Changes in Agroclimatic Conditions for Sunflower Crop in Argentina During the 1961-90 Period

A. J. PAȘCALE and E. A. DAMARIO

Facultad de Agronomía, Universidad de Buenos Aires,
Av. San Martín 4453 - (1417) Buenos Aires, Argentina

ABSTRACT

Estimated total crop production for Argentina in 1994/95 surpasses 45 million metric tons, one of the largest in agricultural records. Soybean and sunflower, both summer oil crops, registered a record cultivated area. Sunflower production has increased four times over the past 30 years to reach the current 4.5 million metric tons. This significant increase deserves an analysis of the biological and ecological contributing factors.

In the last 30 years, summer rainfall had an upward trend in the sunflower region. Therefore, meteorological records for the 1961/90 period were used to prepare agroclimatic maps. Thermal and hydrological conditions were analyzed with emphasis on the critical growth stages for water demand during sowing, flowering and maturity. It can be concluded that in addition to crop breeding and technological advances, the excellent crop yield for the 1985/95 period with a mean yield of 1509 kg/ha was due to a favorable soil water balance during the sunflower growing season.

INTRODUCTION

This paper presents an analysis of soil water availability in the current area of sunflower cropping during the sowing, flowering and maturity months as critical periods for water requirements (Pascale and Troha, 1977) and its relation to the mean yields for the period 1989-1994. The objective is to compare these mean yields with those of a previous work (Pascale et al., 1977) and to verify if a larger water availability due to rainfall increase in the last decades in the Pampas region (Fortelay et al., 1991; Sierra et al., 1993/94) which favored the important expansion of area sown has also influenced the observed yield increase.

MATERIAL AND METHOD

a) Phenological data: The normal sowing, flowering maturity months were determined from experimental yield plots carried out by the Instituto Nacional de Tecnología Agropecuaria and from Sierra and Murphy (1986).

b) Meteorological data: Meteorological data for the period from 79 weather stations in the rainfed crop region were used to compute a monthly soil water balance (Thornthwaite and Matter, 1957). Two time series were used to compute the soil water balance: the 1961/75 which will be referred to as CH/75 and the 1961/90 referred as CH/90. The monthly results were sorted from highest deficiency to largest excess. This permitted to establish the probability of occurrence of different levels of soil moisture (Pascale and Damario, 1977). In the maps, water deficiencies are shown with a negative sign and the excesses with a positive sign.

c) Crop yield data: Sown and harvested area and crop yield at department level were obtained from the National Ministry of Agriculture, Livestock and Fishery. The historical series of area sown and mean yield was obtained from the Buenos Aires Cereal Bureau (1992-93).

RESULTS AND DISCUSSION

A. Sunflower area harvested and yield variability during the 1960-95 period in Argentina.

Figure 1 (top) shows the variability in area harvested from 1960 through 1995. Three sections can be distinguished: the first one reaches the early 70's and shows small increase in area (about 26,000

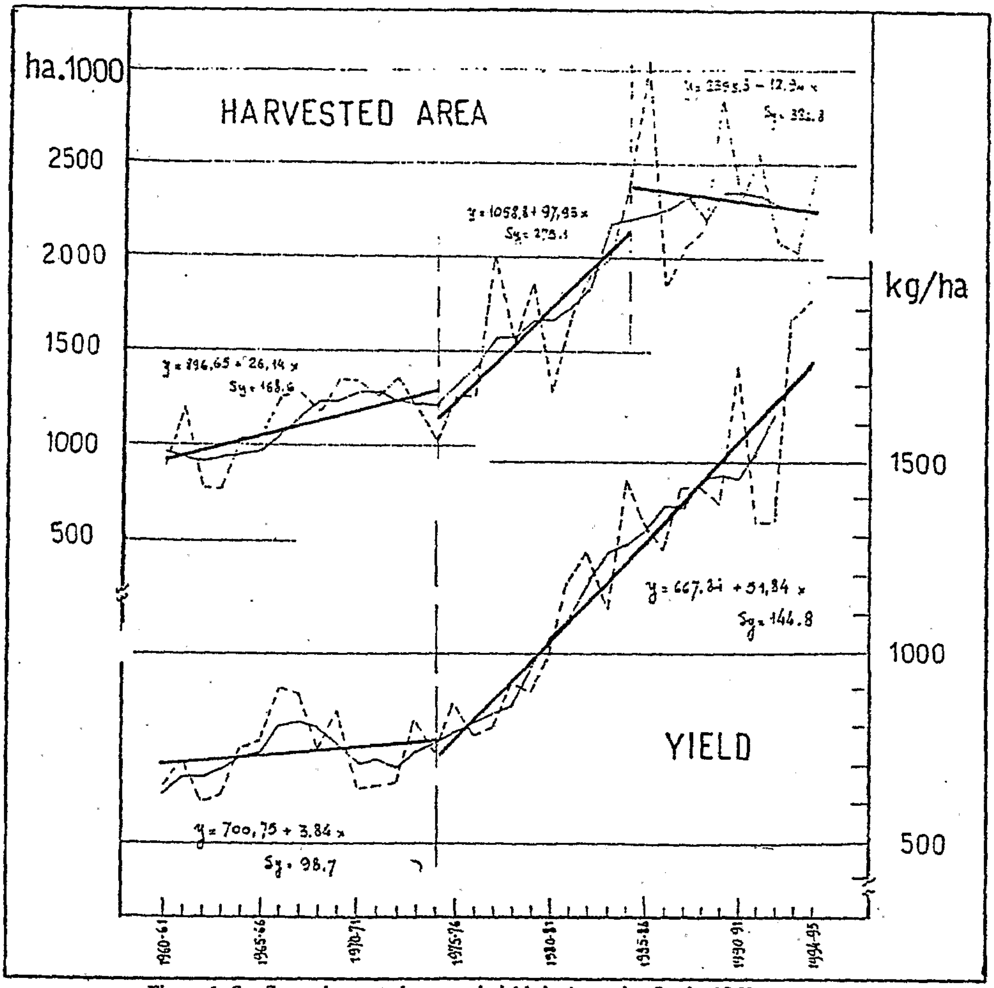

Figure 1. Sunflower harvested area and yields in Argentina for the 1961 - 95 period

has.); the second section (1974 through 1985) shows an increase of about 98000 ha/ yr ; finally, the third section corresponds to the past eleven crop seasons showing a stabilized area with an average harvested area of 2,316,000 has. This area is completely located in the eastern portion of Argentina where rainfed agriculture takes place (shown as unshaded areas in the hydrological condition maps). Also in figure 1 (bottom) is shown the mean yields for sunflower with two different sections: the first section reaches the early 70's with a small yearly increase of 3.8 kg/yr and a mean yield of 73118/ha, the second section from 1974 to 1995 with an average yield of 1238 kg/ha and a steady increase of 52 kg/yr. The second section coincide with the introduction of modern technologies including the almost total elimination of "second" sowing dates, utilization of batter lands and the regional adjustment of crop calendars according to the bioclimatic requirements of hybrid sunflower crops.

The first section (1960-75) was previously analyzed by Pascale et al. (1977) and it will be compared to the years of the 90's (1990-94).

B. Current departmental cropped area and mean yields.

Figure 2 shows the departmental mean yields for 1961-75 (Pascale and Troha. 1977) and the yield for the past five crop seasons (1989-94). There was a shift in the cropped area towards the west

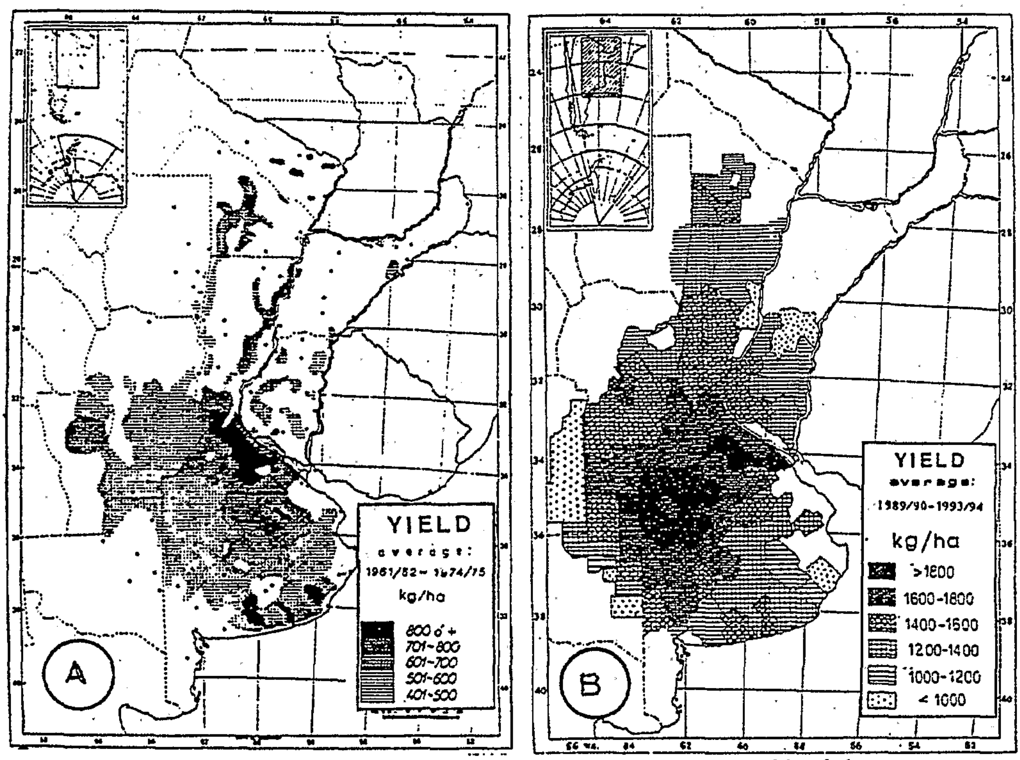

Figure 2. Departmental mean yields. (A) 1961 - 75 period; (B) 1989 - 94 period

and a significant increase the mean departmental yields which are above 1800 kg/ha in the best areas of the Buenos Aires Province. Also, it is evident the presence of sunflower crops in the northeast region of La Pampa. In the past this area was considered marginal to non apt for sunflower. In general, departmental yields increased from 600 kg/ha to more than 1800 kg/ha during both periods considered in the analysis. The regional distribution of sunflower crop during 1989-94 is shown in figure 3.

C. Comparison of regional agroclimatic conditions for the 1961-75 period and the following years until 1994.

The comparative analysis will focus on soil water availability during the crop cycle considering the demonstrated up-trend in summer rainfall starting in the 70's in the sunflower region of the Pampas. There is not such strong evidence on the variability for the mean monthly temperatures. Pascale and Damario (1993/94) have demonstrated a constant decrease in the decadal average of summer temperatures since the beginning of this century.

Provided that the thermal regional regime seems to have not an impact on crop maturity during the past 20 years, the comparison is made only with soil water content during the critical crop stages. Using correlation analysis between yield and soil water content obtained with a serial water balance, Pascale and Troha (1977) verified the negative influence of water deficit during sowing and flowering and water excess during maturity.

Hydrological Conditions During the Sowing Month

Figure 3B shows the median (p=0,5) hydrological conditions during the sowing month for CH/75 and CH/90. The sunflower growing area is included in the rainfed agriculture region of Argentine and the current westward displacement of the crop can be attributed to the higher soil water availability during the summer months.

This is shown by the 0 mm isoline (hydrological equilibrium) during the sowing months. From the north to the limit of Central Cordoba and Santa Fe, the isolines show a similar geographic distribution while southward, the isolines bend to the west in the CH/90 period. They reach La Pampa and finally the Buenos Aires Province. It is worth noting that for median hydrological conditions (p=0,5) during sowing months in the CH/90 period, the area with hydrological equilibrium (0 mm) to small water excess (+ 10 mm) corresponds to the highest yields. Water excess higher than 10 mm during the sowing month does not favor sunflower growth. This is demonstrated by a decreasing area planted or absence of sunflower crops in the mesopotamia region (Corrientes and Entre Ríos provinces). Apparently, the border of the sunflower region is established by the -10 mm isoline during the sowing months in the north and somewhat less in the southwest region.

Hydrological Conditions During the Flowering Month

In most of the sunflower region, the potential evapotranspiration increases as the crop progresses from emergency toward flowering. The rainfall does not totally satisfy the demand, therefore during this period the best hydrological condition should be the equilibrium (0 mm) or a small water deficit or excess.

The median hydrological condition (p=0,5) during the flowering month for the CH/75 period and CH/90 periods is shown in figure 3C.

There is a range from hydrological equilibrium to a small water deficit (up to -10 mm) in the areas of high crop density and yields.

The most evident difference between both periods occurs in the extreme southwest of the region. In this region the water deficit is smaller in CH/90 indicating a quick improvement of hydrological conditions after the decade of the 70's in Buenos Aires and La Pampa provinces and ratified by the displacement of the -10 mm isoline.

As a consequence of the annual rainfall variability the water balance showed that in 20 % of the years (P=0,2) water deficits of -20 to -30 mm has occurred even in the best area of the sunflower region.This is important to highlight because the lack of water during the flowering stage is the most important factor affecting the final crop yield.Also,with a similar probability of one out of five year (P=0,8) water excess of up to 30 mm will occur.This will have a negative impact during the polinization period causing pollen wash-out and/or reduction in activities of polinizing insects.

Hydrological conditions during the maturity months

The flowering-maturity period of sunflower coincide with the highest atmospheric water demand; however, the median hydrological condition (p=0,5) does not indicate the occurrence of water deficits with negative effects for maturing crops such as sunflower, soybean and maize. If these crops overcome the critical water demand during the reproductive growth stage until the grain has reached the maximum size then the hydrological condition should be a moderate deficit for a smooth drying of the grains.

Figure 3D shows the median hydrological conditions (p= 0,5) for both CH/75 and CH/90. It can be observed that with little variations in both periods, the best growing and yield areas have a slight water deficit (up to - 10 mm). In the Chaco growing region, the deficit values are slightly higher.

The counterpart of a normal water deficit favorable for maturity is the unfavorable water excess associated to high atmospheric humidity and lower solar radiation, causing irregular maturity and

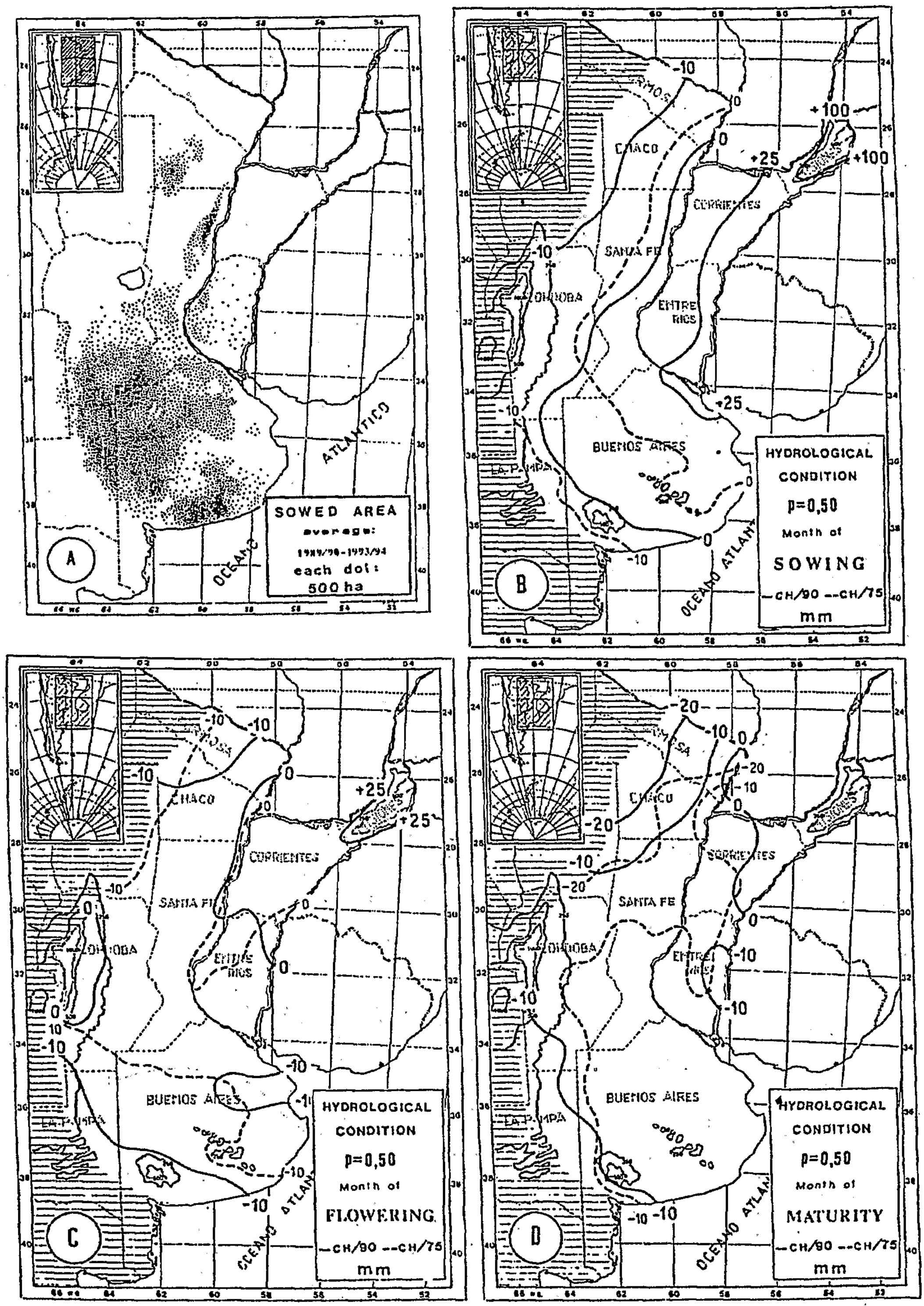

Figure 3. (A) Geographic distribution of the suflower crop in Argentina. Average planted area for the 1989 - 94 period. - Median hydrological conditions for: (B) planting; (C) flowering and (C) maturity.

favoring fungal diseases. This disadvantage is compounded by late sowing which causes the occurrence of the maturity stage during the normally humid autumn months. The current adjustment of the sowing dates and the disappearing of the "second" crops have significantly reduced the problem.

The water excess condition with a probability of one every five years (P=0.8) indicates predominance of equilibrium conditions with an area of moderate excess (about + 20 mm) in southern Santa Fe and northern Buenos Aires during both periods. Again, there is here a displacement toward the SW of higher water availability for CH/90 without harmful effects for the crop.

CONCLUSIONS

The comparison of the soil water balance for the 1961-75 and 1961-90 periods shows that the hydrological conditions of the rainfed sunflower regions of Argentina have evolved towards a better water availability in every growth stage of the crop. The rainfall increase since the 70'S is accompanied by accelerated

technological improvements, more appropriate sowing dates and adaption of high producing hybrids. All of these factors have contributed to the frontier expansion toward the NE region in La Pampa,which was previously considered no apt for sunflower.

Therefore, within the area of current expansion, crop fields have doubled as compared with those recorded in the 70's.

REFERENCES

BOLSA DE CEREALES. 1992/93. Número Estadístico N° 55. Prisma Color, Buenos Aires, 298 pág.

FORTE LAY J.A.; R.M.QUINTELA y O.E. SCARPATI. 1992. Variación de las características hidrometeorológicas de la llanura pampeana argentina. Memorias del *Encuentro Meteoro.* I Congreso Iberoamericano, V Congreso Interamericano de Meteorología. Univ. de Salamanca y Cáceres. España 2a. parte; 142-146

PASCALE, A.J. y A. TROHA. 1977. Factores agrometeorológicos determiianntes del rendimiento en girasol. Tercera Reunión Nacional de Girasol. Instituto Agroindustrial de Oleaginosas Bs.As. *Actas,* 1: 5-15.

PASCALE, A.J.; G.M. MURPHY y A. TROHA. 1977. Condiciones agroclimáticas del cultivo de girasol en la Argentina. Tercera Reunión Nacional de Girasol. Instituto Agroindustrial de Oleaginosas. Bs.As. *Actas,* 1: 16-36.

PASCALE, A.J. y E.A. DAMARIO. 1977. El balance hidrológico seriado y su utilización en estudios agroclimáticos. *Rev. Fac. Agr. de La Plata,* 53 (1-2): 15-34.

PASCALE, A.J. y E.A. DAMARIO. 1993/94. Tendencia de la amplitud térmica diaria en la Argentina desde 1901 a 1990. *Rev. Facultad de Agronomia,* 14 (2): 127-138.

SIERRA, E.M. y G.M. MURPHY. 1986. Agroclimas del cultivo de girasol en la Argentina. *Rev. Facultad de Agronomia,* 7 (1): 25-44.

SIERRA, E.M.; R.H. HURTADO y L.B. SPESCHA. 1993/94. Corrimiento de las isoyetas anuales medias decenales en la Región Pampeana 1941-1990. *Rev. Facultad de Agronomia,* 14 (2): 139-144.

TRORNTHWAITE, C.W. and J.R. MATHER, 1957. Instructions and tables for computing potential evapotranspiration and the water balance. Drexel Institute of Technology. *Public. in Climatology,* 10 (3): 185-311.