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SUNFLOWER PRODUCTION RESPONSE TO DIFFERENT IRRIGATION REGIMES IN CATCH-CROP GROWING.

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Summary

Research was carried out in the years 1987, 1988 and 1989 at the experimental farm of the Grosseto centre of the Tuscan Regional Body for agricultural and forestal development, situated at "Barbaruta".

Sunflower seeding was carried out after winter barley on soil prepared according to the "minimum tillage" technique. In an experimental scheme using a split-plot design, with three replications, two early hybrids ("Romsun HS 90" and "Cerflor") and seven irrigated theses were compared. The theses consisted of : one thesis (0/0) irrigated only at seeding, with a volume of water that would restore field water capacity down to a depth of 50 cm; one thesis fully irrigated according to its requirements throughout the cycle (I), ensuring 100% reintegration of maximum evapo-transpiration minus rainfall above 10 mm; another 5 theses (1/0, 0/1, 2/0, 2/1 and 1/2) which received supplementary waterings in addition to irrigation at seeding. Waterings were carried out in specific phenological phases, in a volume sufficient to restore field capacity to a depth of 50 cm.

In general the "phenological" irrigation criterion adopted allowed considerable savings in water. Two targeted waterings led to mean water savings of 54% (thesis 1/1) with very limited production decrease (7%), compared to the fully irrigated thesis. Thesis 1/1, which received irrigation at the stage of ten true leaves and additionally at the beginning of the flowering stage, showed the greatest water efficiency and lowest evaporation coefficient values.

This study confirmed the influence of water conditions during the vegetative stage on plant height and capitulum diameter. Irrigation during the flowering stage induced a positive influence both on number and weight of achenes and also on oil percentage. Overall, the very early hybrid "Cerflor" presented the significantly highest values for both achenes and oil.

Introduction

In the areas of major cultivation of the sunflower in Italy, its employment as a catch crop is essentially limited by the availability of water in the summer period. In these areas, mainly central and southern Italy, the length of time available to the catch-crop is not a serious obstacle, given the precocity of the harvest of the principal crop (usually barley) and the presence of temperatures sufficiently high even at the end of the sunflower's biological cycle. In addition, adoption of the "minimum tillage" technique can give an efficient contribution in reducing both the losses of humidity from the soil and the time necessary to work it (Marzi et al., 1982; Miele, 1987). The adoption of strip-tillage could moreover allow, together with band fertilization, an extra saving in time (Miele and Palmerini,1989) and could limit weed development, mostly due to the barley lost by the combine harvester which has sprung up together with the sunflower (Covarelli, 1988). A serious handicap is, however, the near absence of rain for long periods, particularly during the vegetative phase of the crop.

Research carried out in Puglia and in Tuscany (Pacucci and Alba, 1977; Tarantino and Alba, 1978; Vannozzi and Paolini, 1978) drew attention to the fact that with a rational employment of limited amounts of irrigation water, it was possible to implement catch-crop cultivation. Subsequently, trials carried out in the same regions, adopting different sowing periods, (Salera et al., 1988; Santamaria et al., 1991), have shown how sowing by June using early sunflower hybrids, it was possible to obtain good yields from the crop when water availability was not a limiting factor.

Having ascertained the real possibilities of sunflower cultivation in catch-crop growing, it is important to investigate more thoroughly the water consumption of the crop in different environments, for the moment scarcely studied (Bonari et al., 1989), and to identify the possibilities for economies both in terms of total irrigation rates and of the number of waterings.

The aim of this research, conducted within the "Oil Plant" Project of the Ministry of Agriculture and Forests, Subproject "Sunflower", was to ascertain, on sunflower sown after barley, if the criterion of using irrigation only at precise phenological phases of the plant, at which it is particularly sensitive to deficits, could provide satisfactory yields with a reduction both in the total irrigation rates and in the number of waterings.

Materials and methods

The present research was carried out in the three-year period 1987-89 on the experimental farm at the Grosseto Centre of the Tuscan Regional Body for agricultural and forestal development, situated at "Barbaruta". In every case the trials took place on the plain of the coastal strip of the middle Tyrrhenian Sea; the physico-chemical and hydrological characteristics of these soils are indicated in Table 1.

Every year, in an experimental scheme using a split-plot design with three replications, comparisons were made, with a catch-crop after barley and using the "minimum tillage" technique, between two sunflower hybrids, characterized by different lengths of biological cycle, "Cerflor" and "Romsun HS 90" (respectively very early and early), in factorial combination with the following seven irrigated theses:

- thesis 0/0, control irrigated only at seeding
- thesis 1/0, one watering at the appearance of the flower bud (Schneiter and Miller's stage R1) (Schneiter and Miller,1981);
- thesis 0/1, one watering at the beginning of anthesis (Schneiter and Miller's stage R5);
- thesis 1/1, two waterings of which the first at the tenth true leaf (Schneiter and Miller's stage V10) and the second at beginning of anthesis;
- thesis 2/0, two waterings, one at the tenth true leaf and the next at the appearance of the flower bud;
- thesis 2/1, three waterings of which two as in the thesis 2/0 and one at the beginning of anthesis;
- thesis I, fully irrigated according to the requirements throughout the biological cycle of the sunflower crop.

At seeding, all the theses also included irrigation rates such as to restore the field capacity of the soil from 0 to 50 centimetres depth.

The fully irrigated thesis (I) ensured 100% reintegration of maximum evapo-transpiration minus effective rainfall (that is, over 10 mm in 24 hours). The latter was estimated on the basis of the evaporate from a class "A" pan (Eo"A"), corrected with the following crop coefficients (Kc):

Kc 0.4 - up to the tenth true leaf (Schneiter and Miller's V10 stage);
Kc 0.7 - up to flower bud;
Kc 1.0 - up to 15 days after the beginning of anthesis;
Kc 0.8 - up to 30 days after the beginning of anthesis;
Kc 0.5 - up to physiological maturity (Schneiter and Miller's R9 stage).

Due to the differing precocity of the experimental hybrids, for the definition of the Kc's the phenological phases were observed on the earliest of the hybrids ("Cerflor") for increasing Kc's (0.4, 0.7 and 1.0) and on the least early hybrid ("Romsun HS 90") for decreasing Kc's (0.8 and 0.5). The change of Kc was made in every case when the phenological phase under consideration was present in 50% of the plants. The calculation of the maximum evapo-transpiration was taken as starting as from the date of the watering carried out after seeding and was common to all the theses.

The irrigation rate, kept constant throughout the irrigation period, was calculated on the basis of the hydrological and physical characteristics of the soil so as to restore 2/3 of the water available to the plant for a soil depth of 50 centimetres. Irrigation was carried out when the crop had used all the water supplied by the previous irrigation, as a result of which the irrigation timetable varied according to the estimated consumption.

On the other hand in the theses which provided irrigation in the phenological phases in which the crop is presumably more susceptible to water stress, the irrigation rate was calculated for each watering operation (based on the humidity profile from 0 to 150 cm recorded in the plots of every thesis before irrigation) so as to restore the soil to field capacity down to a depth of 50 centimetres. In every case irrigation took place when 50% of the plants were in the particular phenological phase and, given the differing precocity of the trial cultivars, in different periods for each of these.

The irrigation system adopted always used a highly efficient distribution method (localized system), with the exception of irrigation at seeding which was carried out simultaneously for all the theses by sprinkling; every experimental hybrid and, within the area of each of them, every irrigated thesis was watered separately.

The ground intended for the trials was prepared with the *minimum* tillage technique on the 16/6/1987, 13/6/1988 and 19/6/1989 after the barley harvest. At tilling 150 kg/ha of nitrogen were distributed, while phosphorus (150 kg/ha) and potassium (100 kg/ha) were added in the summer preceding the preparation of the ground for the cereal crop.

Sowing was carried out by parcel sowing machine on the 19th June 1987, 16th June 1988 and the 22nd June 1989. Each plot, consisting of six rows of plants 60 cm apart, had an area of 25.2 m2 (7.0 m x 3.6 m); both the first order plots (hybrids for comparison) and the second order ones (irrigated theses) were suitably separated from one another by sowing another three rows of sunflower so as to prevent the effects of irrigation being felt also in the adjacent plots. The same density of 6 plants/m2 was adopted for all the theses and all the hybrids. Weed control was carried out by hand.

On the crop were recorded values concerning the date of attainment of the principal phenological phases, expressed in days from emergence and referring to the moment in which 75% of the plants were seen to be in one of the above-mentioned phases.

At maturity observations were carried out on the height of the plant, the head diameter and the sterile part area sometimes present at the centre of the latter, while at harvest achene *humidity and yield expressed in t.ha-1* at 0% humidity were determined. The 1000-achene weight and the percentage content of oil in the achenes (by NMR method) were also determined. Finally for every irrigated thesis the water efficiency (g d.m. achenes/l) and the evaporation coefficients (l/kg d.m. achenes) were calculated. For the observations concerning the yield characters, the test area was limited in every plot to the four central rows, and furthermore eliminating from the latter the last three plants at each end.

The thermopluviometric trend, recorded during the three-year trial period, is shown in Figures 1, 2 and 3.

With the aim of obtaining one factorial experiment only (years x hybrids x irrigated theses), the trials were sown every year on soils with similar physico-chemical and hydrological characteristics.

All the data recorded underwent analyses of variance according to the arrangement in the field of the split plots.

Results and discussion

Year effect. All the characters examined (Tab. 2 and 3), with the exception of plant height and achene production, were seen to be influenced by the climatic trend. In particular the greater rainfall and the lower mean temperatures recorded in 1989 during the trial period (Fig. 3), caused (Tab. 4) a lengthening of the duration of the phenological periods in question and a significant increase in the head diameter, while the central sterility normally present in this latter had almost disappeared. The climatic trend also significantly influenced some of the yield characters (Tab. 5), in particular the 1000-grain weight which was seen to be considerably greater in the last trial year, although this was at the expense of the number of grains per unit area and oil percentage which was lower compared to the other years due to low temperatures during grain filling (Canvin, 1965).

Hybrid effect. The behaviour observed in the hybrids under comparison confirmed, as one would expect, a greater precocity in "Cerflor" in the attainment of the flowering and physical maturity phases (Tab. 4). Analysing the biometric characters, the same cultivar showed on average over the three-year period the greatest plant height (Tab. 4), whereas the values concerning head diameter and percentage of sterility in the head were lower. Concerning production characters (Tab. 5), "Cerflor", while showing a lower 1000-grain weight, permitted a significantly higher return thanks to the higher number of achenes/m2. Even the unit yield of oil of the latter was greater, notwithstanding the smaller percentage content compared to that of "Romsun HS 90".

Irrigation treatment effect. Generally speaking the length of the phenological periods in question (Tab. 4) was influenced by the rate and number of waterings carried out. In fact passing from the less irrigated theses to those which received two or more waterings, a significative increase in the length of the above-mentioned periods was seen, reaching a maximum in theses 2/1 and I.

The different irrigation regimes adopted also significantly influenced the values of both plant height and head diameter (Tab. 4). This first character showed the greatest values, statistically similar among themselves (for P 0.05), in thesis I and in those irrigated mostly in the vegetative phase - theses 2/1 and 2/0; concerning the head diameter, the greatest dimensions were shown by theses I and by those which also received a watering at the beginning of anthesis stage (2/1 and 1/1). On the other hand the smallest plant and head were obtained with the theses 0/0 and those irrigated once only.

Considering the yield characters (Tab. 5), the statistically greater results were in general given, apart from by the fully irrigated thesis (I), by those which received more than one watering of which one in the reproductive phase. In particular, with regard to the number of achenes/m2, the greatest values were obtained by the theses I, 2/1 and 1/1. Even in the case of the 1000-grain weight, thesis I showed the significantly highest value, while 0/0 and 1/0 the lowest.

Concerning achene production, it is quite obvious that a summer-sown crop, even in the best of cases (2.88 t·ha-1), gives decidedly lower yields than spring-sown crops. In fact, right from the first phases of development, the sunflower as a catch-crop is limited by the hydrological state of the ground, impoverished by the preceding crop; subsequently lack of rainfall, high temperatures and high evaporation during the vegetative phase tend to shorten the cycle. During the grain-filling phase the principal factors limiting production are, on the other hand, the insufficient radiation conditions and temperature (Lanza et al., 1988; Santamaria et al., 1991). Similar behaviour by the sunflower was observed in research, also carried out in this same trial area, which included the comparison of different cultivars in two sowing periods as a catch-crop and with total reintegration of evapo-transpiration (Salera et al., 1988).

On average the greatest achene yields were given by the thesis in which total reintegration of evapo-transpiration was carried out, while the lowest was supplied by the non-irrigated control. Good production results, not significantly different among themselves, were obtained also with theses 2/1 and 1/1, highlighting the fact that one or two waterings in the vegetative phase and one only at the beginning of anthesis are sufficient to guarantee excellent levels of production. One watering only in the reproductive phase was sufficient, thanks to the fact that grain filling took place in a period (September) in which rainfall normally occurs.

The percentage oil content in the achenes (% of dry matter) was little influenced by the different irrigation regimes adopted. In fact among the best theses (all those which received one watering at the beginning of anthesis), 0/1 and 1/1 showed values statistically similar even to those of the theses which were less good. Oil production, similarly to achene production by which it was more directly influenced, was higher in thesis I; after the latter the best values, statistically similar among themselves, were shown by theses 2/1 and 1/1.

Interaction effect. Statistical processing indicated how in general (Tabs. 2 and 3) only the interactions years x hybrids and years x irrigation treatments were significant, particularly for the yield characters. For both it seems appropriate to examine oil production, which is directly influenced by both achene production and oil percentage. The interaction years x hybrids (Fig. 4) has shown how the significantly greater yields (for $P \leq 0.05$) were given in 1988 and 1989 by "Cerflor". On the contrary in the first trial year it was "Romsun HS 90" which supplied the statistically greatest value, while in the cooler and rainier year (1989) the latter hybrid was poorly productive, indicating how greatly influenced it was, in catch-crops, by the seasonal trend. Looking at Fig. 5 in which can be seen the interaction years x irrigation treatments, the influence of the different seasonal trends on the production response of the crop is very noticeable. In fact in the third experimental year due to the greater amount of rainfall and lower mean temperatures, which as already mentioned influenced the oil percentage content of the achenes, all the theses gave lower returns. Significantly greater oil yields were achieved, on the hand, in 1988 by the thesis which allowed total reintegration of evapo-transpiration and by theses 2/1 and 1/1.

Water efficiency. The relationship between the dry matter of the achenes produced and the measured EET allows an evaluation to be attempted of the efficiency of the water consumed by the crop and the determination of the evaporation coefficients. Examining these last two factors in Table 6, it is evident that on average the thesis 1/1 is the one which showed the greater water efficiency and the smaller evaporation coefficient values. Good results, not far removed from those of thesis 1/1, were given also by thesis 2/1. Concerning the mean values of total irrigation rates supplied during the three-year period, we note in addition how 163 mm were supplied to thesis 1/1 with respect to 166 mm to thesis 2/1.

Conclusions

In the research area the sunflower catch-crop generally speaking gave production results that can be considered very satisfactory, taking into account the sowing period and the crop yield in a normal period (Vannozzi et al.,1990).

After the fully irrigated thesis (thesis I), those that showed the statistically highest yields were 2/1 and 1/1, with an increase in achene return with respect to the control irrigated only at seeding (thesis 0/0) of about 31%.

In general, the adoption of the "phenological" irrigation criterion allowed considerable savings in water and the reduction in the number of waterings. With only two targeted waterings, of which one at the tenth true leaf and one at the beginning of anthesis (thesis 1/1), average water savings of 54% with respect to thesis I were made possible with a production decrease of only 7%. Thesis 1/1 showed moreover the best water efficiency and the least evaporation coefficient values.

This research has confirmed the influence of hydrological conditions during the vegetative phase on plant height and head diameter; while irrigation at the beginning of anthesis had a positive influence on achene number and weight, in addition to their oil percentage content. The very early hybrid "Cerflor" showed in general the significantly greatest values of both achene yield and oil production.

Tab. 1 - Physical, chemical and hydrological characteristics of the trial soils.

Soil characteristics		Values		
		1987	1988	1989
Sand (%)		16	19	23
Silt (%)		51	47	45
Clay (%)		33	34	32
pH (in water)		7.44	7.76	7.65
Total lime (De Astis) (%)		13.9	13.5	13.3
Total nitrogen (Kjeldahl) (‰)		1.7	1.8	1.7
Assimilable phosphorus (Olsen) (ppm)	P	5.7	5.8	5.6
" " " "	P_2O_5	13.05	13.28	12.82
Assimilable potassium (ppm)	K_2O	429	418	412
Organic matter (Lotti) (%)		1.9	1.8	1.9
Soil dry bulk density ($t \cdot m^{-3}$)	0-25 cm	1.25	1.26	1.25
	25-50 cm	1.24	1.26	1.25
Field capacity "in situ" (w/w)	0-25 cm	33.2	32.7	32.3
	25-50 cm	33.0	32.5	32.3
Relationship between tension (bar) - soil moisture (w/w)	- 0.3 bar	42.7	42.7	44.3
	- 0.5 bar	35.6	35.5	36.6
	- 1.5 bar	28.5	28.2	29.0
	- 3.0 bar	23.4	23.3	23.8
	- 8.0 bar	17.7	17.5	17.8
	-15.0 bar	16.6	16.2	16.7

Tab. 2 - Significance of variance for some phenologic and biometric characters. (*) Significant at the 0.05 probability level; (**) significant at the 0.01 probability level; (n s) not significant at the 0.05 probability level.

Sources of variation	Period em.-b.a.	Period b.a.-p.m.	Period em.-p.m.	Plant height	Head diameter	Head's sterile part area
Years	* *	* *	* *	n s	* *	* *
Hybrids	* *	n s	* *	* *	* *	*
Irrigation treatments	* *	* *	* *	* *	* *	n s
Years x hybrids	*	n s	n s	n s	n s	n s
Years x irr. treat.	n s	n s	n s	n s	n s	* *
Hybrids x irr. treat.	n s	n s	n s	*	n s	n s
Yea. x hyb. x irr. tr.	n s	n s	n s	n s	n s	n s

Tab. 3 - Significance of variance for some yield characters. (*) Significant at the 0.05 probability level; (**) significant at the 0.01 probability level; (n s) not significant at the 0.05 probability level.

Sources of variation	No achenes $\cdot m^{-2}$	1000 grain weight	Yield of achenes	Oil in achenes	Yield of oil
Years	**	**	n s	**	**
Hybrids	**	**	**	**	**
Irrigation treatments	**	**	**	*	**
Years x hybrids	**	n s	**	**	**
Years x irr. treat.	**	**	**	**	**
Hybrids x irr. treat.	n s	n s	n s	n s	n s
Yea. x hyb. x irr. tr.	n s	n s	n s	n s	n s

Tab. 4 - Average effect of year, hybrid and irrigation treatment on phenologic and biometric characters.

Treatment		Period em.-b.a. (days)	Period b.a.-p.m. (days)	Period em.-p.m. (days)	Plant height (cm)	Head diameter (mm)	Head's sterile part area (%)
Year							
	1987	44.0 cC	37.4 bB	81.4 bB	132	151 bB	3.5 aA
	1988	46.1 bB	35.3 cC	81.4 bB	133	148 bB	2.3 aA
	1989	48.2 aA	42.8 aA	91.0 aA	129	175 aA	0.1 bB
Hybrid							
Cerflor		45.8 bB	38.5	84.3 bB	154 aA	154 bB	1.2 b
Romsun HS 90		46.4 aA	38.5	84.9 aA	108 bB	162 aA	1.6 a
Irrigation treatment	0/0	45.5 eD	37.4 cC	83.0 dD	120 dC	147 bB	1.8
	1/0	46.0 cdBD	36.9 cC	82.9 dD	130 cB	152 bB	1.4
	0/1	45.7 deCD	39.2 abAB	84.9 cBC	121 dC	153 bB	1.4
	1/1	46.2 bcAC	38.8 bAB	84.9 cBC	131 bcAB	166 aA	1.0
	2/0	46.0 cdBD	38.5 bB	84.5 cC	137 abAB	153 bB	1.5
	2/1	46.5 abAB	39.1 abAB	85.7 bAB	139 aA	166 aA	1.2
	I	46.7 aA	39.7 aA	86.4 aA	139 aA	169 aA	1.4

Means followed by the same letter do not differ significantly at the 5% level (small letters) and the 1% level (capital letters) according to Duncan's multiple range test.

Tab. 5 - Average effect of year, hybrid and irrigation treatment on yield characters.

Treatments		Number of achenes (no·m-2)	1000 grain weight (g)	Yield of achenes (t·ha-1 0% humid.)	Oil in achenes (% of d.m.)	Yield of oil (t·ha-1)
Year						
	1987	5036 bA	48.5 bB	2.40	50.7 aA	1.22 bAB
	1988	5124 aA	50.0 bB	2.51	51.5 aA	1.29 aA
	1989	3913 cB	63.8 aA	2.45	47.3 bB	1.16 bB
Hybrid						
Cerflor		5511 aA	48.0 bB	2.61 aA	48.1 bB	1.26 aA
Romsun HS 90		3871 bB	60.2 aA	2.30 bB	51.5 aA	1.19 bB
Irrigation treatment	0/0	4188 cC	50.3 dD	2.05 eD	49.4 bc	1.01 eD
	1/0	4430 bcBC	51.3 dD	2.20 dCD	49.5 bc	1.09 dCD
	0/1	4555 bB	53.0 cC	2.34 cC	49.9 ac	1.17 cC
	1/1	5014 aA	55.9 bB	2.68 bB	50.0 ac	1.34 bB
	2/0	4593 bB	52.9 cC	2.35 cC	49.1 c	1.15 cdC
	2/1	4930 aA	56.7 bB	2.68 bB	50.6 a	1.35 bB
	I	5128 aA	58.5 aA	2.88 aA	50.2 ab	1.44 aA

Means followed by the same letter do not differ significantly at the 5% level (small letters) and the 1% level (capital letters) according to Duncan's multiple range test.

Tab. 6 - Hydrological balance components, water efficiency and evaporation coefficent. Three-year mean values.

Irrigation treatments	Total irrig. rates (mm)	Rainfall (mm)	Water storage of the soil utiliz. (mm)	Effective evapotras. (mm)	Water efficiency (g d.m. ach./l)	Evaporation coefficent (l/kg d.m. ach.)
0/0	76	125	-90	171	1.20	835
1/0	141	125	-35	231	0.95	1048
0/1	161	125	-62	224	1.04	959
1/1	163	125	-61	227	1.18	845
2/0	142	125	-48	219	1.07	934
2/1	166	125	-57	234	1.15	871
I	356	125	-96	385	0.75	1337

Fig. 1 - Temperature, rainfall and evaporation patterns at 10-day intervals throughout the growing season (march-october 1987).

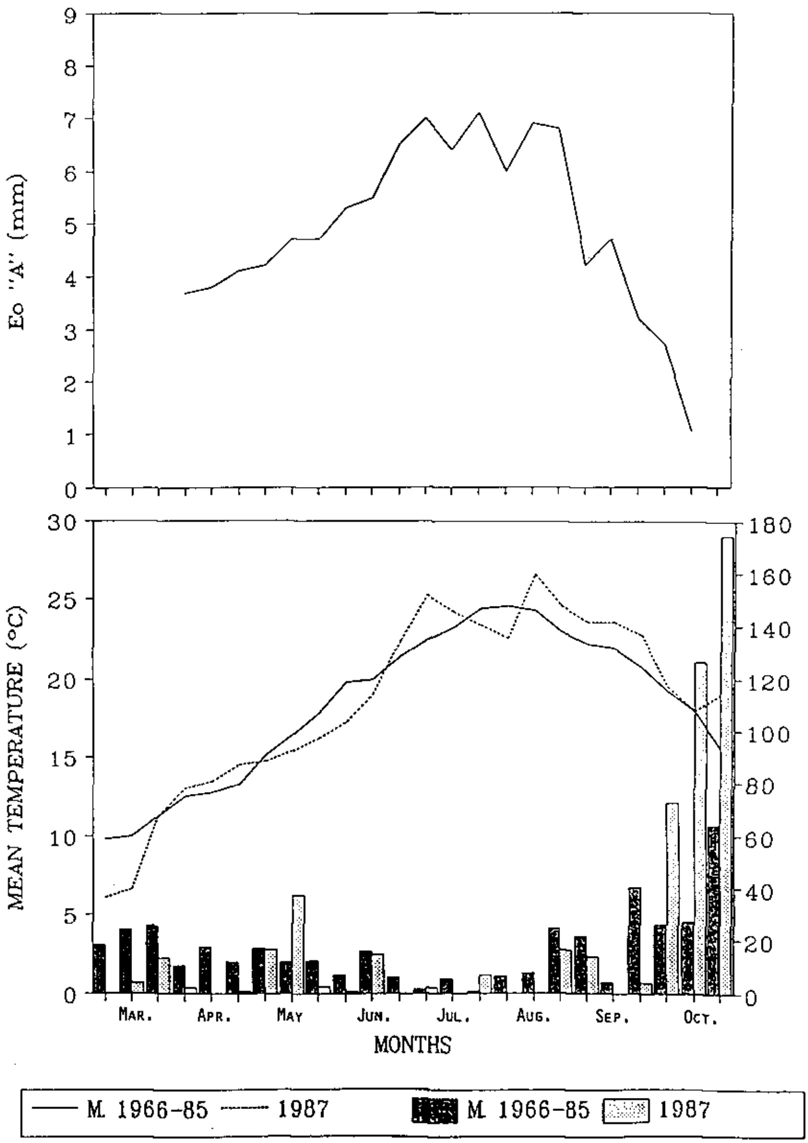


Fig. 2 - Temperature, rainfall and evaporation patterns at 10-day intervals throughout the growing season (march-october 1988).

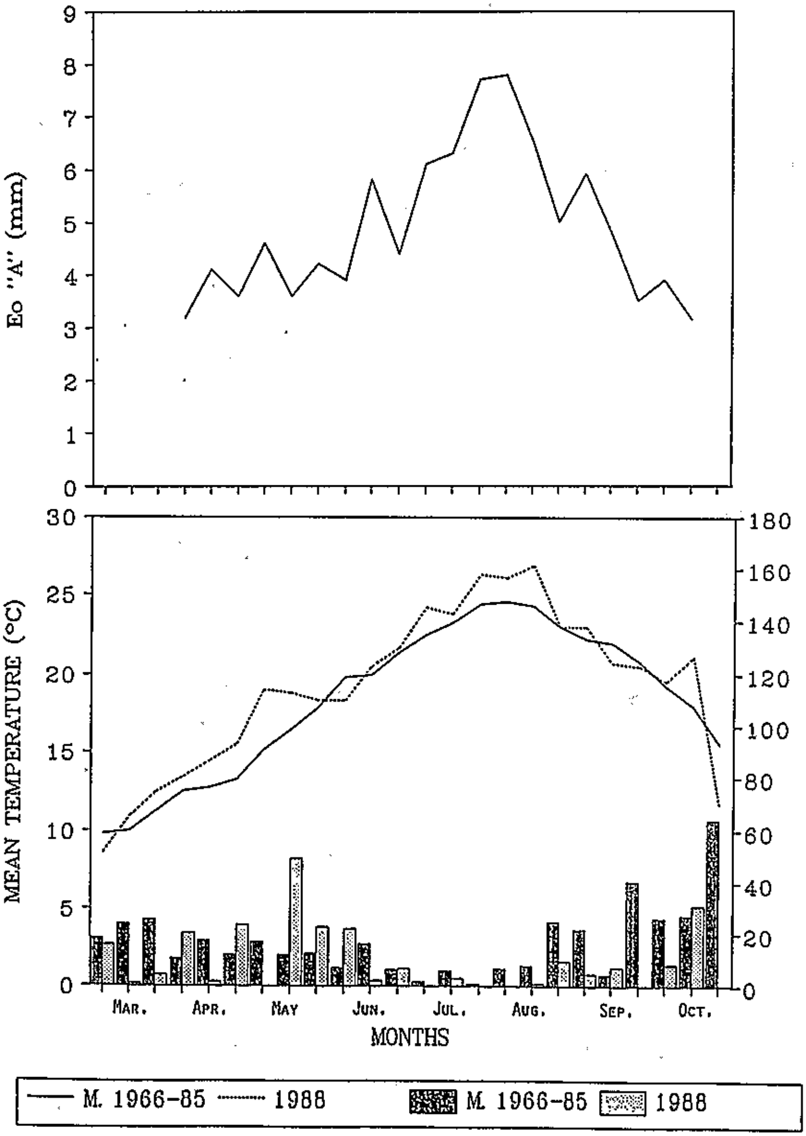


Fig. 3 - Temperature, rainfall and evaporation patterns at 10-day intervals throughout the growing season (march-october 1989).

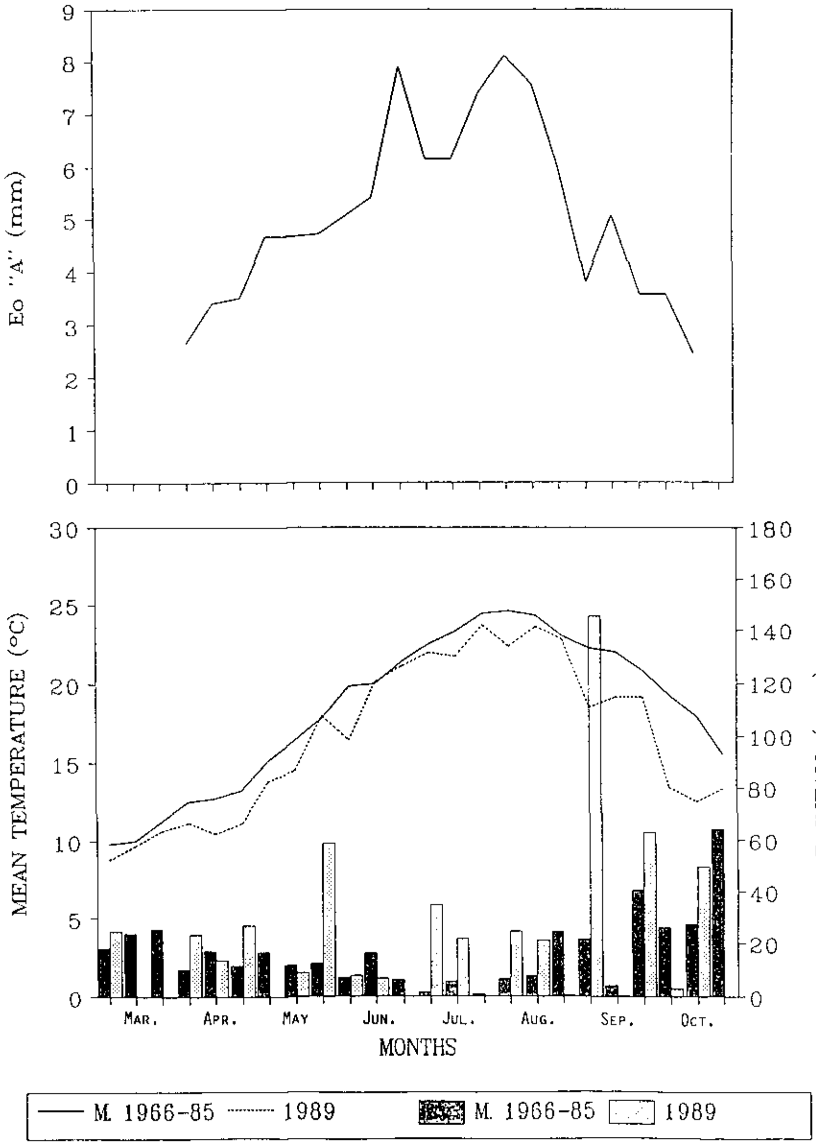


Fig. 4 - Interaction years x hybrids.

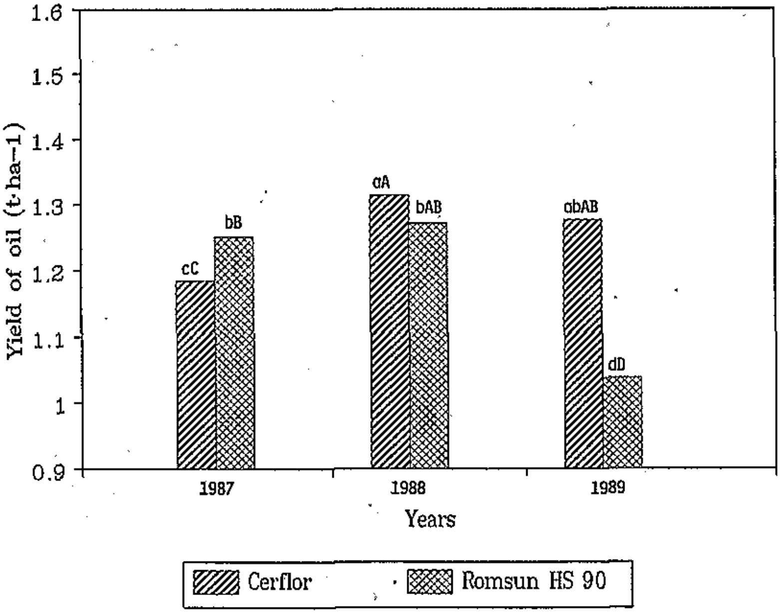
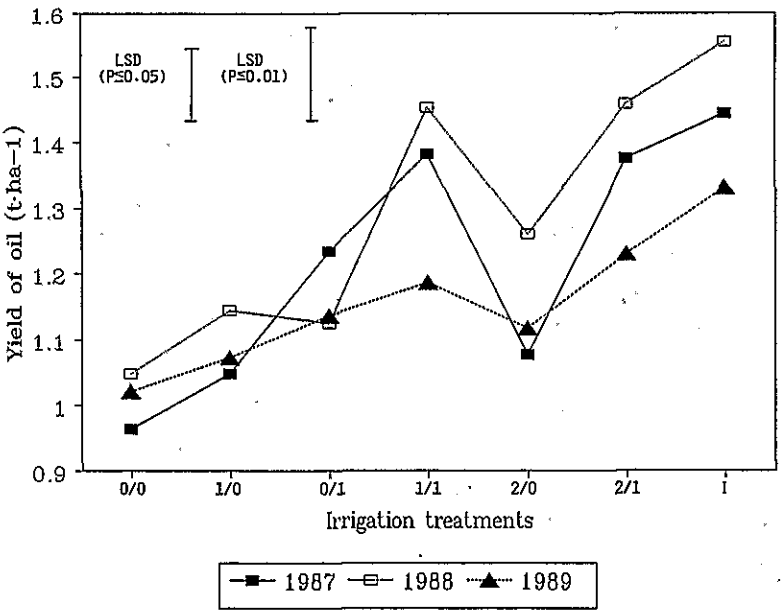


Fig. 5 - Interaction years x irrigation treatments.



REFERENCES

Bonari E., Mazzoncini M., Bertolacci M., Megale P. G., Perioli R. (1989) - "Primi risultati sui consumi idrici e sulle rese di mais, soia e girasole in secondo raccolto dopo frumento e orzo nell'Italia centrale". Irrigazione e drenaggio, 3, 206-211.

Canvin D. T. (1965) - "The effect of temperature on the oil content and fatty acid composition of the oil from several oil seed crops". Can. J. Bot., 43, 63.

Covarelli G. (1988) - "Ricerche sperimentali sul diserbo del girasole in coltura principale ed intercalare". L'Inf. Agr., XLIV, 13, 113-121.

Lanza F., Ciliardi A. M., Ferri D., Losavio N., Santamaria P. (1988) - "Le tournesol en colture derobée en Italie du Sud; prospectives et limites par rapport aux date de semis et aux different hybrides. Premiers resultats des rendments quanti-qualitatifs". Atti XII Conf. Int. sul Girasole, Novi Sad (Jugoslavia), 25-29 giugno, vol. 1, 223-228.

Marzi V., Spanu A., Barbieri G., Mariani G., Monotti M., Montemurro P. (1982) - "Risultati di prove su modalità diverse di preparazione del terreno per la coltura del mais in II raccolto dopo frumento". Annali dell'Istituto Sperimentale per la Cerealicoltura, Roma, 13, suppl. 1, 77-94.

Miele S. (1987) - "Nuove attrezzature combinate per l'impianto del mais". Terra e Vita, XXVIII, 10 suppl., 72-75.

Miele S., Palmerini M. - (1989) - "Risultati di una prova quinquennale di concimazione localizzata in banda del mais (Zea mays L.). Rivista di Agronomia, XXIII, 4, 391-397.

Pacucci G., Alba E. (1977) - "Valutazione di ibridi e varietà commerciali di girasole in coltura principale ed intercalare". Annali Facoltà di Agraria dell'Università di Bari, XXIX, 363-376.

Salera E., Baldini M., Benvenuti S., Vannozzi G. P. (1988) - "Valutazione delle possibilità produttive del girasole in differenti epoche di semina in secondo raccolto. Risultati di un biennio di prove in due ambienti della Toscana litoranea". Atti Cong. su stato attuale e prospettive delle colture oleaginose erbacee in Italia". Pisa 24-26 febbraio, 455-472.

Santamaria P., Ciliardi A. M., Lanza F., Losavio N. (1991) - "Influenza dell'epoca di semina sull'accrescimento, lo sviluppo e la resa del girasole (Helianthus annuus L.) in secondo raccolto". Rivista di Agronomia, 1, 57-62.

Schneiter A. A., Miller J. F. (1981) - "Description of sunflower growth stages". Crop Science, 21, 901-903.

Tarantino E., Alba E. (1978) - "Influenza del regime irriguo e della densità di semina sulle caratteristiche della produzione di alcune varietà commerciali e di nuove selezioni di girasole coltivate in secondo raccolto". Rivista di Agronomia, 3, 136-142.

Vannozzi G. P., Paolini R. (1978) - "La coltura del girasole di secondo raccolto in Toscana. Confronto tra varietà diverse e per differenti epoche di semina. Atti Convegno su aspetti genetici agronomici e patologici del girasole e sulle caratteristiche industriali, alimentari e commerciali del prodotto. Pisa, 14-15 dicembre.

Vannozzi G. P., Salera E., Baldini M. (1990) - "Risultati delle prove di confronto tra varietà di girasole eseguite in Toscana nel 1989". L'Inf. Agr., XLVI, suppl. 12, 6-12.