A Study of El Niño Events and Rice Yield in Taiwan

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ABSTRACT

The impact of El Niño on Taiwan rice yield was investigated. Historical data of temperature, rainfall and rice yield were classified and compared according to the occurrence or non-occurrence of El Niño. Five locations: Hsinchu, Yilan, Chiayi, Tainan, and Kaohsiung were chosen for the analysis. Chi-square tests on the yield data were not significant ($p > 0.05$) for all locations. The spring rainfall, however, increased following the El Niño years of 1982 and 1991. For example, the amount of precipitation increased from 400.8 to 752.5 mm at Hsinchu, Yilan and Chiayi in 1983, and from 307.8 to 330.3 mm at Chiayi, Tainan and Kaohsiung in 1992. The increased spring rainfall had no negative effect on first crop rice yield. The relationship of El Niño and Monsoon rainfall was less apparent: the impact of El Niño on the first crop rice yield was therefore ambiguous. No significant relationship between El Niño and temperature changes was detected during the spring and Monsoon rainfall seasons.

INTRODUCTION

El Niño/Southern Oscillation, often called ENSO, is a seesawing of atmospheric pressure limited to the tropical and subtropical Pacific. It is the most famous one of atmospheric teleconnections (Kerr, 1982). Barnett(1981) has related South Pacific sea surface temperature and sea level pressure to North American air temperature. Sea surface temperature anomalies have a clear positive impact on the tropical forecasts and surface fluxes (Mo and Kalnay, 1991).

Temperature in parts of U.S. has been correlated with El Niño events. An El Niño causes surface temperatures in the tropical Pacific to become warmer than normal, there is a higher probability of an above-average corn crop in the U.S. (Handler and Handler, 1983). More researches used crop yields, such as wheat and corn, as a climatic index to demonstrate a link between crop forecasting and atmospheric outlooks (Steyaert et al., 1978; Starr and Kostrow, 1978; Mostek and Walsh, 1981). One advantage of using agricultural yields as a climatic index of traditional variables such as rainfall and air temperature is that crop outcome is a proxy for a climatic index over the crop region (Handler and Handler, 1983).

The purpose of this study is to understand the relation between El Niño events and first crop rice yields in Taiwan. Historical data of temperature, rainfall and rice yield were classified and compared according to the occurrence or non-occurrence of El Niño.

MATERIAL AND METHOD

Climatic data

The climatic data we employed in this report are from those weather stations of Central Weather Bureau during 1956-1992, including Hsinchu, Yilan, Chiayi, Tainan and Kaohsiung (Figure 1). Among those 5 stations, the historical data from Chiayi started from 1968 due to late establishment. And we use temperature and precipitation as those weather factors. In order to facilitate our analysis, we define the total precipitation of February to April as Spring precipitation; May to June as Monsoon precipitation, called Mei-Yu in Taiwan.

Yield data and El Niño events

Rice is the major crop in Taiwan. Thus, it was selected as our research object. The data of first crop rice yield came from the Taiwan Agricultural Yearbooks compiled by Department of Agriculture and Forestry of Taiwan Provincial Government (edition 1957-1992).

The El Niño events are selected from reported researches (Quinn et al., 1978; Cane, 1983; Bhalme and Jadhav, 1984; Gray, 1984; Liu, 1986). Five years, such as 1972, 1973, 1982, 1983, and 1986, are most significant cases.

Statistics

Independent tests of the occurrence frequency of El Niño and the first crop rice yield were undertaken by running SAS software package (SAS, 1985).

RESULT

In Hsinchu area, among those years with El Niño, there were 7 years whose first crop rice yields were more than the average yield. There were 3 years whose first crop rice yields were less than the average yield. Among those years without El Niño, there were 9 years with more yields than their average yield and 17 years with less yields. Using Chi-square test, we found that it was not significant with Chi-square=3.662 and p=0.056. Therefore, the occurrence of El Niño was independent of the first crop rice yields (Table 1).

In Yilan area, among those years with El Niño, also there were 7 years whose first crop rice yields were more than the average yield. And there were 3 years whose first crop rice yields were less than the average yield. Among those years without El Niño, there were 14 years with more yields than their average yield and 12 years with less yields. Using Chi-square test, we found that it was not significant with Chi-square=0.775 and p=0.379. Therefore, the occurrence of El Niño was independent of the first crop rice yields (Table 2).

In Chiayi area, among those years with El Niño, also there were 6 years whose first crop

rice yields were more than the average yield. And there were 2 years whose first crop rice yields were less than the average yield. Among those years without El Niño, there were 11 years with more yields than their average yield and 4 years with less yields. Using Chi-square test, we found that it was not significant with Chi-square=0.008 and p=0.931. Therefore, the occurrence of El Niño was independent of the first crop rice yields (Table 3).

In Tainan area, among those years with El Niño, also there were 7 years whose first crop rice yields were more than the average yield. And there were 3 years whose first crop rice yields were less than the average yield. Among those years without El Niño, there were 14 years with more yields than their average yield and 12 years with less yields. Using Chi-square test, we found that it was not significant with Chi-square=0.775 and p=0.379. Therefore, the occurrence of El Niño was independent of the first crop rice yields (Table 4).

In Kaohsiung area, among those years with El Niño, also there were 8 years whose first crop rice yields were more than the average yield. And there were 2 years whose first crop rice yields were less than the average yield. Among those years without El Niño, there were 15 years with more yields than their average yield and 11 years with less yields. Using Chi-square test, we found that it was not significant with Chi-square=1.558 and p=0.212. Therefore, the occurrence of El Niño was independent of the first crop rice yields (Table 5).

We have found from the Southern Oscillation Index that 1982, 1986 and 1991 were those years with more noticeable El Niño effects. The weather data showed that the Spring precipitation of the years followed by 1982 and 1991 (with El Niño) increased significantly. The Spring precipitation of Hsinchu, Yilan and Chiayi in 1983 incremented by about 400.8 to 752.5 mm; and those of Chiayi, Tainan and Kaohsiung in 1992 by about 307.8 to 330.3 mm (Figure 2). Monsoon precipitation, however, didn't change as consistently as Spring precipitation. The Monsoon precipitation of Yilan in 1983 was about 65.4 mm lower than the climatic data; whether those of 4 areas (excluding Tainan) in 1992 were lower than the climatic data by about 49.2 to 299.5 mm (Figure 3).

As to the temperature, it was irrelevant between El Niño effects and the temperature during Spring precipitation seasons (Figure 4). The temperature of Monsoon precipitation seasons of Hsinchu, Yilan and Chiayi in 1983 was higher than the climatic data by about 0.4 to 0.8 °C (Figure 5). Though we can tell from the data that those first crop rice yield of the aforementioned five locations in 1983 were greater than the average, it could hardly verify that there was relevance between El Niño effects and the first crop rice yield (Figure 6).

CONCLUSIONS

The results of El Niño impact on the first crop rice yield in Taiwan, such as Hsinchu,

Yilan, Chiayi, Tainan, and Kaohsiung locations, were the following:

(1)Chi-square tests on the relation between El Niño and first crop rice yield were not significant ($P > 0.05$) for all locations.

(2)The spring rainfall increased following the El Niño years of 1982 and 1991 in some locations. For example, the amount of rainfall was increased with 752.5mm, 670.2mm, and 400.8mm at Hsinchu, Yilan, and Chiayi in 1983, respectively. It was increased with 330.3mm, 307.8mm, and 329.4mm at Chiayi, Tainan, and Kaohsiung locations in 1992, respectively.

(3)The relation of El Niño and Monsoon rainfall was less apparent. For example, the amount of rainfall was decreased with 65.3mm at Yilan in 1983. Except that at Tainan, it was decreased with 49.2mm, 163.2mm, 254.5mm, and 299.5mm at as Hsinchu, Yilan, Chiayi, and Kaohsiung in 1992, respectively.

(4)No significant relation between El Niño and temperature changes was detected during the spring and Monsoon rainfall seasons.

(5)The increased spring rainfall had no negative effect on the first crop rice yield. However, it could hardly verify that there was relation between Monsoon rainfall effect or El Niño and first crop rice yield.

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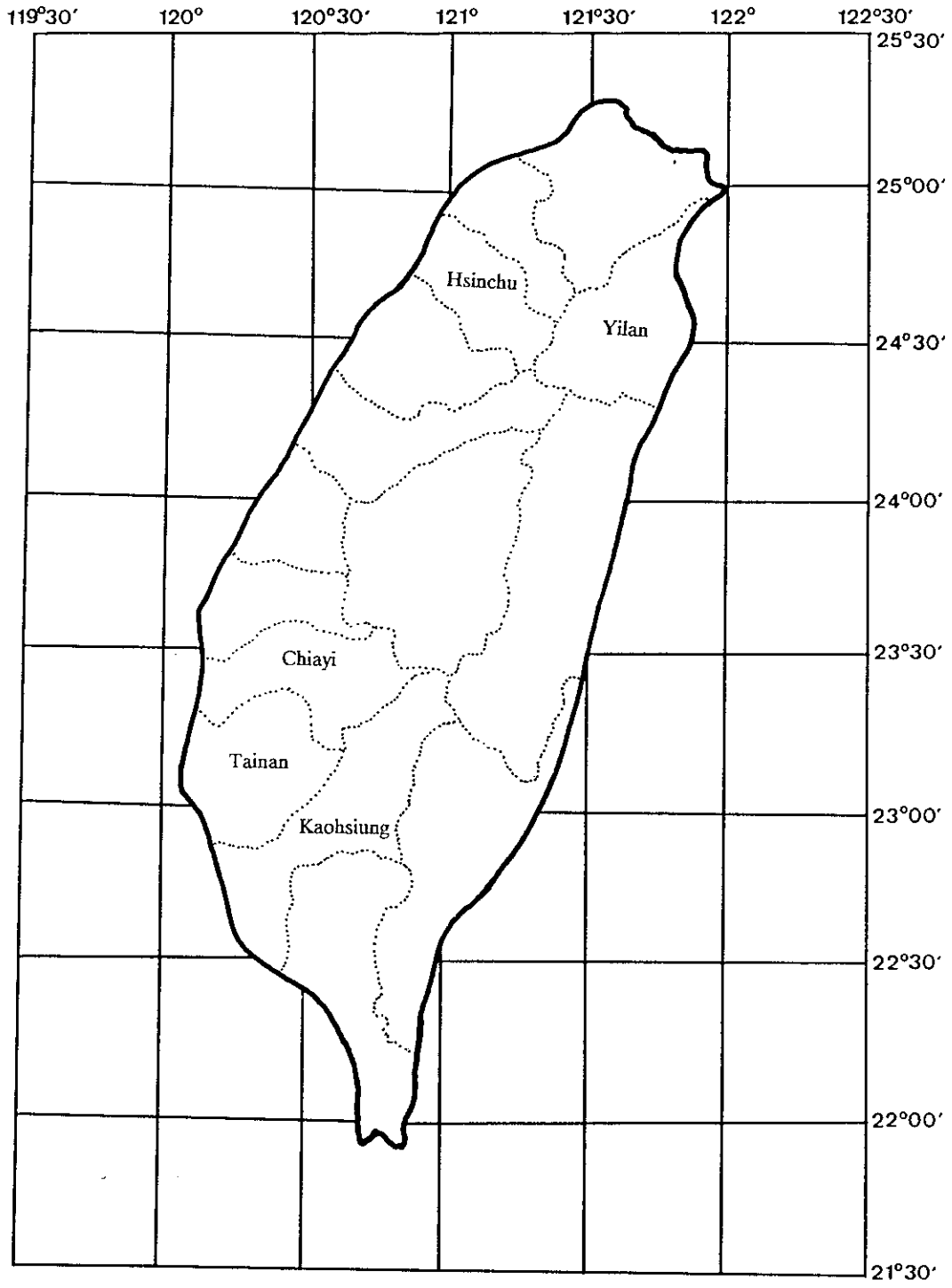

Figure 1. The geographical map for the selected locations in Taiwan.

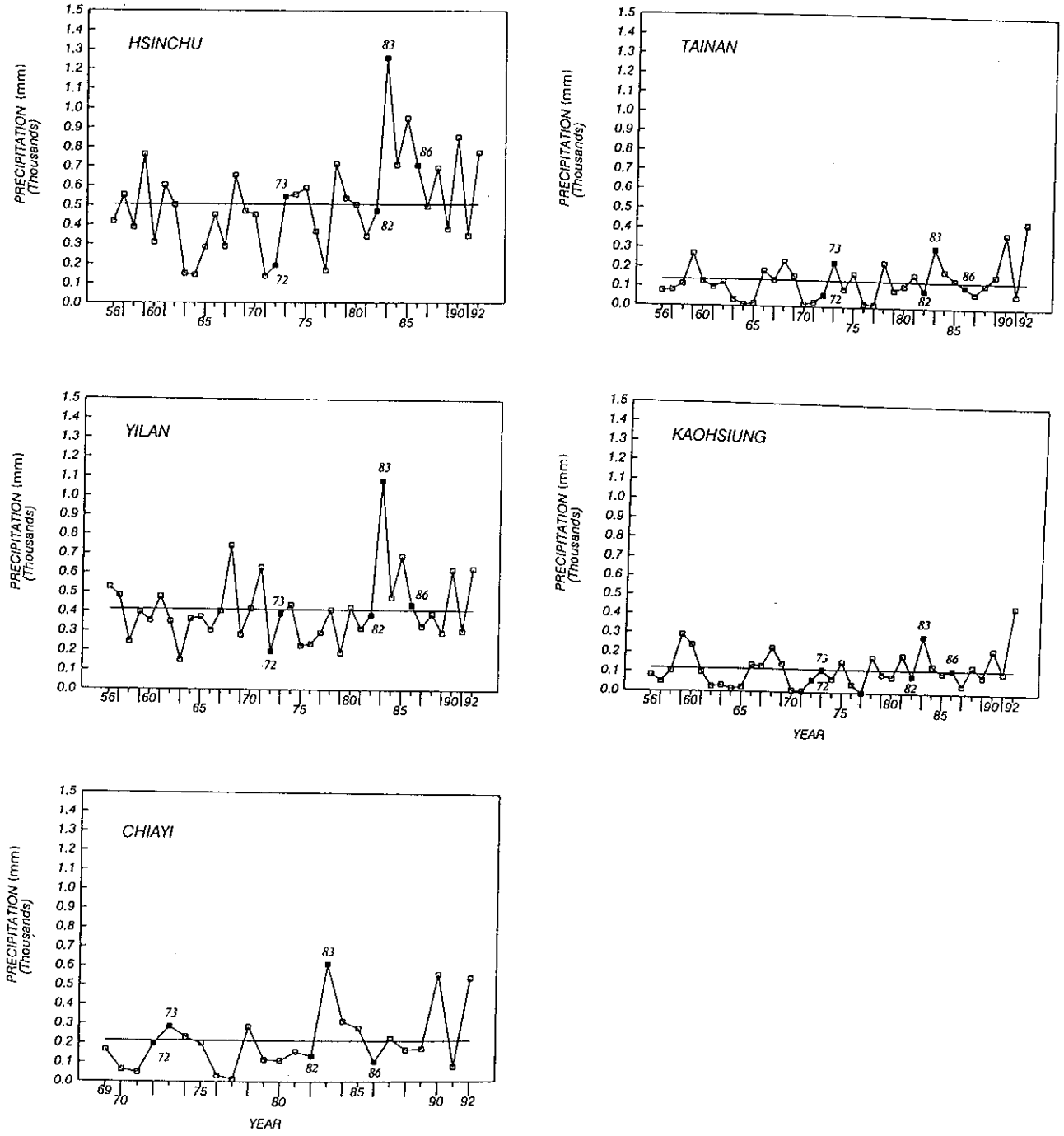

Figure 2. The amount of the spring rainfall (February - April) for the past 37 years in Taiwan.

□ SPRING RAINFALL ■ EL NIÑO YEAR — CLIMATIC VALUE

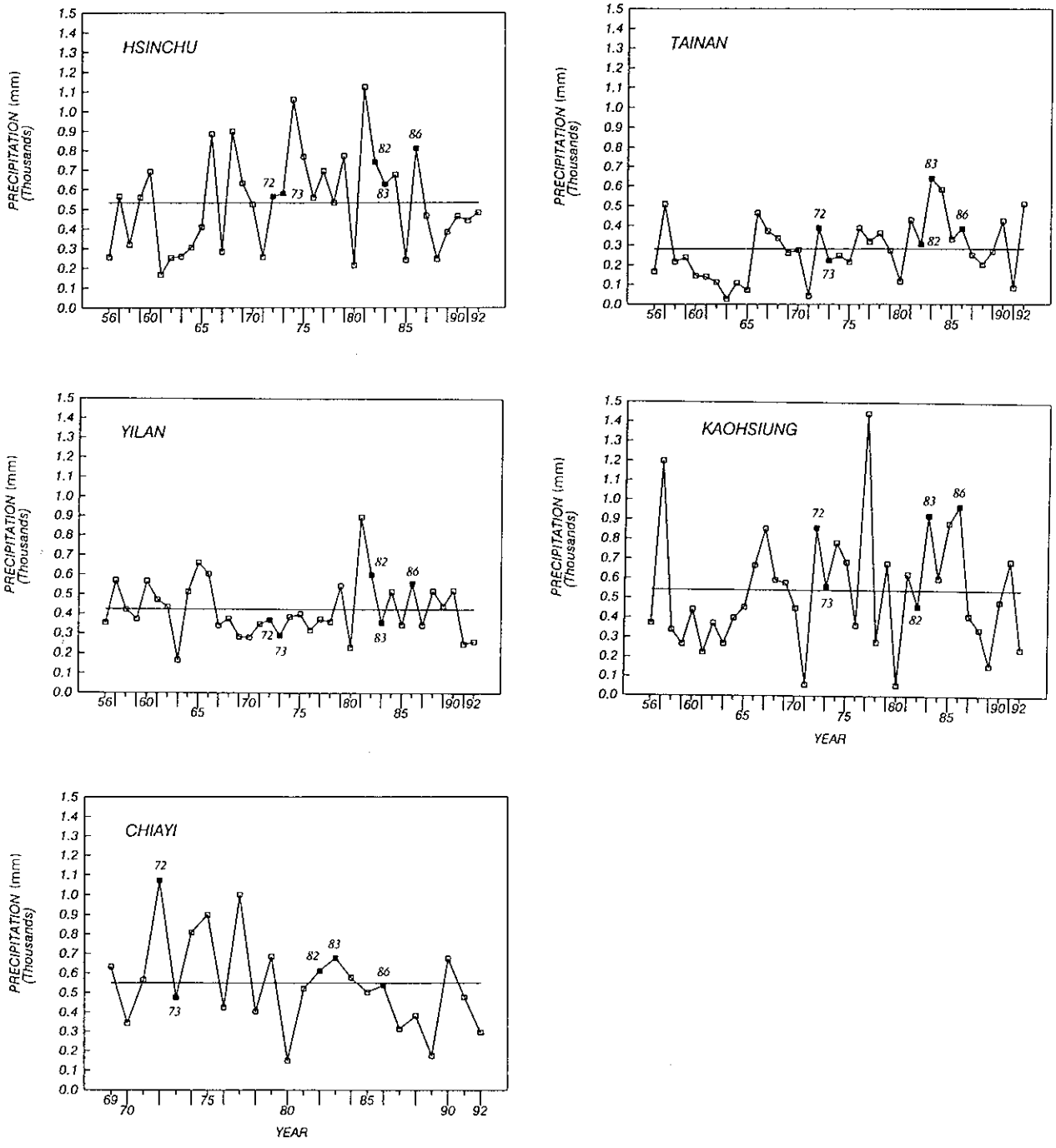

Figure 3. The amount of the Monsoon rainfall (May - June) for the past 37 years in Taiwan.

□ SPRING RAINFALL ■ EL NIÑO YEAR — CLIMATIC VALUE

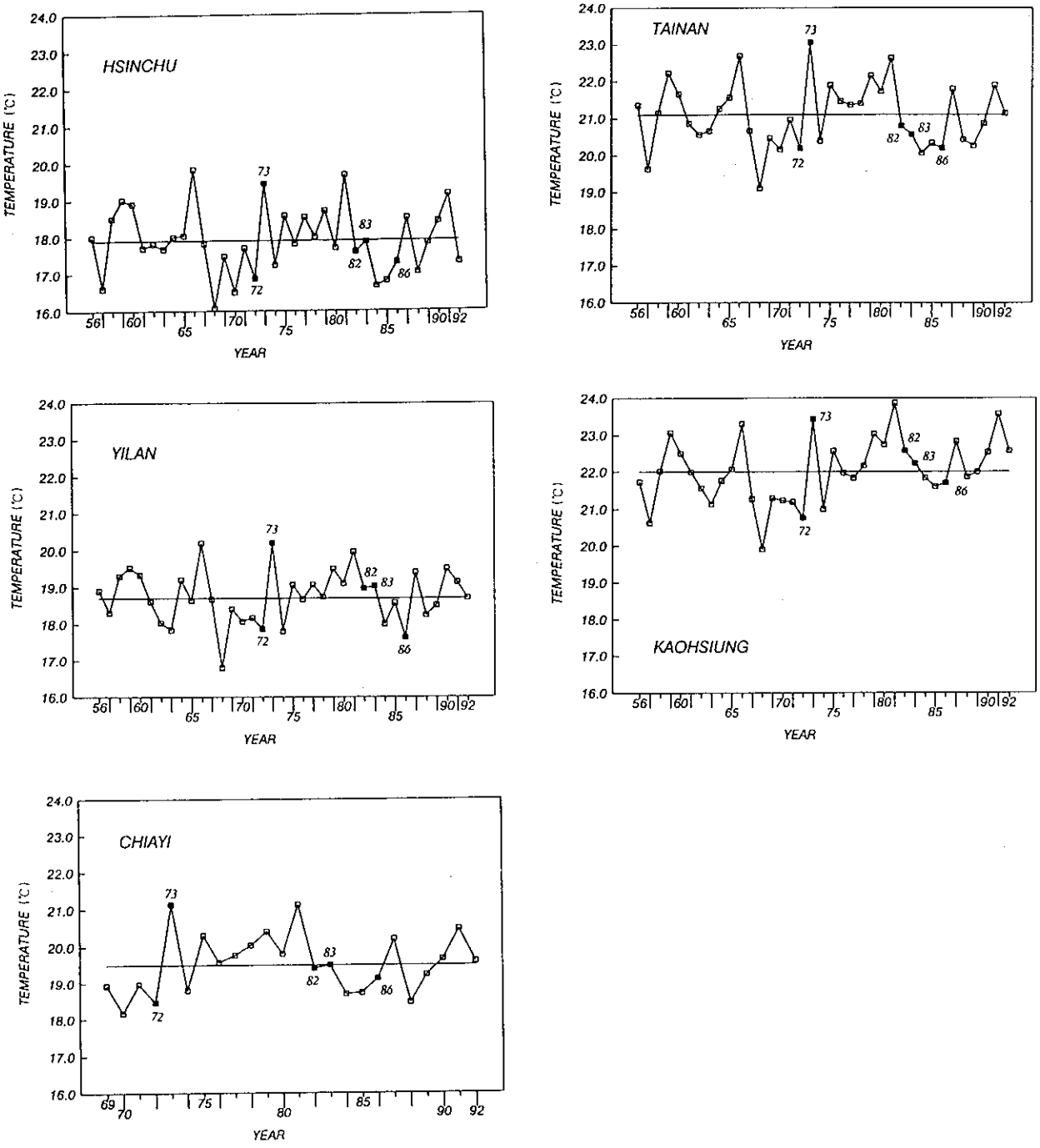

Figure 4. The mean temperature of the spring rainfall period (February - April) for the past 37 years in Taiwan.

□ SPRING RAINFALL ■ EL NIÑO YEAR — CLIMATIC VALUE

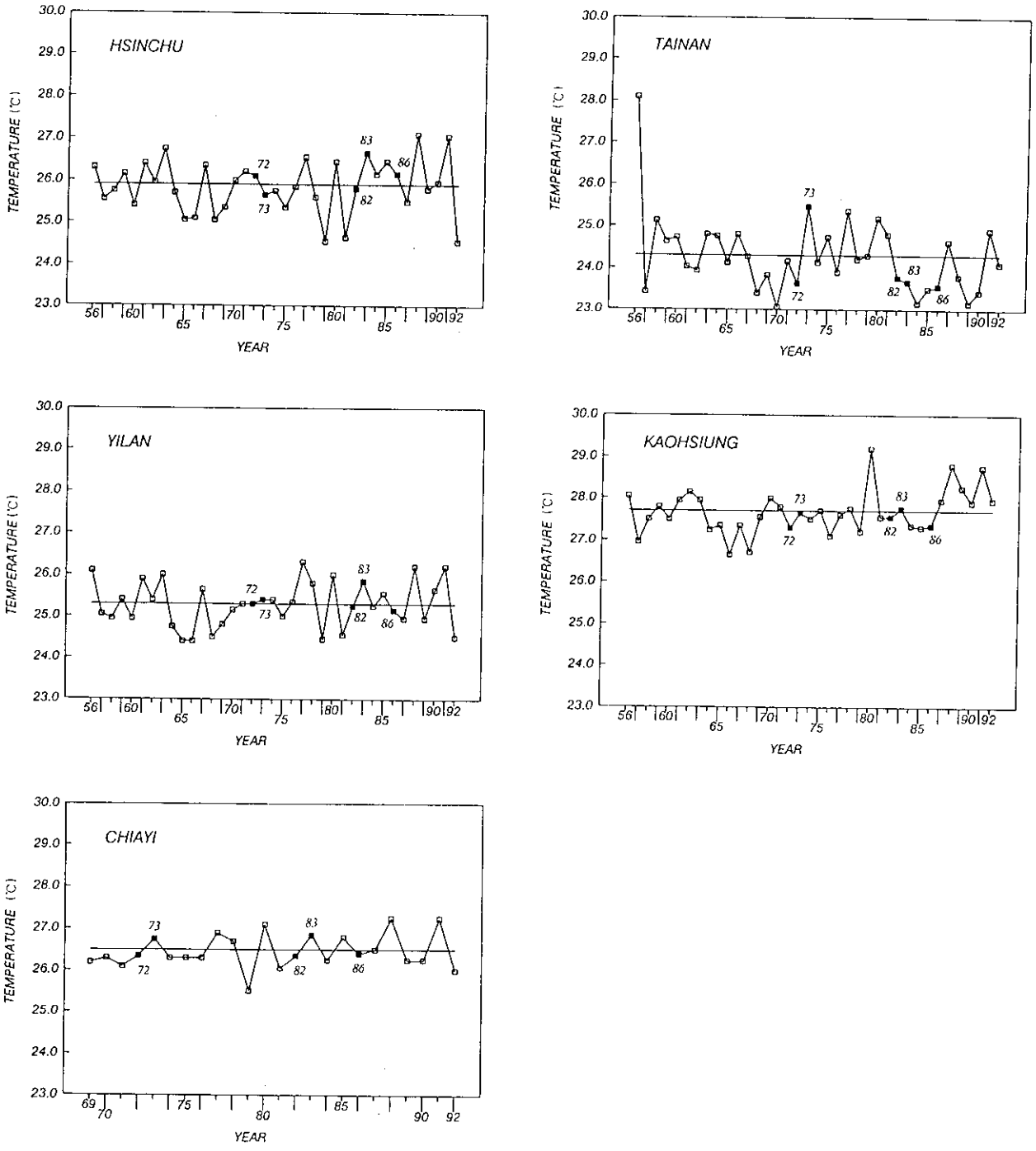

Figure 5. The mean temperature of the Monsoon rainfall period (May - June) for the past 37 years in Taiwan.

□ SPRING RAINFALL ■ EL NIÑO YEAR — CLIMATIC VALUE

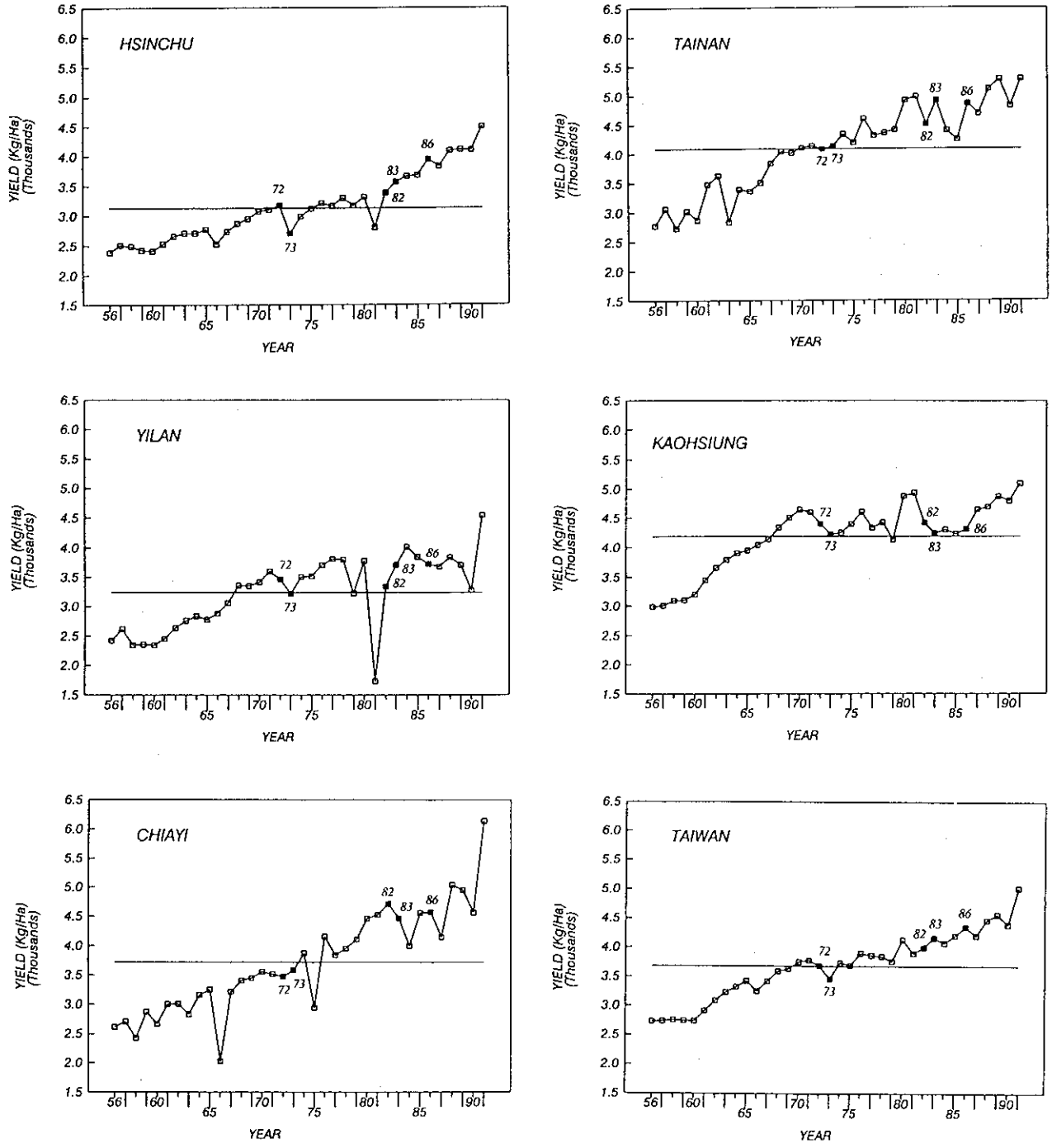

Figure 6. The average yield of the first crop rice for the past 37 years in Taiwan.

□ SPRING RAINFALL ■ EL NIÑO YEAR — CLIMATIC VALUE

Table 1. The 2x2 contingency table of first crop rice yield and the occurrence of El Niño years in Hsinshu.

Rice yield	El Niño years	Non-El Niño years	Total
Above trend	7	9	16
Below trend	3	17	20
Total	10	26	36

Chi-Square (1) = 3.662, P=0.056.

Table 2. The 2x2 contingency table of first crop rice yield and the occurrence of El Niño years in Yilan.

Rice yield	El Niño years	Non-El Niño years	Total
Above trend	7	14	21
Below trend	3	12	15
Total	10	26	36

Chi-Square (1) = 0.775, P=0.379.

Table 3. The 2x2 contingency table of first crop rice yield and the occurrence of El Niño years in Chiayi.

Rice yield	El Niño years	Non-El Niño years	Total
Above trend	6	11	17
Below trend	2	4	6
Total	8	15	23

Chi-Square (1) = 0.008, P=0.931.

Table 4. The 2x2 contingency table of first crop rice yield and the occurrence of El Niño years in Tainan.

Rice yield	El Niño years	Non-El Niño years	Total
Above trend	7	14	21
Below trend	3	12	15
Total	10	26	36

Chi-Square (1) = 0.775, P=0.379.

Table 5. The 2x2 contingency table of first crop rice yield and the occurrence of El Niño years in Kaohsiung.

Rice yield	El Niño years	Non-El Niño years	Total
Above trend	8	15	23
Below trend	2	11	13
Total	10	26	36

Chi-Square (1) = 1.558, P=0.212.