SUNFLOWER RESPONSE TO WINTER PLANTINGS IN A MEDITERRANEAN ENVIRONMENT

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INTRODUCTION

At the present time, sunflower is one of the most important crops in Spain, its area exceeding 1.000.000 ha in 1984, mostly under dryland conditions. Around one third of the total planted area is located in Southern Spain (Andalucía) under a mediterranean-type of climate with mild winters and very hot summers. Sunflower is used on a standard wheat-sunflower rotation and is planted in March, developing during the spring into the hot summer until it is harvested in August. Under these conditions, the crop is subjected to water deficits of variable intensity depending on the amount of stored soil water and on rainfall distribution which is highly variable (Figure 1). In addition to a probable drought, the high summer temperatures during the period of flowering may affect yields. As a result, average dryland yields are low, oscillating between 500 and 1500 kg/ha depending on the year and on soil type.

Two strategies have been developed by agronomists and breeders to improve yields under dryland conditions. One is based on breeding for drought resistance, selecting those genotypes which are most productive under drought. We have shown previously (F e r e r e s et al., 1983) that there is substantial genetic variability in sunflower for drought resistance. We have initiated a breeding program aimed at developing germplasm tolerant to drought under our conditions.

An alternative option is to escape the drought by completing the crop's life cycle before water stress develops. Drought escape was the goal of a breeding program initiated by D o w n e s (1975) using earliness as the major selection criteria. Early maturing hybrids obtained through this program gave better results than late season hybrids under severe water stress conditions (D o m i n g u e z et al., 1978). However, under the typical conditions of South-Western Spain (rainfall in excess of 600 mm) yields of late season hybrids normally exceed those of short-season genotypes (F e r e r e s et al., 1982) because of greater subsoil water extraction and biomass production. One way of escaping drought would be by planting early enough so that the crop develops during winter and spring and avoids the summer drought. The objective of this work was to study the feasibility of winter plantings of three sunflower cultivars and to compare the growth, development and yield of winter plantings against normal spring planting in one environment.

MATERIALS AND METHODS

A three-year experiment was conducted at Cordoba (Spain) during 1981 to 1984. Cumulative rainfall and maximum and minimum temperatures during the three years are shown in Figures 1 and 2. The experiments were car-

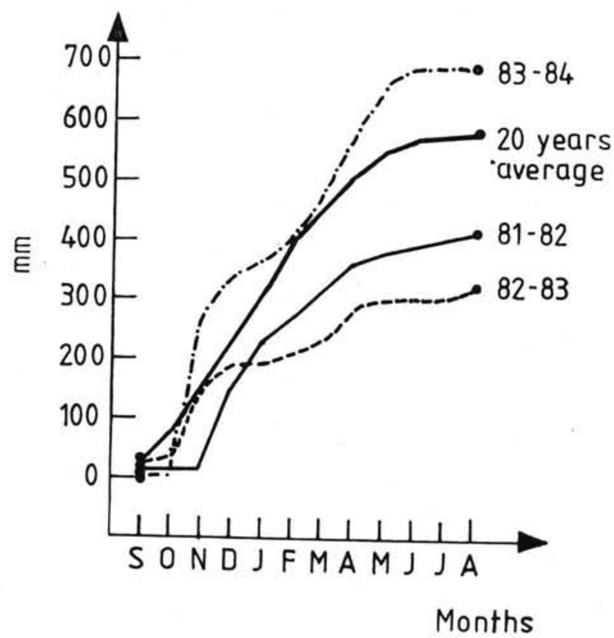

Fig. 1 — Cumulative rainfall for 1981—1982, 1982—1983 and 1983—1984 and the 20 year average for Cordoba

ried out at the experimental farm of the Agricultural Research Center on an alluvial soil of sandy loam texture with a level of water storage similar to the typical vertisols of Western Andalucía.

Seven to ten planting dates were used between December and April at 15 to 30 days intervals. Figure 3 indicates the actual dates of planting as well as the information on crop phenology for each planting date. Three hybrid cultivars were used, an early (SH-3000, cultivar A), medium (Osuna 101-C, cultivar B) and long season cultivar (Sungro 380, cultivar C). Planting density was 50,000 plants/ha with 0.7 m spaced rows. Rainfall during the first and the second experimental year was well below average and preplanting irrigation was needed. In addition, two post-planting irrigations were applied in 1983 in April and May and one irrigation in 1982 (only to the 1 and 15 April plantings) to avoid unusual severe water stress conditions.

The experimental design was a split-plot with three replicates (four in 1984). Individual plots were seven rows of 10 m long. Yield and yield components were determined on the central row (two rows in 1984). Phenology and crop developmental stages were also recorded and seed oil content was measured by N.M.R. technique.

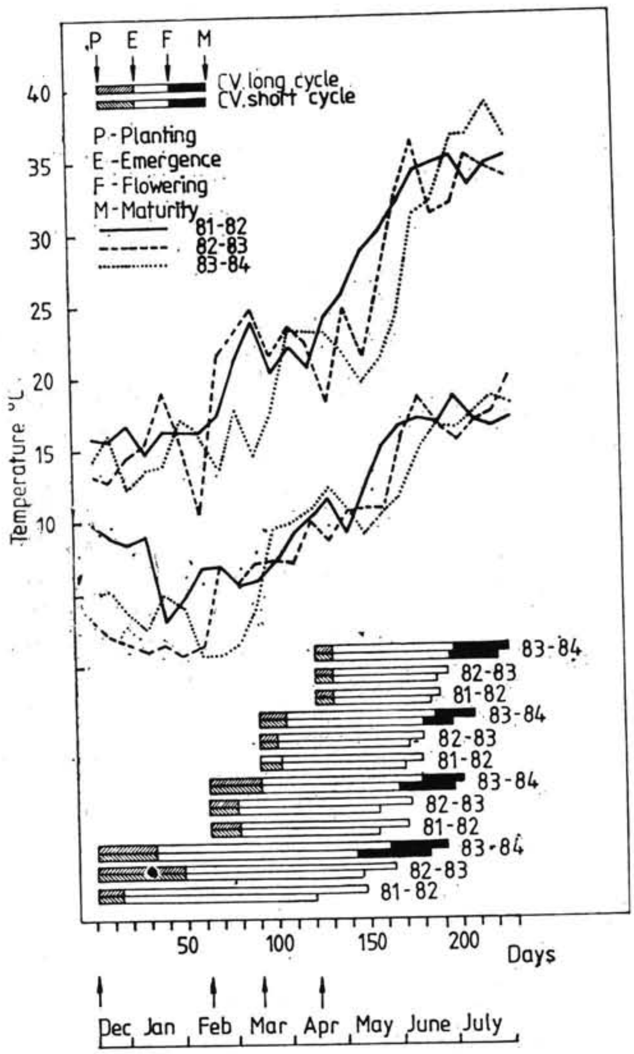

Fig. 2 — Seasonal evolution of the maximum and minimum temperatures for the experimental years. The phenological development for an early and a late-maturing hybrid is also indicated for four planting dates. In 1982, there were 10 days between January and March when daily minimum temperatures at the 15 cm height were below 0°C. In 1983 and 1984 there were 51 and 49 days with minimum temperatures below freezing, respectively. The absolute minimum temperatures at 15 cm height were —2°C in 1982, —9.4°C in 1983 and —6.2°C in 1984

RESULTS AND DISCUSSION

Figure 2 indicates the variation observed in phenological development as a function of planting date for the three hybrids. Results from four planting dates are shown as a sample to demonstrate the large differences among planting dates and years in time of seedling emergence as minimum temperatures were highly correlated with time to seedling emergence. Time from planting to seedling emergence varied from 47 days in December to eight days in April. Despite the extended period of time required for seedling emergence in the winter plantings, plants developed normally except for the planting of 1 December 1983 which had the seedlings exposed to a 17-day period of minimum temperatures below 0°C (down to —6.2°C). Cold damage symptoms in this planting included lateral branching. However, such response was highly variable depending on the hybrid, Sungro 380 being the least susceptible.

Flowering dates also varied with planting dates and, for a given genotype, were directly related to cumulative degree days (G i m e n o, unpublished data). The winter plantings flowered between April 15 and May 31 while normal spring plantings flowered between June 2 and June 28 depending on the cultivar and the year.

Figure 3 presents the yield component information averaged for the three cultivars and for the three experimental years. Grain yield from winter plantings (15 December) was significantly higher than that obtained in normal spring plantings (15 March and on). While yields at normal planting dates averaged around 1 500 kg/ha, our work demonstrates that it is possible to obtain dryland yields in excess of 2000 kg/ha if planting takes place in winter.

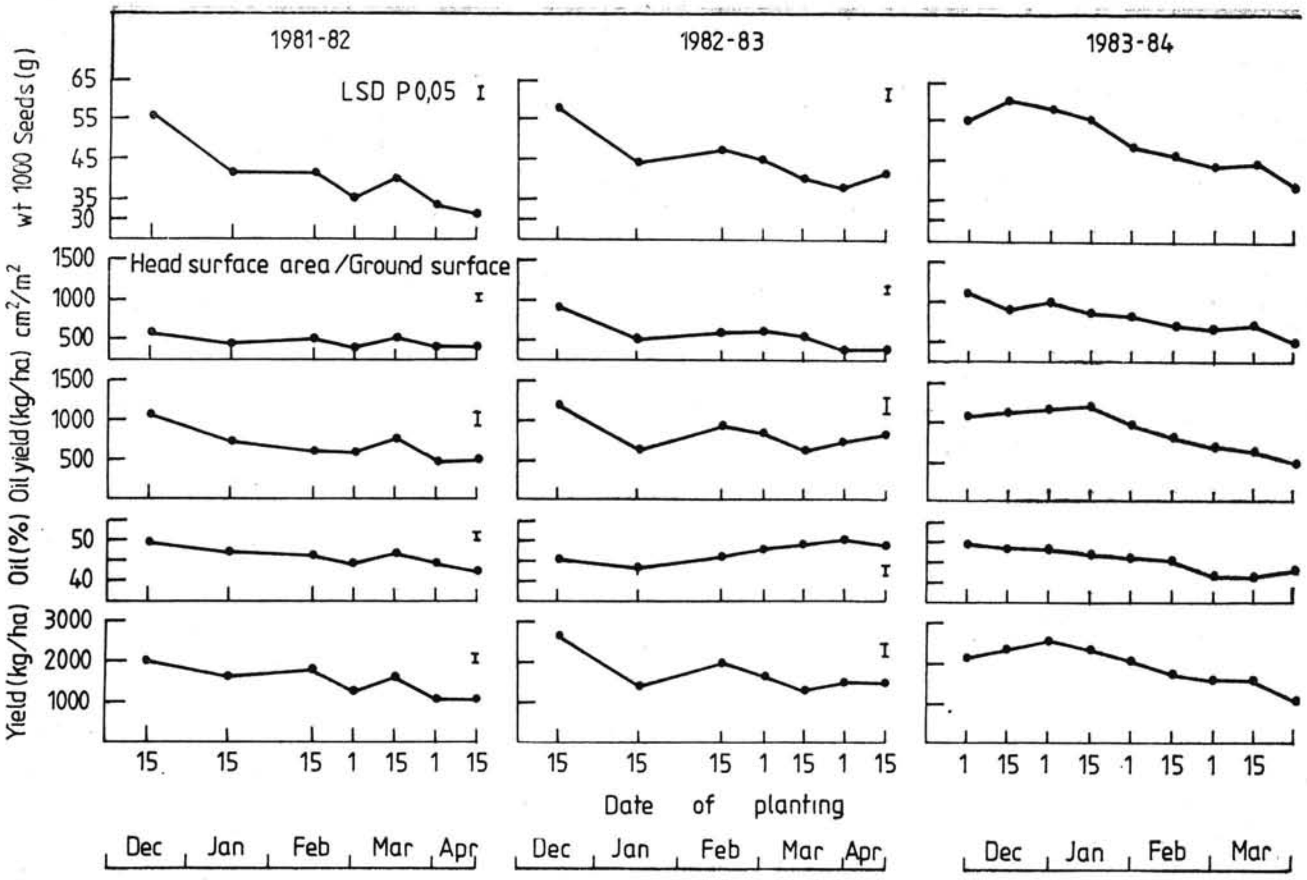

Fig. 3 — Yield, oil content, oil yield and yield components averaged for three hybrids as a function of planting date for the three experimental years.

Oil yield was also higher for winter plantings because the oil content of the seed was higher for the winter plantings in two years out of three.

The higher yields observed in the winter plantings can be attributed in part to larger heads but particularly to the greater weight of individual seeds (Figure 3). Weight of 1000 — seeds was as high as 55 g for winter plantings while it was only around 40 g for normal spring planting dates. These large differences demonstrate that seed filling in plants seeded in winter must have been less affected by water stress than in plants seeded in spring. This was also shown by the length of the seed filling period which was greater for winter plantings (Figure 2).

The response to winter plantings was not uniform among genotypes. Figure 4 presents dates similar to that of Figure 3 except that the individual response of each genotype to planting dates is delineated. One of the most outstanding features of such a response is the very positive response of the long-season hybrid to the earliest planting date tested. In contrast, in two years out of three, the early maturing genotype gave greater yields in January and February plantings as opposed to planting in December. It appears that very early plantings of short-season hybrids might not be desirable under our environmental conditions, probably because of low temperature induction of lateral branching which affected head size.

The yield response averaged for the three years is shown for the early and late maturing genotypes in Figure 5. It can be concluded that winter plantings are advantageous over normal spring plantings under the climatic conditions of Andalucía. The yield advantage (over 33%) is the greatest for the long-season hybrids which appear most suited for planting in mid-December. Optimal planting dates for the early maturing genotypes may vary between late December and 15 February which are, in any case, earlier than planting dates presently recommended. It appears that sunflower is capable of tolerating the low temperatures expe-

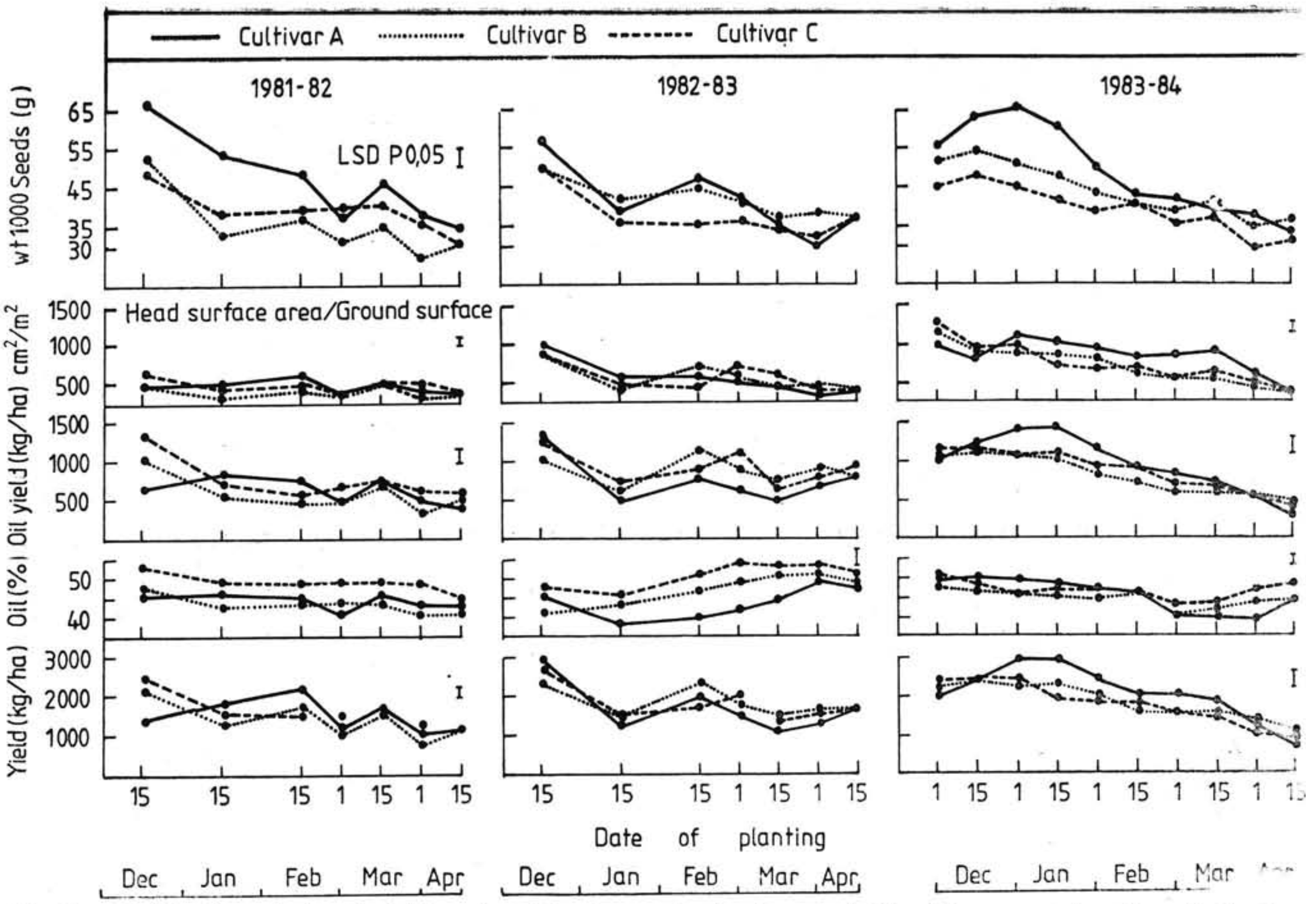

Fig. 4 — Yield, oil content, oil yield and yield components for three hybrid cultivars as a function of planting date for the three experimental years.

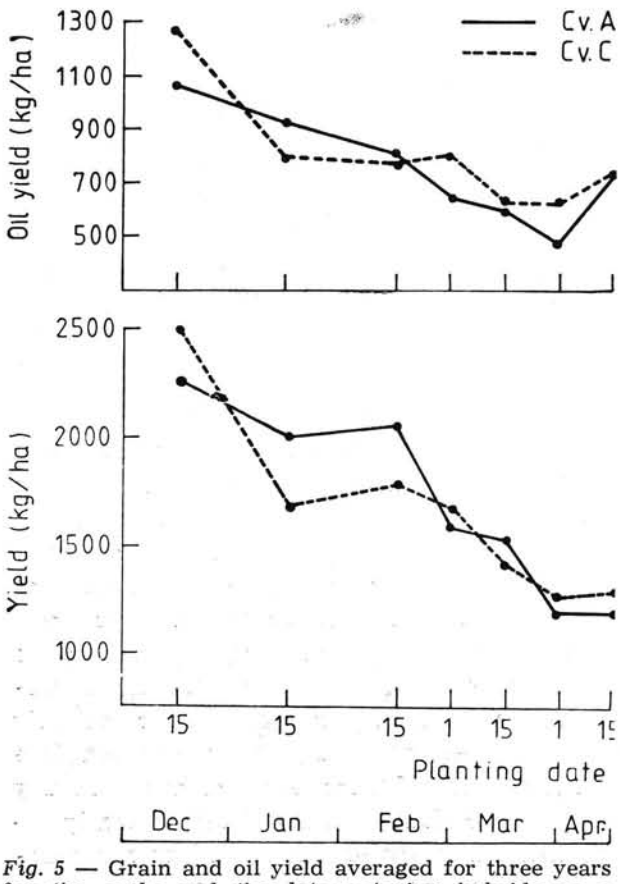

Fig. 5 — Grain and oil yield averaged for three years for the early and the late-maturing hybrids as a function of planting date

rienced in our environment during the germination and seedling stages. Thus, sunflower planted in winter develops during periods of low evaporative demand and high rainfall probability and therefore escapes the early summer drought which is responsible for most of the yield reduction experienced by current spring plantings.

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RÉPONSE DU TOURNESOL AU SEMIS D'HIVER DANS LES CONDITIONS MÉDITERRANÉENNES

Résumé

Les réponses de trois cultivars de tournesol à différentes dates de semis dans les conditions méditerranéennes, ont fait l'objet de recherches à Cordoue, au sud-ouest de l'Espagne. L'objectif consistait dans l'étude de la possibilité d'un semis d'hiver permettant d'accroître les rendements en zone non irriguée et d'éviter la sécheresse estivale. Le rendement en grain se révela maximum pour les semis d'hiver ; dans le cas de cultivars de cycle long, le rendement moyen sur trois ans d'expérience excéda de 33% celui des cultivars normaux semés au printemps (15 mars). Une telle réponse était surtout dûe à une plus longue période de maturation du grain, responsable d'un poids unitaire plus élevé pour les semis d'hiver. Les génotypes précoces ont montré un développement important des ramifications latérales, lorsque des phases de basse température affectaient la croissance des plantules issues de semis d'hiver.

RESPUESTA DEL GIRASOL A SIEMBRAS INVERNALES CON UN AMBIENTE MEDITERRANEO

Resúmen

Se han estudiado en Córdoba, Sur de España, las respuestas a la fecha de siembra de tres genotipos de girasol en condiciones ambientales de tipo mediterráneo. El objectivo principal fue estudiar la posibilidad del uso de siembras invernales como estrategia para incrementar los rendimientos en secano al permitir el escape a las condiciones de sequía del verano. El rendimiento en grano fué máximo para las siembras invernales, incrementándose el rendimiento medio de tres años alrededor de 33% respecto a la siembra normal de primavera (15 de Marzo) para los cultivares de ciclo largo. Esta respuesta fue mayormente debida a un periodo mas largo de llenado del grano que dió lugar a un mayor peso individual de las semillas en las siembras invernales. Los genotipos mas precoces mostraron un mayor grado de ramificación lateral cuando las bajas temperatures afectaron al crecimiento de plantulas en las siembras invernales.