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RESULTS OF THE INTERNATIONAL TRIAL WITH SUNFLOWER HYBRIDS
I. Morpho-physiological characteristics

M. Mihaljčević

University of Novi Sad
Faculty of Agriculture
Institute of Field and Vegetable Crops
Novi Sad, Yugoslavia

SUMMARY

The experiment object were 154 sunflower hybrids developed by research institutes and international breeding companies and intended for growing in the agroecological conditions of Europe, the Americas, Australia, Asia and Africa. The hybrids were tested for the following characters: plant height, head diameter, number of leaves and the sums of effective temperatures to budding, flowering and maturation. Statistical calculations included the cluster analysis with the Euclidean distance treated as a metric distance. Despite a large variability in all the characters tested, the majority of the hybrids were grouped in two clusters. An exception in that sense were the sums of effective temperatures to maturity which were grouped in four out of the five clusters.

INTRODUCTION

If based on data gathered in a single location, with its specific agroecological characteristics, and in a single year, analysis of characters may produce a faulty picture of a sunflower hybrid. Polygenic nature of individual characters, combined with their low heritability, admits a large portion of ecological variance into the phenotypic variance. Further diversification is introduced by the disease agents which prevail on the test location and which may be different from those which prevailed in the location where the hybrid was bred. Therefore, when assessing hybrids selected in a variety of ecological conditions, the grouping according to mutual similarities seems preferable to the comparison against the main hybrids of the test location.

MATERIAL AND METHOD

The experiment object were 154 sunflower hybrids developed by research institutes and international breeding companies and intended for growing in the agroecological conditions of Europe, the Americas, Australia, Asia and Africa.

The hybrids were a part of the demonstration plot of the 12th International Sunflower Conference (Yugoslavia, 1988). They were also sown at the experimental field of the Institute of Field and Vegetable Crops, in a system of random blocks in three replications within a series of small-plot trial with 23 hybrids and NS-H-26 and NS-H-45

as the control in each small plot. The sowing (manual, plant arrangement 70x30 cm, 47,916 plants/ha) was performed at the optimum time for the location (mid-April), on well-prepared chernozem soil. The cultural practices were adapted to the local conditions. Each hybrid was harvested manually, after reaching maturity. This paper presents the results of the analyses of the following characters

- plant height (cm) at the end of flowering, measuring the distance between soil surface and the center of the head;
- head diameter (cm) three weeks after the end of flowering;
- number of leaves at full flower;
- date of budding (SET), when the bud was 0.5 cm in diameter;
- date of flowering (SET), when one third of the disc flowers completed flowering;
- duration of vegetation (SET), from emergence to the occurrence of a 2 cm brown ring in the zone of bracts on the dorsal side of the head.

The sum of effective temperatures (SET) was calculated as a sum of the mean daily temperatures (> 5°C).

The basic sample for the analyses were 30 plants, 10 plants per replication.

A long drought and high temperatures in the course of June, July and August 1988 reduced the effects of the agents of leaf and stem spot (*Phompsis helianthi* Munt.-Cvet., *Alternaria helianthi* (Hansf) Tubaki & Nishihara, *Phoma macdonaldi* Boerema) below the level of significance for the assessment of phenotypic values.

The statistical calculations were done by the System for Statistics SYSTAT Ver. 5.0, software modules STATS and CLUSTER. For clarity, we used the five-group K means analysis with the Euclidean distance treated as a metric distance.

Tab.1 Summary statistics of six characters in hybrid collection

Characters	Number of hybrids	Mean	Se	Min	Max	S	Skewness	Cv
Height of plants	154	176.8	1.7	72	226	21.40	-.93	12.1
Diameter of head	154	24.6	0.2	19	35	2.37	.62	9.6
Number of leaves	154	28.3	0.3	11	38	3.92	-.04	13.9
SET for budding	154	773.2	3.9	638	984	48.38	1.340	6.3
SET for flowering	154	1199.7	6.8	943	1429	84.51	-.31	7.0
SET for maturity	154	2508.0	9.2	2330	2731	115.06	-.01	4.6

RESULTS AND DISCUSSION

The tested hybrids differed significantly in the examined characters. The minimum and maximum phenotypic values for plant height were registered in Sunwheat-102 and S-405, 72 cm and 226 cm, respectively, for head diameter in Contiflor-9 and NS-H-92, 19 cm and 35 cm, respectively, for the number of leaves in Sunwheat-102 and Contiflor-3, 11 and 38, respectively, for the SET to budding in Ro-1155 and Sunbird, 638°C and 984°C,

respectively, for the SET to flowering in Sunwheat-102 and S-530, 943°C and 1,429°C, respectively, and for the SET to maturity in SUN-M-2- and S-430, 2,330°C and 2,731°C, respectively. The coefficients of variation of 12.1 and 13.9, for plant height and number of leaves, respectively, were significantly higher than the coefficients of 9.6, 6.3, 7.0 and 4.6 for head diameter, the SET of budding, the SET of flowering and the SET of maturity, respectively. However, the positive values of skewness indicate the asymmetry towards the values higher than the average ones for head diameter and the SET to budding while the negative values indicate the asymmetry towards the values lower than the average ones for plant height, number of leaves, the SET to flowering and the SET to maturity. Summary statistics for the six characters in the hybrid collection are presented in Table 1.

It is left to investigator to decide the number of clusters. In this case, the partitioning of the set of 154 hybrids into five clusters was determined by the high variabilities of the examined characters as well as by the presence of the hybrids which, due to their extreme phenotypic values, minimum and maximum, had to be classified into separate groups. An attempt to reduce the number of gropu would have led to the inclusion of significantly different hybrids into a single group. The partitioning into five clusters seems to be fully justified by the values between and within the sums of squares and the values of the F-ratio which are presented in Table 2.

Tab.2 Summary statistics for five clusters

Character	Between SS	DF	Within SS	DF	F-ratio
Height of plants	62783.39	4	7289.26	149	320.83
Diameter of head	764.17	4	100.86	149	282.22
Number of leaves	2184.52	4	174.53	149	466.22
SET for budding	313452.16	4	44754.96	149	260.88
SET for flowering	951274.14	4	141513.28	149	250.40
SET for maturity	1944212.25	4	81447.30	149	889.18

The cluster analysis for plant height showed that about 80 percent of the examined hybrids conform to two groups: the hybrids between 148 cm to 174 cm and the hybrids between 175 cm and 197 cm. As the trial was carried out on a chernozem soil which had received 37.5 kg N/ha, it is evident that the current breeding effort is directed towards medium-tall hybrids. About 13 percent of the hybrids were outstandingly tall, from 200 cm to 226 cm. Sunwheat-102 was the extreme case, being the only member of cluster No.4.

A similar distibution was registered for head diameter. About 77 percent of the hybrids were classified in two groups, the group with the minimum head diameter up to 23.0 cm (cluster No. 1) and the group with the diameter up to 28.0 cm (cluster No. 2).

The differences in the number of leaves were larger than in the previous two characters. About 88 percent of the hybrids were classified in three groups. There were as many hybrids in cluster No. 1 (26 to 29 leaves) as in clusters No. 3 and No. 4 (30 to 33 leaves and 21 to 25 leaves, respectively). Sunwheat-102, with 11 true leaves per plant, was the only member of a separate cluster.

Relative the sum of effective temperatures, the variability tended to increase with the age of the hybrids. About 80 percent of the hybrids were similar in the SET to budding.

Cluster No. 1 included 124 hybrids with the values between 721°C and 796°C. About 85% of the hybrids needed between 1,114°C and 1,234°C to flower which puts them in two relatively homogeneous groups. Relative the SET to maturity, the collection was highly variable. The early hybrids (cluster No. 1) and the medium-early hybrids (cluster No. 2) each covered about 30 percent of the tested hybrids. Three very late hybrids (with over 2700°C) were in a separate group. Table 3 shows the limit values for the different clusters.

Tab.3 Mean values, limits and number of hybrids belonging to five clusters

Character	Cluster	Mean	Min	Max	S	No.of Hybrids
Height of plants (cm)	4	72.0	72.0	72.0	0.00	1
	3	128.3	108.0	145.0	11.71	7
	2	164.7	148.0	174.0	6.93	61
	1	184.7	175.0	197.0	5.94	64
	5	209.4	200.0	226.0	7.38	21
Diameter of head (cm)	4	21.4	19.0	22.0	0.84	26
	1	24.1	23.0	25.0	0.82	80
	2	26.9	26.0	28.0	0.80	40
	5	29.4	29.0	31.0	0.73	7
	3	35.0	35.0	35.0	0.00	1
Number of leaves	2	11.0	11.0	11.0	0.00	1
	4	24.0	21.0	25.0	1.01	35
	1	27.5	26.0	29.0	1.09	67
	3	31.0	30.0	33.0	0.94	34
	5	35.8	34.0	38.0	1.29	17
SET for budding	4	653.6	638.0	660.0	8.99	4
	1	759.3	721.0	796.0	17.89	124
	2	835.6	815.0	858.0	14.85	18
	5	884.5	871.0	904.0	11.28	6
	3	982.5	981.0	984.0	1.50	2
SET for flowering	4	984.7	943.0	1034.0	32.39	4
	2	1114.0	1052.0	1163.0	30.83	50
	1	1234.6	1187.0	1266.0	30.97	81
	3	1310.9	1287.0	1353.0	26.04	17
	5	1412.0	1385.0	1429.0	17.00	2
SET for maturity	1	2374.7	2330.0	2413.0	21.25	55
	4	2485.9	2435.0	2520.0	27.74	25
	2	2588.0	2541.0	2615.0	24.97	49
	3	2661.3	2648.0	2685.0	16.87	22
	5	2711.6	2702.0	2731.0	13.67	3

Table 4 contains the names of the hybrids, the breeding institution and the distibution per clusters.

Tab.4 Hybrids, originator and number of cluster for examined characteristic (continued)

Hybrid	Comp.	Plant height	Head diam.	Leaves numb.	SET budd.	SET flower.	SET matur.
NS-H-26	IFVC	2	1	3	1	1	1
NS-H-23	IFVC	1	4	3	1	1	1
NS-H-15	IFVC	1	1	5	1	2	1
NS-H-17	IFVC	5	1	5	1	2	4
NS-H-43	IFVC	5	2	1	1	1	5
NS-H-45	IFVC	1	5	3	1	2	4
NS-H-52	IFVC	1	2	4	1	1	1
NS-H-64	IFVC	2	5	1	1	1	4
NS-H-68	IFVC	2	1	3	1	2	1
NS-H-70	IFVC	2	2	4	1	1	4
NS-H-90	IFVC	2	2	3	1	1	4
NS-H-91	IFVC	2	5	1	1	1	1
NS-H-92	IFVC	2	3	3	1	3	4
DO-704-XL	DAHLGREN	2	5	1	1	2	1
DO-855	DAHLGREN	2	1	3	1	2	1
DO-728	DAHLGREN	1	1	3	1	2	1
DO-705	DAHLGREN	2	2	3	1	2	1
DO-66-EYP	DAHLGREN	2	5	1	1	2	3
SIGCO-422	SIGCO	2	1	4	1	2	1
SIGCO-468	SIGCO	1	1	1	1	1	2
SIGCO-465A	SIGCO	1	2	4	1	2	2
SIGCO-475	SIGCO	1	2	1	1	1	3
SIGCO-4710	SIGCO	3	4	1	1	1	3
HYSUN-24	PAC.SEEDS	1	4	4	1	2	1
HYSUN-34	PAC.SEEDS	1	5	5	1	1	3
HYSUN-44	PAC.SEEDS	5	4	1	1	3	1
HYSUN-54	PAC.SEEDS	5	1	1	1	3	3
PAC-3054	PAC.SEEDS	2	4	4	1	2	1
SUNKING-256	NK-FRA	2	2	4	1	4	1
PHARAON	NK-FRA	2	1	4	1	1	3
SUNBRED-277	NK-FRA	1	1	1	1	1	2
SUNBRED-281	NK-FRA	1	1	1	1	1	3
SUNBRED-285	NK-FRA	2	2	4	1	1	2
MARYFLOR	RUSTICA	1	4	1	1	1	1
EUROFLOR	RUSTICA	1	1	1	1	1	2
TOPFLOR	RUSTICA	1	4	1	1	3	1
MIKAFLOR	RUSTICA	2	2	4	1	2	1
VERAFLOR	RUSTICA	1	4	4	1	1	1
AGSUN-110	AG-SEED	2	2	5	1	1	1
AGSUN-230	AG-SEED	1	4	1	1	1	2
AGSUN-210DW	AG-SEED	3	4	4	1	3	2
SUNCROSS-40R	AG-SEED	1	2	1	1	1	3
SUNCROSS-60	AG-SEED	5	4	1	1	1	1
CITOSOL-3	C.R.I.-HUN	1	1	1	1	2	1
CITOSOL-4	C.R.I.-HUN	2	1	1	1	1	1
VIKI	C.R.I.-HUN	2	4	1	1	1	1
BLUMIX	C.R.I.-HUN	1	4	3	1	1	1
VIGOR	C.R.I.-HUN	1	2	1	1	2	1
MAXIFLOR	RUSTICA	2	2	3	1	2	2

Tab.4 Hybrids, originator and number of cluster for examined characteristic (continued)

Hybrid	Comp.	Plant height	Head diam.	Leaves numb.	SET budd.	SET flower.	SET matur.
CERFLOR	RUSTICA	1	1	1	1	2	1
RUSTIFLOR	RUSTICA	1	2	1	1	1	2
ARIFLOR	RUSTICA	1	1	4	1	2	1
FLORICA	RUSTICA	1	1	3	1	1	2
DKS-39	DEKALB	3	1	3	1	1	3
G-100	DEKALB	2	2	1	1	1	2
DK-4020	DEKALB	1	4	1	2	3	2
DKS-37	DEKALB	2	1	3	1	1	4
FLORAKISZ	DEKALB	2	1	1	1	1	2
IS-3107	CRIADERO SPS	1	1	1	1	1	4
SPS-3130	CRIADERO SPS	5	1	5	2	1	3
SPS-3160	CRIADERO SPS	5	1	5	2	3	3
SPS-3094	CRIADERO SPS	5	4	5	2	1	4
SPS-7115	CRIADERO SPS	1	1	1	1	1	4
CONTIFLOR-3	CONTINENTAL	5	4	5	5	2	3
CONTIFLOR-7	CONTINENTAL	5	4	5	2	1	2
CONTIFLOR-8	CONTINENTAL	5	1	3	5	1	2
CONTIFLOR-9	CONTINENTAL	5	4	5	2	1	2
P-86	CONTINENTAL	1	1	1	2	2	4
OD-105	VSGI	5	1	3	1	2	4
OD-106	VSGI	3	1	4	1	2	4
OD-122	VSGI	2	4	4	1	1	4
OD-123	VSGI	1	1	4	1	2	4
OD-128	VSGI	2	4	4	1	1	2
SUNWHEAT-102	SEEDTEC	4	4	2	2	4	1
ST-314	SEEDTEC	2	2	3	1	1	3
ST-335	SEEDTEC	1	2	3	1	1	3
ST-349	SEEDTEC	1	1	4	1	1	3
ST-330	SEEDTEC	2	1	4	1	2	2
T-548	TRIUMPH				1		2
T-557DW	TRIUMPH	3	1	4	2	3	2
T-560A	TRIUMPH	2	4	1	1	1	3
T-565	TRIUMPH	1	1	3	1	1	3
T-575	TRIUMPH	2	2	5	3	5	3
VYP	KOIPESOL	1	2	4	1	1	4
TESORO-92	KOIPESOL	2	4	4	1	2	2
FLORIDA-2000	KOIPESOL	1	1	1	1	3	2
EMANO	ESP.de CULT	3	1	4	1	1	2
MONRO-45	ESP.de CULT	2	1	3	1	2	4
TOLEDO-55	ESP.de CULT	2	1	4	1	1	4
TOLEDO-2	ESP.de CULT	2	4	1	1	3	2
IS-33142	VAN DER HAVE	2	1	4	1	2	2
IS-33241	VAN DER HAVE	2	1	1	1	2	2
IS-61074	VAN DER HAVE	2	1	4	1	2	2
DOBRITCH	IWS-BGR	1	1	3	1	1	1
SUPER START	IWS-BGR	1	1	1	1	1	1
ALBENA	IWS-BGR	1	1	3	4	2	1
RO-1418	ICCPT	2	1	3	4	2	4
RO-1390	ICCPT	1	1	3	1	1	1
RO-1155	ICCPT	2	2	4	4	2	1

Tab.4 Hybrids, originator and number of cluster for examined characteristic (continued)

Hybrid	Comp.	Plant height	Head diam.	Leaves numb.	SET budd.	SET flower.	SET matur.
RO-924	ICCPT	1	2	1	1	1	4
RO-1213	ICCPT	1	1	1	1	1	4
FLOROM-328	ICCPT	2	2	1	1	2	1
SUN-M-20	AGR.CAN.RES.	1	1	1	4	4	1
SF-100	CARGILL-USA	3	2	1	1	1	2
SF-102	CARGILL-USA	2	2	1	2	1	2
ADVANCE	CARGILL-AUS	5	1	3	2	1	1
CANNON	CARGILL-AUS	1	1	1	2	1	2
DYNAMITE	CARGILL-AUS	2	2	4	1	1	2
S-407	CARGILL-ARG	5	1	5	5	3	3
S-405	CARGILL-ARG	5	1	5	5	3	5
S-430	CARGILL-ARG	5	1	1	1	3	5
S-530	CARGILL-ARG	5	4	3	5	5	1
GIRAFLOR	SEMILLAS PAC	2	2	1	1	1	2
GIRAPAC	SEMILLAS PAC	1	1	1	1	1	2
ALHAMA-EXTRA	SEMILLAS PAC	1	1	1	1	1	1
SH-31	SEMILLAS PAC	2	1	4	1	2	2
SH-3322	SEMILLAS PAC	1	2	1	2	1	2
SH-3822	SEMILLAS PAC	1	1	4	1	2	2
SH-3622	SEMILLAS PAC	1	5	1	2	1	1
FRANKASOL	CARGILL-FRA	1	1	1	1	2	1
ALPHASOL	CARGILL-FRA	2	4	1	1	2	1
MIRASOL	CARGILL-FRA	1	2	3	1	1	1
CARGISOL	CARGILL-FRA	2	1	1	1	1	2
PARDISOL	CARGILL-FRA	2	1	1	2	2	4
FLORASOL	CARGILL-SP	2	1	1	1	1	2
RIOSOL	CARGILL-SP	2	2	1	2	1	1
OROSOL	CARGILL-SP	1	2	3	2	1	1
IS-7111	IS-USA	2	1	4	1	2	2
IS-33076	IS-USA	1	1	1	1	1	2
ISOMAX	IS-USA	2	1	4	1	1	1
IS-32025	IS-USA	2	1	1	1	2	2
HYSUN-354	CONTISEED	2	2	3	1	1	2
SUNBIRD	CONTISEED	1	1	5	3	2	3
HYSUN-340	CONTISEED	2	1	4	1	2	1
POCIN	VNIIMK	2	1	1	1	4	1
OML-57	VNIIMK	1	1	1	1	2	2
OML-17	VNIIMK	1	1	5	1	1	1
M-701	MORGAN-ARG	1	1	1	1	1	3
M-702	MORGAN-ARG	1	1	4	1	1	1
M-731	MORGAN-ARG	5	1	3	1	3	2
M-732	MORGAN-ARG	1	1	1	1	1	2
M-733	MORGAN-ARG	1	1	1	1	1	2
HYSUN-32	NICKERSON	1	2	3	1	1	2
HYSUN-33	NICKERSON	5	1	5	1	3	2
OS-325	OS-YUG	1	2	3	2	1	4
OS-393	OS-YUG	5	1	5	5	3	4
ELIA	C.S.T.	2	2	3	1	3	2
VEGA	C.S.T.	2	2	1	1	1	1
GUADALSUR	C.S.T.	1	2	3	1	2	1

Tab.4 Hybrids, originator and number of cluster for examined characteristic (continued)

Hybrid	Comp.	Plant height	Head diam.	Leaves numb.	SET budd.	SET flower.	SET matur.
PINTO	C.S.T.	2	1	1	1	2	1
RODEO	C.S.T.	1	2	1	1	2	1
HNK-81	IREG.INST.	2	1	1	1	2	3
IBH-166	IREG.INST.	1	2	4	1	2	4
BARBARA	IREG.INST.	2	1	1	1	2	1

CONCLUSION

When hybrids developed in a wide range of agroecological conditions are evaluated for phenotypic values in a single location and a single year, there is a risk of misjudging their actual potentials because characters with low heritability, i.e., characters in which ecological variance takes a larger portion of phenotypic variance are taken into consideration. It appears that more useful information may be obtained about hybrids by sorting them into groups, no matter how broad these may be. In our case, despite the large variabilities for all characters studied, the hybrids were generally grouped in two clusters. The only exception was the SET to maturity which differentiated the hybrids in four out of the five clusters.

RÉSULTATS DES ESSAIS INTERNATIONNAUX CONCERNANT LES HYBRIDES DE TOURNESOL. I. CARACTÉRISTIQUES MORPHO-PHYSIOLOGIQUES

RÉSUMÉ

Cent cinquate quatre hybrides de tournesol, créés par des instituts de recherche et des compagnies internationnales de sélection ont été testés dans des conditions agroécologiques européennes, américaines, australiennes, asiatiques et africaines. Les hybrides ont été étudiés pour les caractéres suivants: hauteur des plantes, diamétre des capitules, nombre de feuilles et somme des températures à la floraison et à la maturation. Le traitement statistique a compris la "cluster analysis" avec une distance Euclidienne traitée comme une distance métrique. Malgrès une large variabilité au sein de tous les caractéres étudiés, la majorité des hybrides étaient réunis dans deux groupes, exeptée la somme des températures jusqu'à maturité qui étaite groupée dans quatre des cinq groupes.

RESULTADOS DE LOS ENSAYOS INTERNACIONALES CON HIBRIDOS DE GIRASOL

RESUMEN

El objetivo experimental fueron 154 híbridos de girasol, desarrollados por Institutos de Investigación y Compannnías Internacionales de semillas, y dirigido para cultivo en las condiciones agroecologicas de Europa, America, Australia, Asia y Africa. Los híbridos fueron testados para los siguientes caracteres: Altura de planta, Diámetro capítulo, Número de hojas y Suma de temperaturas efectiva hasta botón floral, floración y maduración. Los cálculos estadísticos incluyeron el análisis Cluster con la distancia Euclidiana tratada como una distancia métrica. A pesar de la gran variabilidad en todos los carácteres estudiados, la mayoria de los híbridos fueron agrupados en dos Cluster (Grupos). Con la excepción en este sentido fué la suma de temperatura efectivas hasta madurez que dueron agrupados en cuatro o cinco grupos.