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SUNFLOWER (*Helianthus annuus* L.) IN TWO-YEAR ROTATIONS WITH DURUM WHEAT, WITH OR WITHOUT CATCH SOYBEAN

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SUMMARY

This work is a part of a joint project on Cropping Systems, supported by the Italian Ministry of Agriculture, which is still in progress in the experimental farm of Foggia.

The results of six-years of comparison between 2 two-year rotations (durum wheat following sunflower, with or without catch soybean) are reported.

Each crop was submitted to two levels of agrotechnical inputs - medium high and medium low - including different soil tillage methods, fertilizing, irrigation, weed and pest control.

Sunflower yields showed a decreasing trend from the first to the last years of the trial, partly depending on the worsening of climatic conditions and on the increase of pest damages.

The two input levels gave alternate yield responses although no great difference was observed in most cases between them.

The presence of soybean as catch crop in the rotation resulted in a progressive increase of seed yield.

INTRODUCTION

The present crisis of the agricultural market as well as the removal of EEC subsidies led to the collapse also of sunflower price and to the subsequent reduction of cropped areas. However, the new acreage subsidies, provided by the EEC regulation 3776/91 for oil crops and the still undoubted agronomic validity of this species, characterized by the excellent adaptation to the critical conditions in these southern areas, the moderate water requirements, the limited cultivation costs and the favourable market demand, open new coltivation possibilities to sunflower in the South of our country.

Within this framework, the appropriate reduction of agrotechnical inputs for environmental protection, may be even more fruitful than in the past in improving the yield efficiency of sunflower to increase farmers' income (Valorosi and Frascarelli, 1992).

MATERIALS

The research was carried on from 1986 to 1991 in Foggia at the experimental farm of the Institute. The area is characterized by an "accentuated thermome-

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diterranean climate" (FAO-UNESCO) and an alluvial "vertisol" (Typic chromoxerert, according to the Soil Taxonomy - USDA), clay-silty-loam, of good agronomic fertility (total N = 0.139%; available P_2O_5 = 74 ppm; exchangeable K_2O = 1598 ppm; O.M. 2.1 %; pH (water) = 8.0). This note analyses 3 two-year cycles of a sunflower-durum wheat rotation, with and without a catch soybean, submitted to 2 agrotechnical input levels. The research is part of a more general study on a strip-plot experimental design, with 9 rotations and 2 input levels arranged by orthogonal strips, with 3 replicates and 400 m^2 elementary plots. To test the year effect, the experimental design involves the simultaneous presence in the field of both crops of each rotation every year. The agrotechnical levels, designated as M-H (medium-high: optimal) and M-L (medium-low: traditional in the test area) are differentiated by soil tillage methods, irrigation, fertilizing, weed and pest control.

The bioagronomic data observed were submitted to the analysis of variance for each year; once the variance homogeneity was checked, an overall six-year analysis was carried on considering the year as the random factor and the rotation and the input level as fixed factors.

CLIMATE

Table 1 summarizes the climatic data observed during the 6 years of the trial compared with those of the reference mean (40 years).

As to the "rainfall" factor which mostly affects yields, in particular in the trial area, the most unfavourable years were respectively 1990 (119.8 mm rainfall), 1987 and 1991; the latter also showed a very high evaporation rate (1118.2 mm) mainly due to South-South Western dry winds. 1991 and 1988 were characterized by higher temperatures, which exceeded and reached on the average nearly 28 C in August.

To assess how much did these factors affect, with irrigation, the sunflower yield, some climatic indices were determined from sowing till harvest (potential evapotranspiration- ETP, according to the Penman-Monteith formula; total and effective (GDD) heat units (HU); water deficit (WD) and correlated to the seed yield. The most significant results of these analyses are presented below.

RESULTS AND DISCUSSION

Figure 1 shows that in spite of the evident dispersion of some values, the total water supply to plants, constituted by rainfall plus irrigation (the soil WD did not show any appreciable variation) is positively correlated with yields ($r = 0.63$), which seem moderately interpolated by a second degree curve. The correlation between yield and water deficit seems better, showing an r

= -0.75. The correlation between yields and heat units was also highly significant (r = 0.82), thus accounting for the higher yields of the first three years, as described later. The high temperatures recorded in 1990 did not have the same effect: it's the higher water deficit which had the severely limiting effect on yields.

A preliminary valutation of some possible correlations between yield and its components was effected. The most significant results were found for the total (r = 0.84) and fertile head diameter (r = 0.75), for the weight of 1000 seeds (r = 0.76) and of plant residues (r = 0.68), as observed by other Authors (Foti and Abbate, 1982; Vannozzi et al., 1986). A significant but negative correlation was found for the oil content (r = -0.45).

The analysis of variance carried on the 6 years of the trial for the major growing and yield parameters of sunflower (Table 2) shows that the higher significance of the differences observed between variables may be attributed to the "year factor". A moderate significance was also observed for rotations, in terms of yields and head diameter, whereas for the agrotechnical input levels the plant height was the unique significant parameter.

The mean corresponding values of field and laboratory data for each tested variable are reported in table 3.

This table shows clearly the progressive worsening of nearly all the characters through the years; the seed yield, in particular, decreased by 2.26 t ha^{-1} from the first to the sixth year. The 1000 seed weight also decreased (from 81 to 55.2 g) the same as total diameter and fertil head diameter (from 20.5 to 15.7 and from 18.1 to 12.1 cm, respectively).

These results cannot be attributed only to the progressive plant disease, but also, to a great extent, to the sharp worsening of climatic conditions, rainfall in particular. The unique character which showed a gradual improvement over time was the oil yield which is, as known, negatively correlated to yield; the higher oil content value (59.3%) indeed refers to 1990 which experienced the lowest 1000 seed weight (54.5 g) with one of the lowest seed yield values (2.76 t ha^{-1}). As a consequence of these relations, in the unit oil yield, closely related to the seed yield, a partial compensation of values was recorded.

In the comparison between the two rotations with and without the catch soybean, although the differences observed resulted to be significant to the analysis of variance (Table 2) only for seeds and oil yield and for the total and fertile head diameter, the analysis of mean data reported in Table 3 shows for all tested variables some predominance of rotations with soybean, with 0.27 and 0.20 t ha^{-1} differences respectively for seed and oil yield and 0.42 and 0.55 cm for total and fertile head diameters.

As for the interaction "rotations x years", it is interesting to observe in the histogram showing its effects - although non significant - on seed yield (Fig. 2) that in the first year only - not at all significant for the assessment of the rotation - a basic equality of the mean yields of the two rotations was observed, whereas in the second one, the rotation with the soybean seems somewhat predominant and greatly increased the following years with a maximum difference of 0.48 t ha^{-1} in 1990.

The effects of the two different agrotechnical input levels, on the other hand, resulted inconsistent and affected only the mean plant height, which changed from 158.3 to 150.8 cm respectively from the "M-H" to the "M-L" level.

These results do confirm, the results of previous research carried out in the same area. In fact, the most differentiated agronotechnical means interventions in the two experimental levels of the trial, tillage (with and without clod overturning and breaking) and nitrogen (75 and 150 Kg N ha^{-1}) and phosphatic fertilizations did have any appreciable effect on the yield of crops even more demanding than sunflower, especially in the years, like the three last ones of the experiment, in which the unfavourable climatic conditions had a more severe and limiting effect than all other factors, including irrigation. The latter, which among all agrotechnical means is the one inducing the most evident effects on the yield level of spring-summer crops in Southern areas, was deliberately poorly differentiated in the two input levels *of our research*, to prevent, on the one hand- by reducing to the M-B - a condition too much severe in terms of yield for renewal crops in rotation (including sunflower), and, on the other, by increasing the M-H- a condition of doubtful economic and agronomic effectiveness.

CONCLUSIONS

The six-year research, carried in a typical Southern Italy area, usually characterized by hot and dry summer in which particularly high dryness and temperatures were recorded in the test period, enables expressing a positive judgement on the possibility to introduce sunflower in rotations not too short.

Yields varied between 4.7 and 2.5 t ha^{-1}, worsening from the first to the sixth year, partly depending on pest damages which were progressively more intensive, and also, to a greater extent, on the worsening of the dry weather conditions.

As to the year variability, the one due to the effect of experimental factors was much lower. However, between the two rotations of *"sunflower - wheat"*, with and without the catch soybean, the first was mostly prevailing, except for the first year, showing a 0.3 t ha^{-1} yield increase proving the effectiveness of the catch crop at least for the purpose of improving the soil structure.

On the other hand, no yield difference was observed as a consequence of the different agrotechnical input levels. This result seems undoubtedly positive in order to reduce production costs as well as the environmental impact.

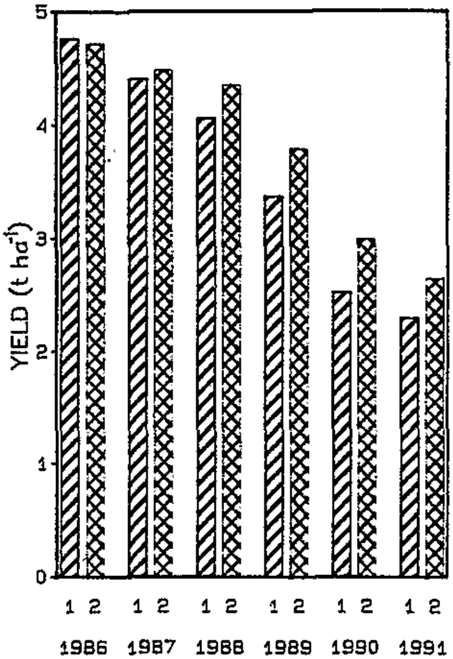


Figure 1 - Quadratic regression between yield and water supply (a), yield and water deficit (b); linear regression between yield and heat units (c).

Table 1 - Climatic data through the sunflower cropping season.

Years	1986	1987	1988	1989	1990	1991	40-year mean
				rainfall (mm)			
April	8.4	4.2	49.6	23.2	56.6	72.8	41.0
May	1.0	97.8	63.0	27.0	31.0	30.4	43.6
June	87.4	21.4	38.9	80.0	14.6	23.6	30.6
July	67.6	16.6	0.2	56.0	16.0	12.6	24.7
August	1.8	-	49.2	26.2	1.6	2.8	11.7
Total	166.2	140.0	200.9	212.4	119.8	142.2	151.6
				class A pan evaporation (mm)			
April	125.0	144.6	106.8	143.7	108.4	98.2	116.4
May	192.2	148.4	149.5	178.0	185.5	178.1	173.5
June	214.0	211.9	196.2	206.1	242.2	282.5	234.1
July	233.4	286.2	334.0	252.9	331.9	302.9	295.1
August	163.1	95.6	100.2	183.3	72.8	256.5	166.6
Total	927.7	886.7	886.7	964.0	940.8	1118.2	985.7
				mean temperature (C)			
April	14.1	13.7	13.6	13.8	13.1	11.5	12.9
May	21.3	15.6	18.7	16.5	18.3	15.0	17.2
June	22.0	21.2	21.4	20.5	22.7	23.1	21.9
July	24.9	26.7	27.3	24.8	25.7	25.5	24.7
August	28.2	26.0	27.7	25.1	26.4	26.5	25.2
Avg.	22.1	20.6	21.7	20.1	21.2	20.3	20.4

Table 2 - ANOVA table (Pr>F) of some crop parameters throughout the 6 years of the trial.

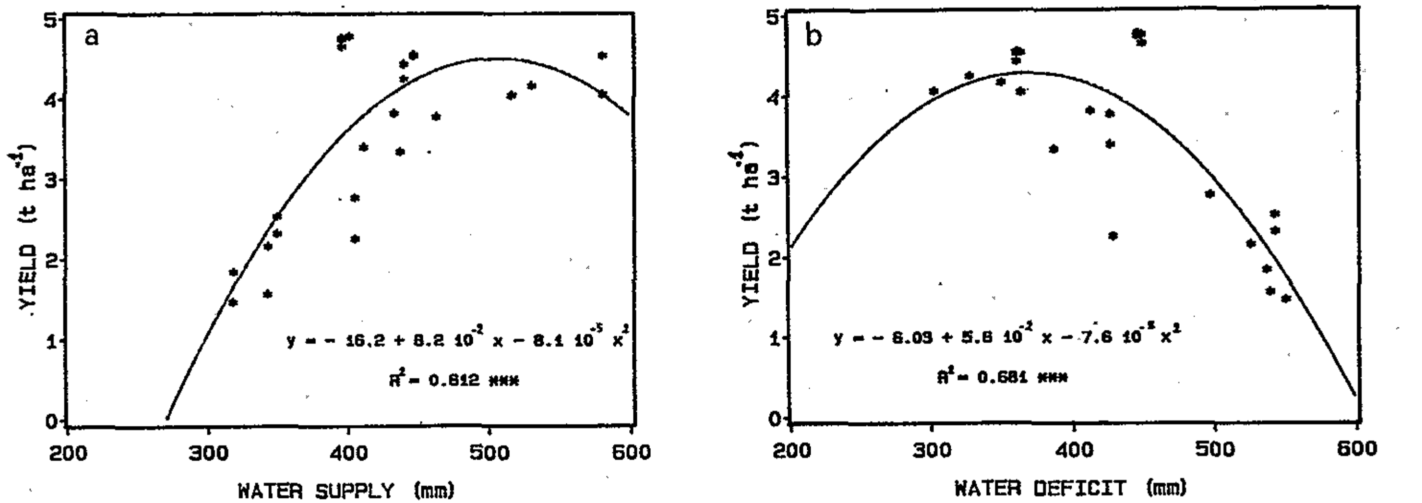
Source of variation	df	1	2	3	4	5	6	7	8	9
Reps	2	**	-	-	-	-	**	-	**	***
YEAR (Y)	5	***	***	***	***	***	***	***	***	**
ROTATION (R)	1	**	-	-	**	-	-	-	-	**
Y*R	5	-	***	-	*	-	*	-	-	-
INP. LEVEL (L)	1	-	-	-	-	-	***	-	-	-
Y*L	5	-	-	-	-	-	-	-	-	-
R*L	1	-	-	-	-	-	-	-	-	-
Y*R*L	5	-	-	-	-	-	-	-	-	-

*, **, *** Significant at 0.05, 0.01 and 0.001 P levels, respectively.
Legend: 1-Seed yield; 2-Total dry matter; 3-Weight of 1000 seeds; 4-Total head diameter; 5-Fertile head diameter; 6-Plant height; 7-Plant population m^{-2}; 8-Oil content; 9-Oil yield.

Table 3 - Bioagronomic data observed on sunflower during the 6 years: means of major factors.

Treatments		1	2	3	4	5	6	7	8	9
YEAR	1986	4.74	12.79	81.66	20.55	18.13	176.7	5.57	47.82	2.27
	1987	4.45	9.06	65.57	20.16	16.61	139.9	6.12	48.46	2.16
	1988	4.21	11.05	62.41	18.14	13.46	160.7	6.74	49.66	2.10
	1989	3.59	11.91	64.35	18.57	15.08	152.1	6.38	59.31	2.13
	1990	2.76	6.09	54.48	16.29	11.65	141.7	5.78	54.14	1.50
	1991	2.48	6.65	55.25	15.72	12.08	155.5	5.62	-	-
ROTATION	S-W	3.57	9.50	63.23	18.03	14.23	154.1	5.97	51.01	1.93
	S-W+Sb	3.84	9.68	64.68	18.45	14.78	154.9	6.10	52.75	2.13
INPUT LEVEL	M-H	3.72	9.72	63.49	18.17	14.33	158.3	6.13	51.42	2.02
	M-L	3.69	9.46	64.41	18.31	14.67	150.6	5.95	52.34	2.04
Mean		3.70	9.59	63.95	18.24	14.50	154.5	6.04	51.88	2.03

Legend: 1-Seed yield (t ha^{-1} at 10% moisture); 2-Total dry matter (t ha^{-1} at 0% moisture) ; 3-Weight of 1000 seeds (g at 10% moisture); 4-Total head diameter (cm); 5-Fertile head diameter (cm); 6-Plant height (cm); 7-Plant population (n m^{-2}); 8-Oil content (%); 9-Oil yield (t ha^{-1}).



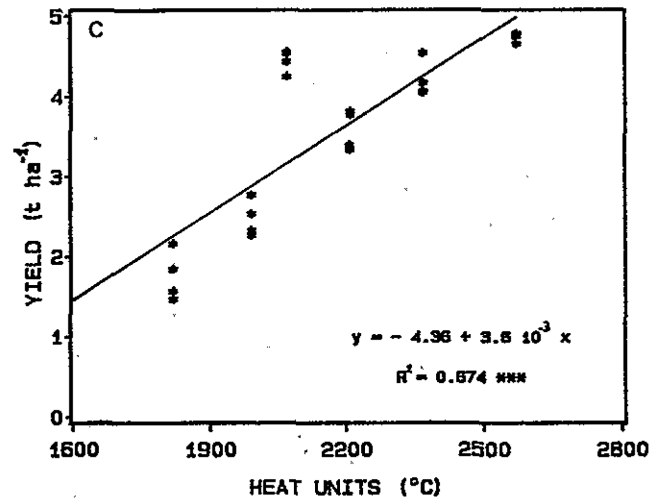


Figure 2 - Seed yield at 10% moisture in the 6 trial years and for 2 compared rotations: 1-S-W and 2-S-W+Sb.

REFERENCES

FOTI S., ABBATE V. (1982) - Analisi delle variazioni della resa e delle sue componenti nel girasole (Helianthus annuus L.) in coltura asciutta. Riv. di Agron., suppl. 2, 214-222.

RIZZO V., DI BARI V., MAIORANA M., CONVERTINI G., RINALDI, M.(1992) - La soia come coltura intercalare in rotazioni triennali nel Mezzogiorno d'Italia. Agricoltura Ricerca (in press).

VALOROSI F., FRASCARELLI A. (1992) - Girasole. La nuova regolamentazione comunitaria di mercato: contenuto e probabili effetti. L'Inf. Agr., 8, 35-38.

VANNOZZI G. P., BELLONI P., MARTORANA F. (1986) - Correlazione tra fattori produttivi nel girasole (Helianthus annuus L.). Sementi Elette, VI, 25-31.