oil yield) the value 0.409. More than 75 % of P_{12} data from single localities and in various years show the value 0.8, i.e. a very close relation. Maximum P_{12} values close to 1.0 are characteristic for Federal Republic of Germany and Poland, i.e. for the most northern localities. In these areas the achene yield is of a decisive importance.

The most frequent cases are P_{13} values between 0.1 and 0.5 that occur in 71 % of data. Of the biennial experimental cycles, the cycle 1978—1979 with P_{13} value about 0.5, was the most suitable one for the increased effect of oil content on the oil yield. According to the P_{13} values, the years 1980—1981 follow with P_{13} value about 0.4, then 1982—1983 with P_{13} value between 0.3 and 0.4, and finally the years

1976—1977 with P_{13} value about 0.3 were the less suitable ones for the materialization of the effect of oil content. Values of directional coefficients expressed in % of their share in the common sum for single localities are summarized in the *Table 4.*

The average values of the relative P_{12} and P_{13} share are 68.6 % and 31.4 %, respectively. South France (Montpellier) shows an extremely high share of oil content on oil yield whereas the lowest effect of oil content on oil yield is evident in Portugal (Elvas). The relation between the given parameters was evaluated by calculating the equations of quadratic and cubic regression. Relation north latitude — oil content $y = -115.65 + 6.957\ x - 0.0741\ x^2$. North latitude — share of oil content $y = 22.0 + 2.0\ x - 0.0004\ x^3$. The set of localities shows a rather broad span in the calculated values of oil content. The minimum in Spain represents 41 %, the maximum in Hungary more than 47.4 %. Within the span of north latitude from 45° to 48°, i.e. between Yugoslavia and Czechoslovakia stretches the area of the maximum oil content that include six localities representing the northern zone of commercial sunflower growing in Europe. In additional six localities between 43° and 45° north latitude on the one hand, and between 48° and 51° north latitude on the other hand, the oil content reaches still a relatively high level. All localities situated south of 42° and north of 52° have a less suitable oil content from the point of view of production (course of dependence in Fig. 2). The calculated values for the share of oil content on oil yield show a high effect even of a low oil content also in the southern areas of Europe. It is evident that the maximum share of oil content on oil yield has manifested in South European localities moreover situated close to the sea, and a lower share of oil content in the northern and inland areas. Six localities with the highest oil content also belong to this second group (course of dependence in Fig. 3).

CONCLUSIONS

If temperatures and precipitations at single localities are considered, the obtained information can be summarized into the following points deduced from the comparison of the course of both relations.

1. Localities in the area 45—48° north latitude showed the highest oil content.

2. The highest share of oil content on oil yield was evident in localities between 38° and 43° north latitude.

3. Localities situated more toward the north than 49° north latitude had a low oil content and at the same time a low share of oil content in oil yield.

4. In the areas over 44° north latitude increased humidity of locality resulted in a reduced share of oil content in oil yield.

In the southern areas the oil content in relation to oil yield materializes in an increased degree or in a corresponding mode. In intermediately located areas it materializes in a corresponding mode or a somewhat decreased degree and finally in the northern it materializes less than it corresponds to its level.

L'INFLUENCE DE LA TENEUR EN HUILE SUR LA VARIABILITÉ DES RENDEMENTS EN HUILE DE TOURNESOL EN EUROPE

Résumé

Partant des données obtenues par le Réseau F.A.O. de recherches pour le tournesol dans la période 1976—1983, les auteurs ont évalué la variabilité de la teneur en huile des akènes dans les conditions géographiques d'Europe et la contribution de ce caractère au rendement total d'huile.

La plus haute teneur en huile a été enregistrée dans les localités situées entre 45—48° latitude nordique. Dans les localités entre 38°, et 48° latitude nordique, la teneur en huile a eu la plus grande contribution à la formation du rendement en huile. Dans les localités plus au nord que 49° latitude, la teneur en huile a été plus faible et en même temps a eu une moindre contribution à la formation du rendement en huile. Dans les zones plus nordiques que 44° latitude, à cause d'une plus grande humidité, la teneur en huile a peu contribué à la formation du rendement.

VARIABILIDAD DEL RENDIMIENTO EN ACEITE DEL GIRASOL DE ACUERDO CON EL CONTENIDO EN ACEITE DEL CULTIVAR

Resúmen

Utilizando los datos obtenidos dentro de la red F.A.O. de girasol durante el periodo 1976—1983, los autores evaluan la variabilidad en el contenido de aceite del girasol de acuerdo con las condiciones geográficas en Europa, así como la participación de éste caracter en la totalidad del rendimiento en aceite. Los más importantes puntos concluidos son los siguientes.

Las localidades entre 45° y 48° de latitud norte muestran los más altos contenidos en aceite. La mayor participación del contenido de aceite en el rendimiento total de éste era evidente en las localidades situadas entre 38° y 43° de latitud Norte. Las localidades situadas más al Norte de 49° de latitud Norte, mostraron un bajo contenido en aceite y al mismo tiempo una baja participación del contenido de aceite en el rendimiento total de éste. En áreas del Norte de 44° de latitud Norte, el incremento en humedad de la localidad resultó en una reducida participación del contenido de aceite en el rendimiento de aceite.