EFFECTS OF DIFFERENT SOWING TIMES ON SUNFLOWER

(R. Sarno, C. Leto, R. Cibella, A..Carrubba)

Istituto di Agronomia generale e Coltivazioni erbacee

Università degli Studi

Viale delle Scienze - 90128 - Palermo

SUMMARY

The research was carried out during a three-years period *(1987-1988-1989) in a representative area of the Sicilian* semi-arid environment. Aim of the trial was to evaluate the bio-agronomic behaviour of a Sunflower variety (FLOROM 305), in order to find out the most favourable sowing time for the Sunflower on dry conditions.

INTRODUCTION

Due to its water and temperature requirements, Sunflower is cultivated in Italy as a spring-summer crop, making use, when necessary, of irrigation. In Southern areas, however, the restrictions imposed by the unfavourable climatic conditions (high temperatures, presence of hot winds, lack of water) may set a limit to crop productivity, making it aleatory or uneconomical because of the indispensable resort to irrigation.

For this reason, agronomical research fixed as its goal the individuation of innovative cropping techniques, able to put Sunflower in condition to escape as much as possible from the limitations imposed by environment, allowing for example the best exploitation of the natural water resources. One of the possible ways to approach this problem is the individuation of the most convenient sowing time. This, if opportunely chosen, could allow the crop to pass through its most sensitive to termical and water stresses phenophases in the most favourable periods.

Keeping in consideration the expecial climatic conditions of the Southern environments, the yield possibilities of Sunflower by moving up the sowing time to the winter season were examined, relying upon the generally mild and rarely on extreme limits temperatures, and upon the winter rainfalls, able to satisfy crop requirements for most of the biological cycle.

This work reports the results obtained from a three-years comparison period among different sowing times of Sunflower in the inner Sicilian areas.

MATERIALS AND METHODS

The trial was carried out, in 1987, 1988 and 1989, in the experimental farm "Sparacia" (Cammarata - AG), a representative area of the hilly inner Sicily, located at an average altitude of 400 m above sea level. From the climatical point of view, the area may be classified among the hot Mediterreanean ones (fig.

1). The soils on which the fields have been set up, rather clayey (tab. 1), in the preceding years had always been cultivated with Barley.

The trial was executed following the randomized block design with three repetitions, with plot area of 36 m^2 (6 x 6 m), distance between rows of 60 cm and essay area of 14.40 m^2.

During the whole three years period a Summer ploughing, 30 - 35 cm deep, was executed; at the same time the soil was fertilized with 100 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1}. In Autumn a tillage was done to break clods; afterwards, immediately before sowing, another tillage was done for weed control and to prepare a good sowing bed.

At sowing time 150 kg N ha^{-1} in ureic form were distributed, and seeds were interred by hand; with a further intervention, at the growth stage of 4-5 true leaves, plant density was thinned out to 5 plants m^{-2}. Seeds of the variety Florom 305, a medium-early one, was used.

Five different sowing dates for each year were tested, with 15 days intervals one from another starting from February 1st. Weed control was obtained only with harrowing and, in order to avoid damages from birds, every head was covered with a small mesh-sack.

Harvesting was always hand-made, in the 1st half of August, according to the ripening level of the thesis.

During the trial, dates of most important growth stages (emergence, appearance of flower bud, flowering and physiological maturity) were collected. The length of the different growth stages has been measured in days; for each of them the corresponding thermic sums, expressed in growth degree days (GDD), have been calculated. The calculation was performed according to the Gilmore and Rogers (1958) method, following the formula:

$$GDD = \Sigma(Tmax + Tmin)/2 - Tbase, \quad \text{where:}$$

- T max: highest day temperature; when it exceeds 30°C, the correction:

$$Tmax = 30 - (Tmax - 30) \quad \text{is done;}$$

- T min: lowest day temperature; when it is below the base temperature, this one is used for calculation;

- T base: 5°C.

The higher and lower termical cardinals (5°C and 30°C) were the same suggested by Baldini et al. (1990).

At the harvesting time, the average plant height for each plot was measured; from a parcel sample of 20 plants, head diameter and diameter of their barren area was measured; the ratio between the corresponding areas was expressed as sterility per cent.

Yield data have been expressed in t ha^{-1} with a standard moisture content of 10 %. Furtherly, the weight of 1000 seeds, also at 10 % moisture, was measured, and oil content of seeds was determined.

All the collected data (tab. 2) have been submitted to Bartlett's test for variance homogeneity and then to statistical analysis; the differences among the means have been extimated through Tukey's "W" test (1953).

The simple correlation coefficients among yield, most important yield factors, duration of the most important growth stages and the corresponding thermical sums, were finally calculated (tabs. 3, 4 and 5).

RESULTS AND DISCUSSION

Years

- 1987

In this first year of trial, average temperatures (fig. 2) were rather low from February to April, even if mimimum values rarely fell below zero. In the same period, the fairly good rainfall amount (approx. 152 mm from February to the end of April) supported above all the first two thesis.

As for the yield, the complexively obtained field average was 2.1 t ha^{-1}; the different sowing times contributed to form this value in an extremely varying way, going from a minimum of 1.4 t ha^{-1} for the fifth sowing time to a maximum of 2.7 t ha^{-1} for the first one.

Oil content of the seeds ruled around rather high values, from a minimum of 36.9 % for the fifth sowing time to a a maximum of 45.5 % for the first one, with an average as to the factor "year" of 41.1 %.

- 1988

Average temperatures (fig. 3) were almost costantly higher than the typical values of the area. Above all in the first ten days of May and during the Summer months, maximum values have been exceptionally high, due to strong Sirocco winds. As for the natural water supply, rainfalls occurred from the first days of February to the first ten days of March, even if quite moderate, showed favourable effects on the first two thesis. The occurrance of long dry periods from March to April has instead seriously damaged above all the last two sowing times.

The occurrance in this second year of trial of overall unfavourable climatical conditions, caused the average yield (1.7 t ha^{-1}) to be the lowest of the whole three - years period. In particular, the occurrence of the Sirocco winds just in correspondence with the phases of development and filling of seeds, had negative effects both on their weight (45.5 g every 1000 seeds, that was the lowest value of the three-years period) and on the value of head sterility. This one seemed to be, among the yield factor, the most influenced by the strong thermical stress suffered by the crop, showing the highest average value of the three-years period (10 %), with values always exceeding 10 % in the second, the third and the fourth sowing times.

Also seeds oil content showed the lowest values of the three-years period (field average 38.4 %), with strong variations among the different sowing times. The highest value (42.5 %), even if not significantly different from the one of the 1st and 2nd sowing time, was registered on the 4th thesis, while the lowest value (34.2 %) was showed by the last one.

- 1989

In this last year of trial, average temperatures (fig. 4), were characterized by slightly lower values than those registered in the former years, with recurrence of low temperatures in the first ten days of May. Afterwards, temperature values ranged around the typical seasonal ones, about 24-25 °C in July-August.

Rainfalls, instead, ranged around rather low values (138 mm during the whole period from February to August).

The occurrance of, above all, better climatic conditions than those obtained in the other two years probably allowed to obtain the highest yield (2.6 t ha^{-1}) in the whole trial. Expecially the first sowing time could take advantage of small but constant water amounts during all the period from the sowing date to the filling of seeds, so expressing a significantly different productive level from all the other thesis.

This superiority has been also showed, even if in a less marked way, by the seed oil content, that in the earliest sowing time reached an average value of 42.6 %.

Sowing times

Biological cycle

The effect "sowing times" has influenced, more than the effect "year" did, the development of the bio-productive cycle in Sunflower.

In all the three-years period, in fact, the earliest thesis reached the ripening time in 184-185 dd, after accumulating respectively 1619 (1st year), 1976 (2nd year) and 1800 (3rd year) GDD, calculated following the above written method.

The following four sowing times reached the physiological maturity by the 16th August of each year, that means after 172, 160, 149 and 136 dd from the respective sowing dates, taking into account 1780, 1751, 1748 and 1679 GDD for each (figs. 8, 9 and 10).

This significant shortening of the cycle was caused by the progressive reduction of all the examined growth stages, expecially those immediately preceding the appearance of flower bud. The thesis sowed in 5th time, for example, started the flowering time in approximately half time than the first one (figs. 5, 6 and 7). The statistical analysis shows, in fact, a marked positive correlation between seeds yield and cycle lenght (tab. 4), both total and partitioned into its different substages.

Seeds yield and GDD in the different phases until flowering seemed to be inversely correlated, while the sum of GDD from flowering to maturity stages showed with yield a significant positive correlation (tab. 5).

Yield and its components

Even if the different climatical conditions of the three trial years markedly affected seed yield, a strong differentiation of this trait was caused also by the different sowing times, independently of the year.

In all the three trial years, in fact, anticipating sowing time caused a marked yield increase, pointing out the significant productive superiority of the earliest sowing time in comparison with all the others.

The analysis of the yield components put in evidence how all of them contributed in a various way in obtaining the final result, showing variations which followed those of seed yield.

Conditions being equal, the superiority of most productive thesis was due both to their higher weight of 1000 seeds and to their bigger head size and less barren area.

Among the examined yield components, nevértheless, above all the weight of 1000 seeds and the head diameter seemed to contribute in differentiating the thesis, showing variations mostly ranging as the seed yield did. In confirmation of that, both these factors showed, in all the three years of trial, a strong positive correlation with seeds yield.

Unlike the other two traits, instead, head sterility seemed to be more affected by the year, and therefore by the climatic trend of the whole cycle, than by the sowing time, showing as to this factor, average values always ranging between 6 and 9 % .

CONCLUSIONS

The results allowed to point out a positive correlation between yield and heat units, above all on charge of the period between flowering and physiological maturity.

The thermic accumulation in the growth stages before the flowering time, instead, seemed to have a negative effect on final yield, probably because, under limit conditions like the experimental ones, high temperatures mostly cause stress conditions. It is likely that, during the vegetative development of Sunflower, soil moisture or other external factors may have some influence on seed yield, much more than thermic accumulation that on the contrary could represent a limiting factor.

The statistical analysis, in fact, pointed out for each year a marked positive correlation ($r= 0.890$, $r= 0.819$ and $r= 0.892$) between the total rainfall amount and the seeds yield.

The data analysis allowed, moreover, to remark how seeds yield of Sunflower is extremely variable according to the sowing times. The anticipation of sowing date seems a decisive factor for the good outcome of the crop, above all when climatic conditions have a limiting effect.

The cultivation of Sunflower in winter time, in environments such as the experimental one, seems to be able to allow good yield outcomes. The results, however, leave the way opened to deepen the knowledges of the aptitude of Sunflower to a further anticipation of the sowing time.

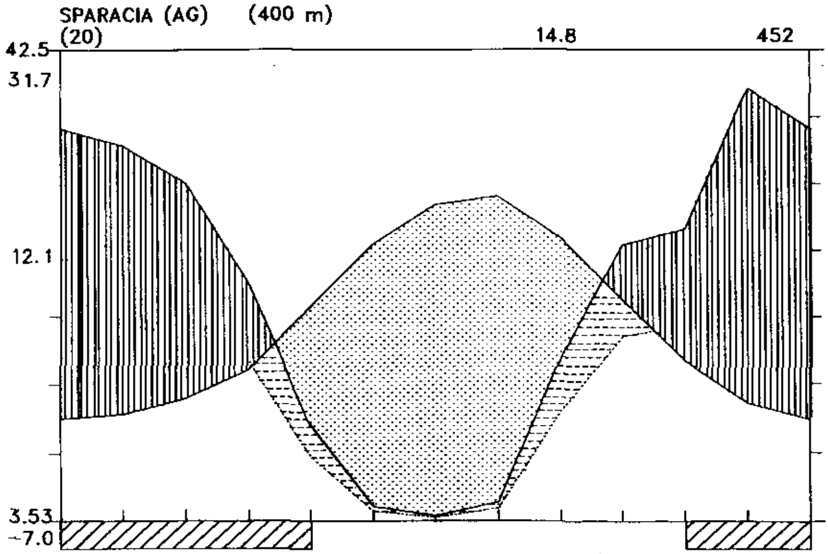


Fig. 1 — Climodiagram of the trial area (according to Walter and Lieth, 1960)

Fig. 2 — Ten days values of rainfall and temperatures recorded at Sparacia (AG) in 1987

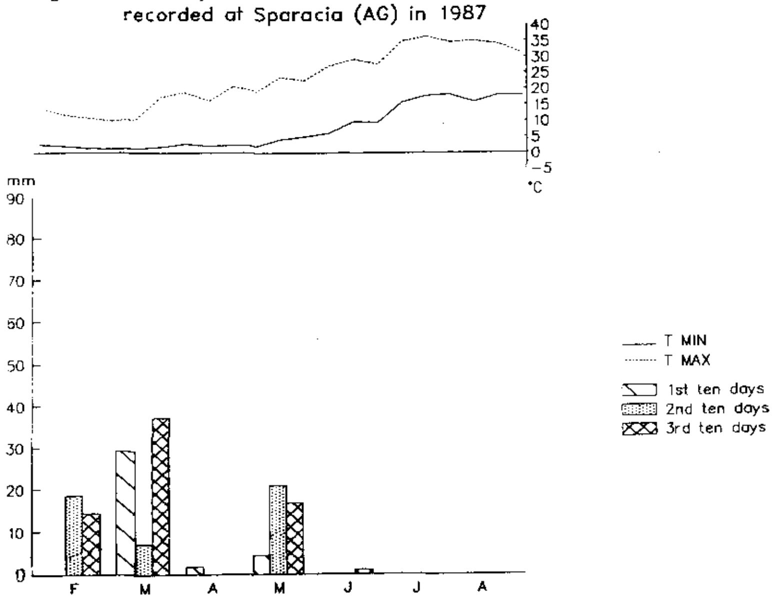


Fig. 3 – Ten days values of rainfall and temperatures recorded at Sparacia (AG) in 1988

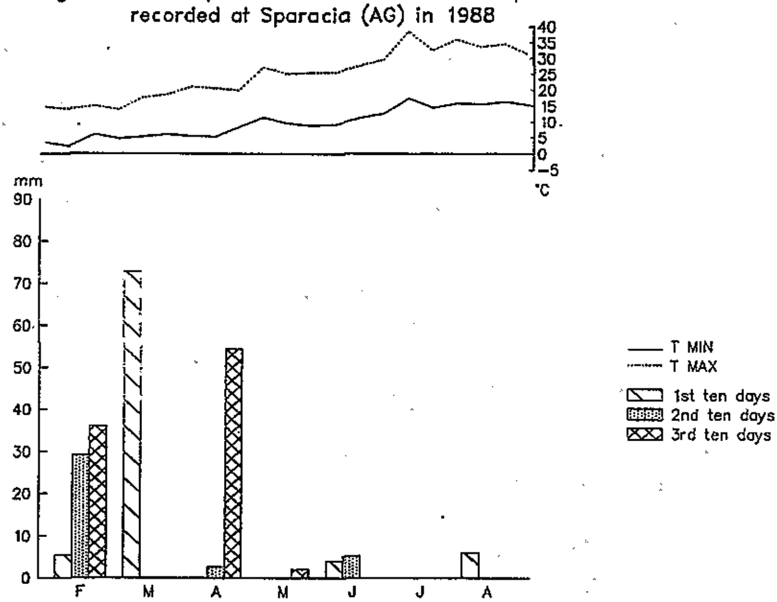


Fig. 4 – Ten days values of rainfall and temperatures recorded at Sparacia (AG) in 1989

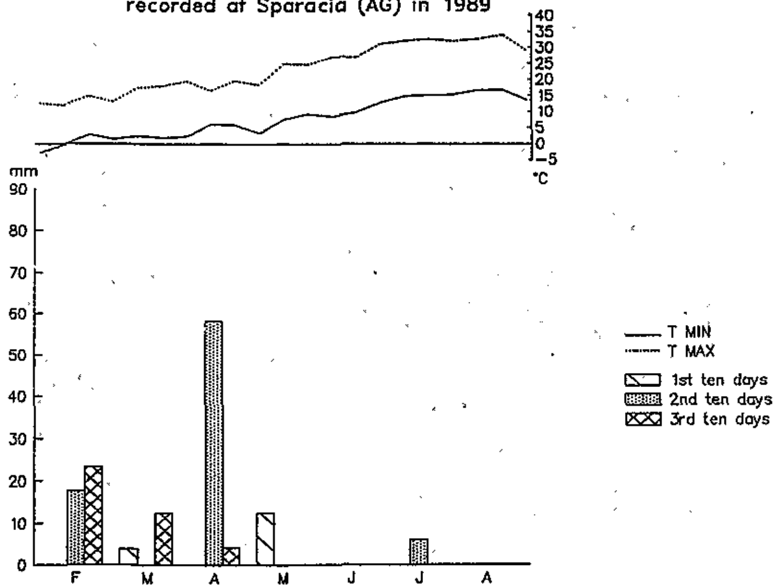


Fig. 5 — Growth stages 1987

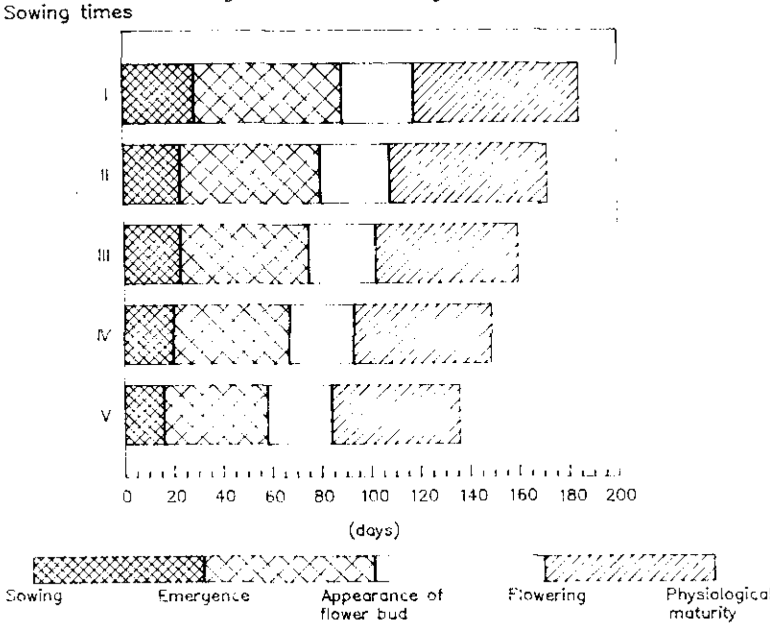


Fig. 6 — Growth stages 1988

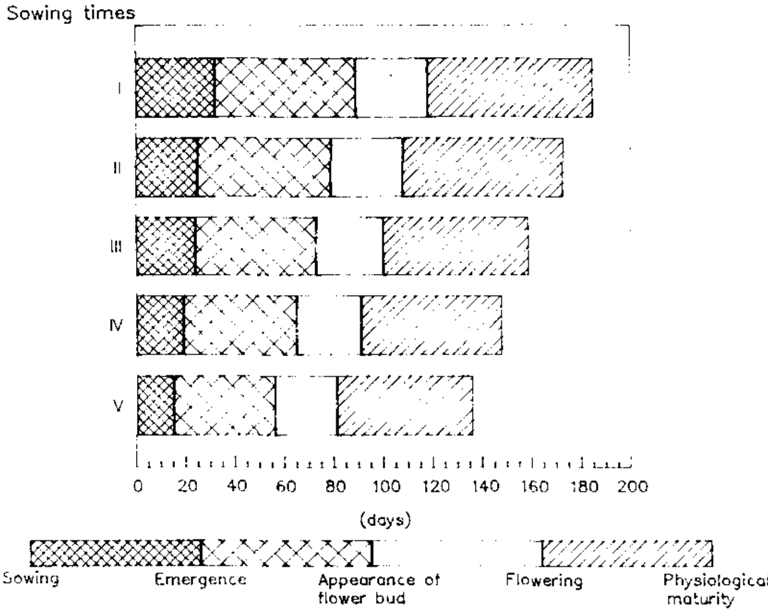


Fig. 7 – Growth stages 1989

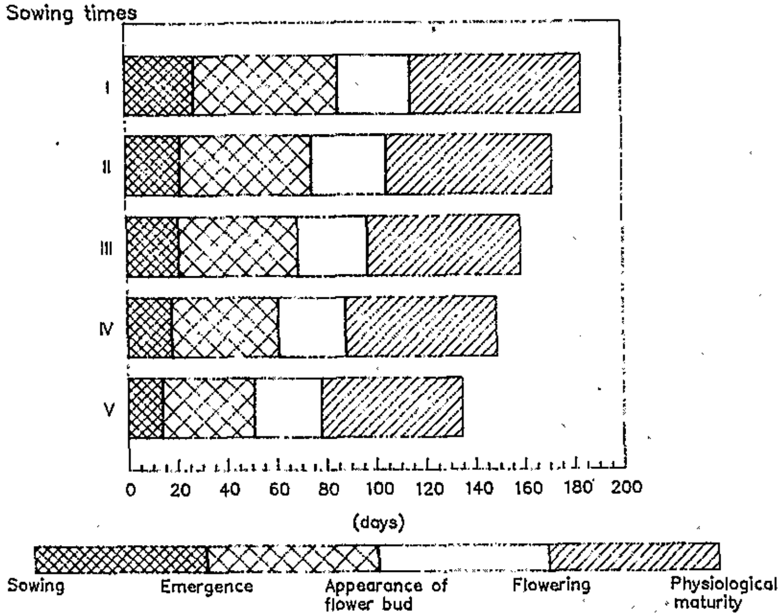


Fig. 8 – growth stages in relation to GDD – 1987

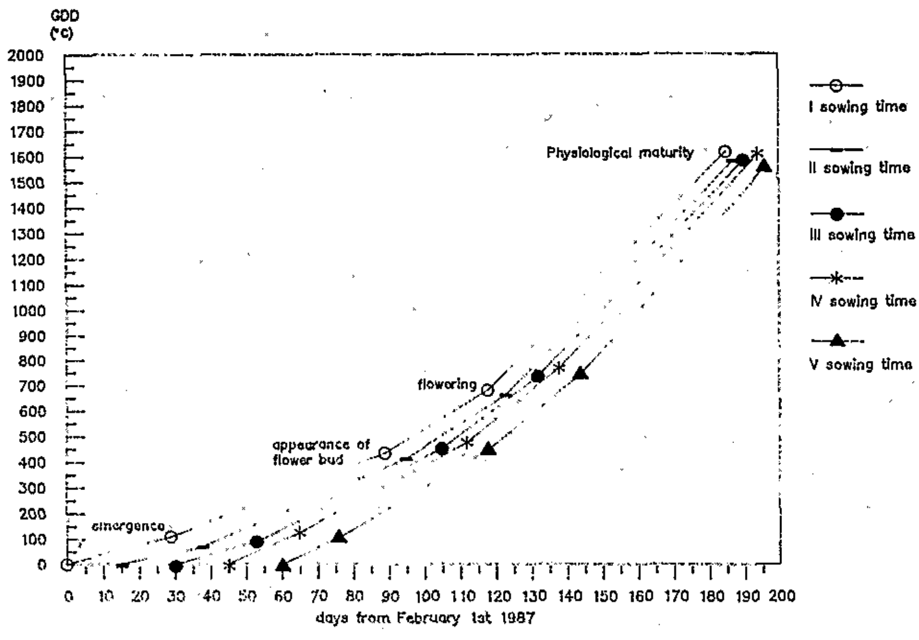


Fig. 9 – growth stages in relation to GDD – 1988

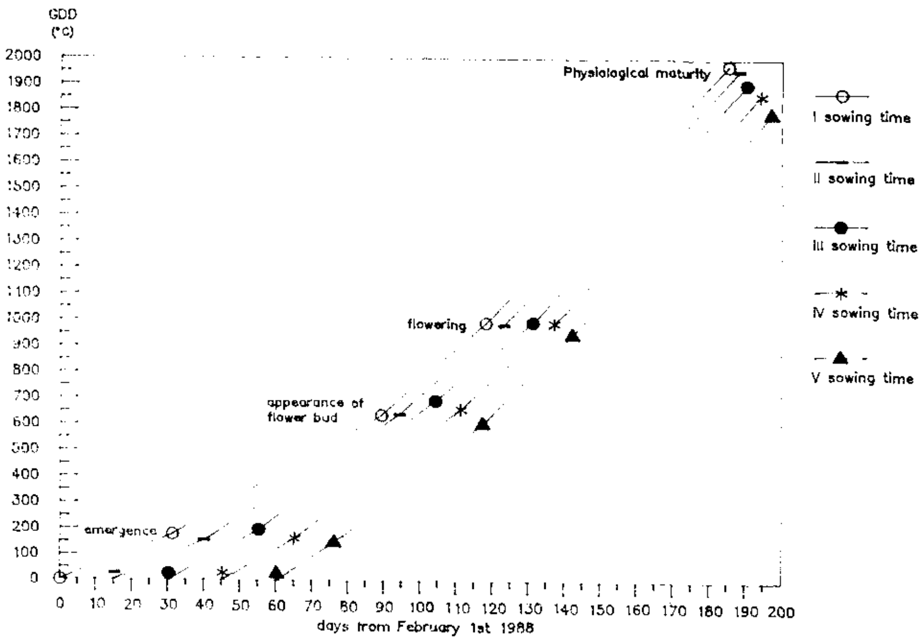
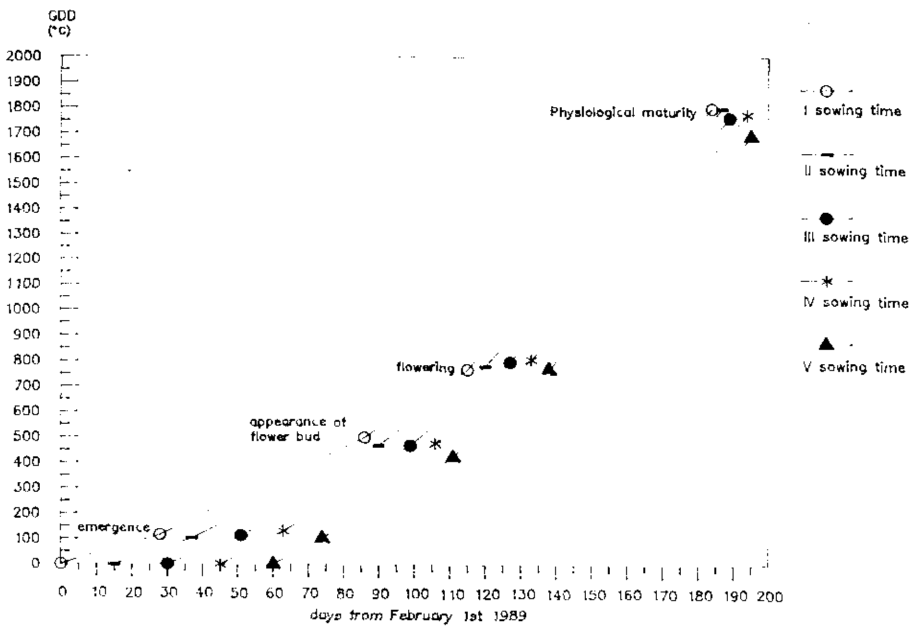


Fig. 10 – growth stages in relation to GDD – 1989



Tab. 1 - PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE SOILS

	1987	1988	1989
Sand (%)	28	34	29
Silt (%)	28	26	29
Clay (%)	44	40	42
pH	8,22	8,17	8,21
total $CaCO_3$ (%) (De Astis)	6,8	6,3	6,5
active $CaCO_3$ (%) (Droineau)	4,8	4,4	4,6
Organic matter (%) (Lotti)	1,3	1,1	1,0
total N (‰) (Kjeldahl)	1,0	1,1	1,0
assim. P_2O_5 (ppm) (Olsen)	16,9	27,5	23,4
exchang. K_2O (ppm) (Intern. Meth.)	371,9	435,2	453,7

TAB. 2 - YIELD AND BIOLOGICAL CHARACTERISTICS

		YIELD ($t.ha^{-1}$)			Weight of 1000 seeds (g)			Plant height (cm)			Head diameter (cm)			Head sterility (%)			Oil content (%)		
YEARS																			
1987		2.1	B	b	47.6	B	b	101	B	b	12.9	C	c	6.2	B	b	41.1	A	a
1988		1.7	C	c	45.5	B	b	119	A	a	14.9	B	b	10.5	A	a	38.4	B	b
1989		2.6	A	a	58.6	A	a	115	A	a	16.5	A	a	7.2	B	b	41.2	A	a
SOWING TIMES																			
I		2.8	A	a	64.6	A	a	115	A	a	16.6	A	a	6.4	A	a	43.0	A	a
II		2.4	B	b	53.3	B	b	108	A	a	15.2	B	b	8.2	A	a	41.0	A	ab
III		2.1	C	bc	49.6	BC	bc	111	A	a	15.2	B	b	8.4	A	a	39.0	B	bc
IV		1.8	C	cd	46.0	C	c	112	A	a	14.0	C	bc	9.0	A	a	41.0	A	ab
V		1.5	D	d	39.5	D	d	111	A	a	13.0	C	c	7.9	A	a	37.3	B	c
INTERACTIONS "YEARS X SOWING TIMES"																			
1987	I	2.7	B	ab	64.3	AB	ab	119	AB	ab	14.2	BE	be	4.5	C	b	45.5	A	a
	II	2.4	BE	bc	51.8	CF	ce	101	DE	ad	13.6	CE	cf	5.8	BC	ab	42.5	AB	ab
	III	2.0	DF	be	48.2	DG	ce	98	CE	bd	13.2	DE	df	5.7	BC	ab	41.3	AB	ac
	IV	1.8	EG	ce	41.5	GI	eg	96	DE	cd	12.9	EF	ef	6.4	BC	ab	39.4	BD	bd
	V	1.4	GH	df	32.2	I	g	92	E	d	10.8	F	f	8.7	AC	ab	36.9	CE	ce
1988	I	2.4	BE	bc	58.1	BD	bc	117	AC	ac	16.5	B	ab	8.7	AC	ab	40.9	BC	ac
	II	2.1	CF	bd	49.4	CG	ce	116	AD	ac	16.3	B	ac	10.3	AC	ab	39.5	BC	bd
	III	1.8	FG	ce	43.9	EG	df	122	A	a	16.1	B	bc	12.0	AB	ab	35.1	DE	de
	IV	1.4	GH	ef	43.0	FH	dg	120	AB	ab	13.0	DF	df	13.3	A	a	42.5	AB	ab
	V	1.0	H	f	33.1	HI	fg	119	AB	ac	12.0	EF	ef	8.3	AC	ab	34.2	E	e
1989	I	3.3	A	a	71.4	A	a	110	AE	ad	19.0	A	a	5.9	BC	ab	42.6	AB	ab
	II	2.6	BC	ab	58.5	BC	bc	108	AE	ad	15.8	BC	bd	8.5	AC	ab	41.1	BC	ac
	III	2.4	BD	bc	56.7	BD	bc	112	AD	ad	16.2	B	bc	7.6	AC	ab	40.5	BC	ac
	IV	2.3	BF	bc	53.4	CE	bd	122	A	a	16.1	B	bc	7.3	AC	ab	41.2	AC	ac
	V	2.2	BF	bd	53.2	CE	bd	121	AB	ab	15.4	BD	be	6.7	AC	ab	40.9	BC	ac

Means not followed by the same letter, including partials, are significantly different by $P \leq 0.05$ (capital letters) and $P \leq 0.01$ (small letters) (Tukey's test)

TAB.3 - CORRELATIONS AMONG YIELD CHARACTERS IN SUNFLOWER

1987 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
YIELD	----	.858 **	.663 **	-.735 **	.620 *	.889 **
Weight 1000 s.		-----	.799 **	-.793 **	.789 **	.954 **
Head diameter			----	-.864 **	.721 **	.705 **
Head sterility				----	-.686 **	-.691 **
Plant height					----	.638 *
Oil content						----

1988 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
YIELD	----	.873 **	.912 **	-.216	-.356	.405
Weight 1000 s.		-----	.718 **	-.011	.789 **	.954 **
Head diameter			----	-.242	-.240	.089
Head sterility				----	.506	.209
Plant height					----	-.325
Oil content						----

1989 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
YIELD	----	.909 **	.684 **	-.116	-.543 *	.342
Weight 1000 s.		-----	.796 **	-.180	-.590 *	.410
Head diameter			----	-.470	-.294	.597 *
Head sterility				----	-.149	-.440
Plant height					----	-.168
Oil content						----

TAB.4 - CORRELATIONS AMONG YIELD CHARACTERS AND GROWTH STAGES LENGHT

1987 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
Sowing-emergence (dd)	.846 **	.935 **	.747 **	-.737 **	.701 **	.958 **
Emerg.-flow. bud (dd)	.913 **	.941 **	.732 **	-.744 **	.657 **	.950 **
Flow.bud-flower. (dd)	.888 **	.914 **	.645 **	-.641 **	.690 **	.936 **
Flower.-phys.mat (dd)	.919 **	.931 **	.728 **	-.702 **	.669 **	.957 **
Tot.cycle length (dd)	.927 **	.952 **	.750 **	-.736 **	.681 **	.975 **

1988 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
Sowing-emergence (dd)	.953 **	.896 **	.859 **	-.105	-.295	.384
Emerg.-flow. bud (dd)	.894 **	.842 **	.775 **	-.130	-.526 *	.553 *
Flow.bud-flower. (dd)	.878 **	.833 **	.778 **	-.166	-.572 *	.584 *
Flower.-phys.mat (dd)	.935 **	.859 **	.849 **	-.253	-.529 *	.388
Tot.cycle length (dd)	.966 **	.902 **	.868 **	-.116	-.394	.433

1989 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
Sowing-emergence (dd)	.908 **	.903 **	.743 **	-.089	-.699 **	.315
Emerg.-flow. bud (dd)	.466	.448	.314	.200	-.805 **	.016
Flow.bud-flower. (dd)	.598 *	.512	.289	.217	-.735 **	.039
Flower.-phys.mat (dd)	.861 **	.822 **	.614 *	-.002	-.740 **	.294
Tot.cycle length (dd)	.883 **	.857 **	.650 **	-.030	-.765 **	.296

TAB. 5 - CORRELATIONS AMONG YIELD CHARACTERS AND GDD

1987 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
Sowing-emergence GDD (°C)	-.267	-.182	-.141	.081	.022	-.226
Emerg.-flow. bud GDD (°C)	-.471	-.494	-.210	.224	-.566 *	-.484
Flow.bud-flower. GDD (°C)	-.859 **	-.843 **	-.618 *	.580 *	-.611 *	-.873 **
Flower.-phys.mat GDD (°C)	.896 **	.893 **	.685 **	-.649 **	.650 **	.920 **
Tot.cycle length GDD (°C)	.624 *	.694 **	.652 **	-.657 **	.531 *	.690 **

1988 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
Sowing-emergence GDD (°C)	-.459	-.385	-.561 *	.247	.391	-.048
Emerg.-flow. bud GDD (°C)	-.068	-.058	.002	.669 **	.377	.253
Flow.bud-flower. GDD (°C)	.283	.343	.046	-.492	-.674 **	.335
Flower.-phys.mat GDD (°C)	.947 **	.881 **	.850 **	-.080	-.441	.481
Tot.cycle length GDD (°C)	.955 **	.884 **	.879 **	-.005	-.347	.465

1989 (d.f. = 13)	YIELD ($t.ha^{-1}$)	Weight 1000 seeds (g)	Head diameter (cm)	Head sterility (%)	Plant height (cm)	Oil content (%)
Sowing-emergence GDD (°C)	-.017	-.053	.222	-.084	.368	.073
Emerg.-flow. bud GDD (°C)	-.885 **	-.855 **	-.674 **	.034	-.730 **	.298
Flow.bud-flower. GDD (°C)	-.932 **	-.959 **	-.802 **	.165	.587 *	-.387
Flower.-phys.mat GDD (°C)	.829 **	.775 **	.587 *	.016	-.694 **	.292
Tot.cycle length GDD (°C)	.676 **	.580 *	.474	.084	-.593 *	.214

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