# A REVIEW OF WEATHER FACTORS AND EPIDEMICS OF FOLIAR DISEASES OF BRASSICAS 1981-1990

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## CONTENTS



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# VEGETABLE BRASSICA - REVIEW OF WEATHER FACTORS AND FOLIAR DISEASE EPIDEMICS, 1981-1990


## Summary

The incidence of the main foliar diseases in vegetable brassica - ringspot, light leaf spot, white blister, powdery mildew and dark leaf spot - over the period 1981-1990, was determined from intelligence records, survey reports and personal communication. Using known epidemiological requirements of some of these diseases, their severity in particular years in certain areas of England and Wales, could be correlated with weather conditions. Most of the information is based on Brussels sprouts. Ringspot was predominantly a disease of the western part of the country, particularly the north-west, west Midlands, south west and Wales, while light leaf spot was most severe in certain years in Humberside and East Anglia and occasionally in the north west and Wales. White blister appeared sporadically in any part of the country, but most consistently in the north-west and west Midlands. Dark leaf spot was epidemic nationally in the early 1980s, but has rarely been of importance since 1983. Powdery mildew was mainly a disease of the eastern side of the country, especially East Anglia and showed marked seasonal variations.

Where disease progress information was available from ADAS trials, there was good correlation between development of ringspot, light leaf spot and powdery mildew with known meteorological requirement of these diseases.

## Introduction

Over the last 20 years the area of oilseed rape has expanded dramatically - from 6,866 ha (1972) to 124,948 ha (1981) to 343,189 ha (1990). The last decade has seen the area of fodder brassicas fall by half, while that of vegetable brassica has been more stable (Table 1).

While fodder brassicas are grown in the predominantly livestock areas, North and West, both oilseed rape and vegetable crops are most widely grown in similar areas - East Midlands, South East and West Midlands in particular (Table 2).

With increasing demand for high quality, blemish-free vegetables there was concern in the early 1980s for the transfer of foliar diseases from the rapidly increasing oilseed rape area into vegetable brassicas. At this time the use of pesticides, especially fungicides, became popular in both oilseed rape and vegetable crops.

This review has attempted to describe the main foliar diseases in vegetable brassicae, highlighting known epidemiological information on the various diseases. From ADAS intelligence reports, scientific papers, and other publications, high and low years for specific diseases in different parts of the country have been summarised. From weather data, explanations for epidemic and low disease years have been suggested.

Table 1. **Area (ha) of brassicas in England and Wales 1981, 1985 and 1990**

| Crop | 1981 | 1985 | 1990 |
|---|---|---|---|
| Oilseed rape | 124,948 | 271,604 | 343,186 |
| Fodder brassica | 70,770 | 50,536 | 34,271 |
| Vegetable brassica | 34,990 | 41,689 | 30,441 |
| (Brussels sprouts | 12,162 | 9,913 | 7,115) |

Table 2. **Distribution of brassica crops in England and Wales 1990**

| Area | Oilseed Rape | Fodder Brassica | Vegetable Brassica |
|---|---|---|---|
| North | 21,394 | 5,498 | 431 |
| Yorkshire & Humberside | 52,874 | 3,739 | 1,402 |
| East Midlands | 86,984 | 2,015 | 14,263 |
| East Anglia | 42,431 | 1,151 | 1,910 |
| South East | 92,890 | 3,930 | 4,898 |
| South West | 17,934 | 9,989 | 1,653 |
| West Midlands | 23,707 | 3,149 | 2,589 |
| North West | 4,241 | 484 | 2,903 |
| Wales | 734 | 4,316 | 392 |
| Total | 343,189 | 34,271 | 30,441 |

## What are the main foliar diseases of vegetable brassicae?

There are six fungal leaf diseases which have all been prominent in some years during the last decade. These are ringspot, light leaf spot, dark leaf spot (Alternaria), white blister, powdery mildew and downy mildew. Brief details of these are given below:-

### Ringspot (Mycosphaerella brassicicola)

Ringspot attacks Brussels sprouts, cabbage, cauliflower and kale, particularly in wet seasons. It is more common where crops are grown frequently on the same land and, while predominantly a disease of the wetter and western areas, it has also been troublesome elsewhere in the UK. Circular grey black spots, up to 1.5 cm diameter, are formed on leaves, stems and seed pods, being more frequent on the outer and lower leaves. The tiny black fruiting bodies of the fungus are dotted over the surface of the spots in concentric rings and distinguish this disease from Alternaria. Badly affected leaves turn yellow and wither prematurely.

The chief sources of infection are the remains of diseased leaves in the soil and mature brassicas near younger crops. Airborne spores (ascospores) are released from infected debris during cool, moist weather, and infection occurs under similar conditions. Infection and disease development are dependent on high humidity and temperatures of 15-20°C. The fungus penetrates the leaves through stomata. Although

spore cases (pycnidia) are formed in abundance on the ringspots, the spores produced may not be infective and their role is uncertain (8, 15).

**Light leaf spot (Pyrenopeziza brassicae)**

This disease is common on many brassica crops but its incidence is usually low. The fungus produces concentric rings of pinkish-white spore droplets on affected leaves. Young lesions show little discoloration but they become paler in the centre and eventually bleached with age. Individual spores may merge to produce large bleached patches, especially on the lower leaves.

Leaves, flower buds and seed pods, can be affected. Superficial blackening or pink streaking at the base of upper leaf petioles of cauliflower may occur, although symptoms may not be noticed until the crop is cut. Irregular black speckling may spread over the outer leaves of Brussels sprout buttons and eventually cause a superficial soil rot. Spore spread and fungal development are favoured by cold, wet conditions (10-15°C), spread by rain splash and airborne spores (conidia)and ascospores from debris. Symptoms develop rapidly during cold wet weather (16, 17).

**Dark leaf spot (Alternaria brassicae and A. brassicicola)**

These organisms cause large zonate black or dark brown spots on the leaves of all brassicas and may also produce a brown decay of cauliflower curds. Young lesions are small discrete black spots, rather similar to those caused by other pathogens, particularly on sprout buttons. They are common in seed crops where black spots on stems and pods can cause premature ripening and complete loss of yield. They also cause losses to cabbage during storage.

The disease is favoured by warm moist conditions and spread by wind-borne spores over a distance of at least 1 km. On spring-sown crops the disease is often found towards the end of July, developing during the autumn months. A. brassicicola is still generally the dominant species in seed crops, but A. brassicae has increased in recent years and is now the major pathogen in some crops. The two species differ in their temperature requirements: A. brassicicola is more readily checked by low temperature than is A. brassicae (3, 4, 9,

**White blister (Albugo candida)**

Both seedlings and mature plants are attacked. Raised white patches, smooth and glossy at first, but later becoming powdery, appear mainly on the underside of the leaves or on stems and inflorescences. Marketable quality of Brussels sprouts is reduced by the presence of affected buttons. The forms of the fungus on cruciferous weeds such as shepherd's purse are usually distinct and will not transfer from weeds to commercial varieties.

Primary infection is by motile spores from germinating resting bodies in soil. Secondary spread is by windborne and rain-splashed spores from the white pustules. This disease is usually seen in late summer and in the autumn, and is favoured by periods of high humidity and temperatures between 10 and 20°C. Generally, the disease is more troublesome in the western coastal areas of Britain (13).

**Powdery mildew (Erysiphe cruciferarum)**

The fungus is recognised by the powdery white appearance on the leaves and stems of most brassicas and also on Brussels sprout buttons. The disease usually appears on the upper surface of the leaves as small spots coalescing to cover the whole of the leaf surface. Affected sprout buttons show a black spotting following frost, which reduces market acceptability, particularly on crops for processing.

Spread is by wind-borne spores. On spring-sown crops the disease is often found towards the end of July and can develop rapidly during August and September. The disease is severe in hot dry summers as infection is favoured by warm (15-20°C) conditions with periods of high humidity.

Most leaf brassicas are susceptible to powdery mildew and only the more recent F1 hybrid Brussels sprout varieties have been bred for resistance to the disease (14).

**Downy mildew (Peronospora parasitica)**

This disease attacks brassica seedlings, especially cauliflowers raised under protection. Several attacks have occurred on seedlings raised in

peat modules. Yellow patches develop on the upper surface of diseased leaves with corresponding white sporing patches on the under-surface. Seedlings affected at the cotyledon stage are invariably killed. The effect of severe infection on vigour of young plants may reduce final weight.

Mature field-grown crops may also be affected late in the year when symptoms appear as ill-defined yellowish-brown areas between the main veins. The white mould growth develops on the under-surfaces of these veins in moist weather. Cauliflower curds may also become affected at this time and symptoms appear on the florets as black spots, streaks on the flower stem and discolouration of the surface and within the curd. On Brussels sprouts the development of discrete black spots on the outer button leaves affects quality. Similar symptoms may be caused by other fungi.

Infection usually occurs in plants raised under glass during the winter and early spring, especially if ventilation is inadequate. It is particularly damaging when the cotyledons are affected. Cauliflowers are very susceptible and can be killed. Outdoor plants are usually only affected during periods of high humidity, but symptoms can be found throughout the year.

Other diseases such as White leaf spot (Pseudocercosporella capsellae) and Phoma leaf spot (Leptosphaeria maculans) are infrequently seen. In some years black rot (Xanthomonas campestris) can be troublesome, especially in cauliflowers, but tends to be associated with seed stocks. Of several viruses that attack brassicae, cauliflower mosaic and turnip mosaic, are the two most frequently seen, but severe outbreaks are uncommon.

**What external factors except weather influence disease incidence in vegetable brassicae?**

a. Brassica Cropping

Over the last 10 years the total area growing vegetable brassicae has only slightly diminished. Over the same period, oilseed rape production has increased almost three-fold - 125,000 in 1981 to 343,000 in 1990. As the concentration of both oilseed rape and vegetable brassicae is in the eastern part of the country, there is increased pressure for disease transfer. In

the early 1980s, when Alternaria was evident in both oilseed rape crops and vegetable brassicae, especially Brussels sprouts, this was attributed to the interaction between the two crops (6).

A survey of foliar diseases in Brussels sprouts was undertaken by ADAS between 1983 and 1985. No disease gradients were observed in crops adjacent to oilseed rape, and only the incidence of light leaf spot was consistently greater in crops adjacent to oilseed rape compared with those distant from oilseed rape. The incidence of the three main oilseed rape related diseases in crops adjacent ( 50 m) and distant from oilseed rape, as shown in Table 3 (7).

Table 3. **Incidence of oilseed rape related diseases in Brussels sprout crops adjacent to (A) and distant from (D) oilseed rape**

| | Alternaria spp | | | | Peronospora parasitica | | | | Pyrenopeziza brassicae | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Plants | | % Buttons | | % Plants | | % Buttons | | % Plants | | % buttons | |
| Year | A | D | A | D | A | D | A | D | A | D | A | D |
| 1983 | 37.5 | 46.9 | 1.50 | 3.00 | 55.2 | 35.7 | 1.10 | 0.20 | 5.2 | 1.7 | 2.60 | 1.60 |
| 1984 | 14.4 | 19.0 | 0.34 | 1.86 | 8.2 | 27.5 | 0.00 | 0.17 | 26.7 | 14.9 | 9.96 | 3.36 |
| 1985 | 10.0 | 9.0 | 0.31 | 0.15 | 13.2 | 11.2 | 0.00 | 0.22 | 22.0 | 16.0 | 8.21 | 2.25 |

b. Varieties

Annual NIAB recommended list of varieties of oilseed rape includes disease resistance rating of the varieties to stem canker, light leaf spot, and downy mildew in autumn. Apart from powdery mildew resistance in Brussels sprouts, no such ratings are given for foliar diseases in any of the vegetable brassicae. Information is being gathered each year from variety trials being undertaken by the NIAB on leaf and button diseases in Brussels sprouts. From these observations, provisional disease resistance ratings of the various varieties to ring spot, white blister and light leaf spot, are published in the NIAB Fellows Newsletter. Part of recently produced information is given in Table 4.

Table 4. **Disease resistance ratings for varieties of Brussels sprouts**

| Variety | Ringspot | White blister | Light leaf spot |
|---|---|---|---|
| Adeline | A | D | D |
| Cavalier | C | C | A |
| Dolmic | B | C | C |
| Gabion | A | C | B |
| Oliver | D | C | C |
| Richard | C | B | A |
| Roger | C | C | C |
| Topaz | B | B | B |

A = very resistant; B = moderately resistant; D = very susceptible.

c. Fungicide usage

The last decade has seen a dramatic increase in fungicide use in both oilseed rape and vegetable brassicae crops (see Table 5). Two, three or more sprays are now common on these crops. Surveys and concluded trials done by ADAS have shown the value of correct disease diagnosis, disease risk assessment and correct timing of sprays. Following from such trials growers can now reduce fungicide usage in many cases whilst having a major effect on disease severity. These are illustrated in Tables 6, 7 and 8 (18).

Table 5. **Pesticide usage - survey reports for oilseed rape and vegetable brassicae**

| | TOTAL FOLIAR APPLIED FUNGICIDES | | | |
|---|---|---|---|---|
| | Oilseed Rape | | Vegetable Brassicae | |
| Year | Treated hectares | Tonnes applied | Treated hectares | Tonnes applied |
| 1981 | - | - | 4,099 | Not recorded |
| 1982 | 53,571 | 44 | - | |
| 1986 | - | - | 45,029 | 36.6 |
| 1988 | 287,865 | 212 | - | - |
| 1990 | 433,432 | 257 | - | - |

MAFF Pesticide Usage Surveys

Table 6. **Effect of fungicide sprays on the incidence of dark leaf spot in Brussels sprouts 1983-1985 (percentage plants with leaf symptoms and percentage buttons affected) in survey crops**

| | NUMBER OF SPRAYS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | | 1 | | 2 | | 3+ | |
| | % Plants | % Buttons | % Plants | % Buttons | % Plants | % Buttons | % Plants | % Buttons |
| 1983 | 47.1 | 1.80 | 44.8 | 0.43 | 4.4 | 0.02 | - | - |
| 1984 | 20.4 | 1.90 | 13.2 | 1.20 | 20.0 | 0.40 | 5.3 | 0.80 |
| 1985 | 12.0 | 0.37 | 8.9 | 0.10 | 2.8 | 0.30 | 15.1 | 0.13 |

Table 7. **Effect of fungicide sprays on the incidence of light leaf spot and ringspot in Brussels sprouts in 1985 (percentage plants with leaf symptoms and percentage buttons affected) in surveyed crops**

| | NUMBER OF SPRAYS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | | 1 | | 2 | | 3+ | |
| | % Plants | % Buttons | % Plants | % Buttons | % Plants | % Buttons | % Plants | % Buttons |
| Light leaf spot | 19.4 | 4.98 | 19.2 | 5.00 | 15.3 | 1.91 | 12.5 | 0.21 |
| Ring spot | 14.5 | 2.68 | 16.5 | 2.05 | 3.0 | 0.15 | 0.0 | 0.00 |

Table 8. **Spray timing for button diseases in Brussels sprouts**

| | Treatments - Sprays applied 22 Aug (Benlate + Folio) | 11 Sep (Benlate + Folio) | 4 Oct (Benlate + Folio) | 23 Oct (Benlate + Folio) | Ringspot (% leaf area affected) 17 Dec | Diseased buttons (%) (>5% button area affected) Ringspot | Diseased buttons (%) (>5% button area affected) Light leaf spot |
|---|---|---|---|---|---|---|---|
| 1. | Untreated control | | | | 2.9 | 63.0 | 88.7 |
| 2. | + | + | + | - | 0.2 | 24.0 | 63.7 |
| 3. | + | + | - | - | 0.4 | 43.2 | 67.5 |
| 4. | + | - | + | - | 0.3 | 29.7 | 60.0 |
| 5. | - | + | + | - | 0.1 | 35.2 | 63.0 |
| 6. | + | - | - | - | 0.8 | 44.0 | 92.7 |
| 7. | - | + | - | - | 2.5 | 73.5 | 96.2 |
| 8. | - | - | + | - | 0.1 | 20.0 | 68.7 |
| 9. | + | + | - | + | 0.9 | 28.7 | 51.2 |
| 10. | - | + | - | + | 0.2 | 45.0 | 70.2 |
| 11. | - | + | + | + | 0.1 | 3.0 | 38.0 |

A mixture of Benlate and Folio was applied in 1, 2 or 3 spray programmes for the control of foliar and button diseases in Brussels sprouts cv Rampart in north Devon in 1990. All treatments significantly reduced the low level of foliar ringspot which developed during the dry autumn. By December, severe infections of ringspot and light leaf spot were evident on buttons. Whilst there was no significant yield differences, button quality was increased by all two and three spray programmes. Most benefit, came from a spray applied on 4 October with additional benefits from 23 October treatment. Light leaf spot was not well controlled on this experiment. Replicated experiments have shown that well timed fungicide sprays can provide good control of Alternaria, powdery mildew, white blister and ringspot. Results with light leaf spot have been less satisfactory overall, and only partial control has been achieved. Control of downy mildew in field crops has received limited attention.

## Method

Information for this review has been obtained from ADAS intelligence reports, disease surveys, published papers, published and unpublished trial results, and from ADAS advisers - horticulturists and plant pathologists. All weather data have been obtained from ADAS National Agrometeorology Unit, based at Wolverhampton.

**Approaches used in compiling this review**

1. Review available ADAS disease intelligence data over the last 10 years (1981-90) to determine local and/or national epidemic disease years for specific diseases.

2. From trial results, determine progress of various disease epidemics in any particular year and relate, if possible, to weather data.

3. Obtain meteorological data for specific localities and relate to any epidemic disease in particular years.

## Results

### A. Disease Incidence and Severity

A questionnaire was sent to Plant Pathology colleagues in all the main vegetable brassicae growing areas in England and Wales (see Appendix VII). Using this intelligence information, disease severity for each major disease in each year was determined to give both Regional and National rating for the individual diseases. The results are summarised in the following tables 9 to 14 using the following key for incidence and severity:-

| | | |
|---|---|---|
| - | = | not seen or reported |
| * | = | slight infection reported or seen |
| ** | = | some moderate infection |
| *** | = | some severe outbreaks/generally severe |

**Brussels sprout disease surveys (1983-85)**

Commercial crops of Brussels sprouts were selected throughout England and Wales, the number selected being proportional to the acreage grown in the area. In 1983 a total of 139 crops were assessed for diseases between October and December. The following year, 137 crops were visited and 166 in 1985. A summary of the results is given in Table 15, with full disease incidence for each area in each year in Appendix I (18).

Table 15. **Mean incidence of diseases of Brussels sprouts in England and Wales 1983-85 (percentage plants with leaf symptoms (L) and percentage buttons affected (B))**

| Year | Albugo candida | | Alternaria spp. | | Erysiphe cruciferarum | | Mycosphaerella brassicicola | | Peronospora parasitica | | Pyrenopeziza brassicae | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | B | L | B | L | B | L | B | L | B | L | B |
| 1983 | 21.2 | 2.2 | 45.0 | 2.7 | 28.5 | 1.6 | 13.9 | 1.1 | 39.8 | 0.4 | 3.1 | 0.2 |
| 1984 | 10.0 | 0.9 | 17.9 | 1.5 | 35.0 | 1.7 | 16.0 | 0.8 | 22.8 | 0.1 | 17.7 | 5.0 |
| 1985 | 8.0 | 0.8 | 9.0 | 0.2 | 23.0 | 0.9 | 11.0 | 1.8 | 11.7 | 0.2 | 18.0 | 3.9 |

In all three years, disease levels were generally low - the majority of crops with less than 1% leaf and button area affected. Each year, powdery mildew was the most severe disease with 19.7% of crops having more than 1% leaf area affected. The severity of button infection did not always follow the pattern of leaf infections. This was especially so for light leaf spot which was difficult to find on leaves but still gave severe button infection.

Table 16. **Severity of diseases of Brussels sprouts in England and Wales 1983-85 (percentage plants in each category)**

| | Albugo candida | | | | Alternaria spp. | | | | Erysiphe cruciferarum | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Leaf area | | % Button area | | % Leaf area | | % Button area | | % Leaf area | | % Button area | |
| | >1 | >10 | >1 | >10 | >1 | >10 | >1 | >10 | >1 | >10 | >1 | >10 |
| 1983 | 5.0 | 0.7 | - | - | 10.8 | 0.0 | - | - | 10.8 | 2.2 | - | - |
| 1984 | 4.4 | 0.0 | 0.7 | 0.0 | 2.2 | 0.0 | 1.5 | 0.0 | 19.7 | 3.6 | 2.2 | 0.0 |
| 1985 | 2.4 | 0.0 | 4.2 | 0.0 | 1.2 | 0.0 | 1.2 | 0.0 | 19.9 | 6.6 | 6.6 | 0.0 |

| | Mycosphaerella brassicicola | | | | Peronospora parasitica | | | | Pyrenopeziza brassicae | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Leaf area | | % Button area | | % Leaf area | | % Button area | | % Leaf area | | % Button area | |
| | >1 | >10 | >1 | >10 | >1 | >10 | >1 | >10 | >1 | >10 | >1 | >10 |
| 1983 | 6.5 | 0.7 | - | - | 22.7 | 6.5 | - | - | 0.0 | 0.0 | - | - |
| 1984 | 10.9 | 1.5 | 1.5 | 0.7 | 19.0 | 0.7 | 0.0 | 0.0 | 6.6 | 0.0 | 14.6 | 5.8 |
| 1985 | 10.2 | 1.8 | 3.6 | 1.2 | 9.0 | 0.0 | 1.8 | 0.0 | 7.8 | 0.0 | 15.1 | 0.6 |

## Table 9.

# National Disease Summaries.

| Year | Ringspot | Light Leaf Spot | White Blister | Alternaria | Powdery Mildew |
|---|---|---|---|---|---|
| 1981 | * | * | * | ** | * |
| 1982 | * | * | * | ** | * |
| 1983 | * | * | ** | ** | ** |
| 1984 | ** | ** | ** | * | ** |
| 1985 | ** | ** | ** | * | * |
| 1986 | ** | ** | * | * | * |
| 1987 | * | * | * | * | * |
| 1988 | * | ** | ** | * | * |
| 1989 | * | * | ** | * | ** |
| 1990 | ** | * | ** | * | *** |

* slight infection reported ** generally moderate infection

*** severe infections in most areas

## Table 10.

# Regional Disease Summaries. Ringspot.

\- nil or not recorded * slight ** moderate *** severe infections in most areas

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| York/Humberside | - | - | - | - | * | - | - | - | - | - |
| East Midlands (Lincs) | - | - | - | * | * | *** | ** | ** | * | * |
| E. Anglia (Beds, Norfolk, Suffolk) | * | * | * | * | * | * | * | * | * | * |
| S. East (Kent) | - | * | * | * | * | - | - | * | * | * |
| S. West (Glos) | ** | ** | * | * | ** | ** | * | ** | ** | * |
| W. Midlands (Hereford & Worcester) | ** | *** | ** | * | * | * | * | * | * | ** |
| N. West (Lancs & Mersey) | *** | *** | *** | ** | ** | * | *** | ** | ** | ** |
| Wales | *** | ** | *** | *** | *** | ** | *** | * | * | *** |

Table 11.

# Regional Disease Summaries. Light Leaf Spot.

- nil or not recorded * slight ** moderate *** severe infections in most areas

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| York/Humberside | ** | ** | * | *** | ** | ** | *** | ** | ** | ** |
| East Midlands (Lincs) | * | * | * | ** | ** | * | * | * | – | * |
| E. Anglia (Beds, Norfolk, Suffolk) | * | * | * | ** | ** | ** | ** | ** | ** | * |
| S. East (Kent) | – | – | – | * | ** | – | – | ** | * | – |
| S. West (Glos) | * | – | – | – | ** | * | * | ** | * | * |
| W. Midlands (Hereford & Worcester) | – | – | * | * | ** | ** | * | * | * | * |
| N. West (Lancs & Mersey) | *** | ** | ** | ** | ** | * | * | * | * | * |
| Wales | ** | * | ** | ** | *** | *** | * | * | * | * |

## Table 12.

# Regional Disease Summaries. White Blister.

- nil or not recorded * slight ** moderate *** severe infections in most areas

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| York/Humberside | * | - | - | - | ** | - | * | * | ** | ** |
| East Midlands (Lincs) | - | - | * | * | * | - | - | ** | ** | ** |
| E Anglia (Beds, Norfolk, Suffolk) | - | * | ** | * | * | ** | * | ** | ** | * |
| S. East (Kent) | - | ** | ** | * | ** | - | - | ** | * | * |
| S. West (Gloucs) | * | - | ** | * | ** | ** | * | ** | * | * |
| W. Midlands (Hereford & Worcester) | * | * | ** | * | ** | * | * | ** | ** | ** |
| N. West (Lancs & Mersey) | * | - | *** | * | ** | * | ** | ** | ** | ** |
| Wales | ** | * | ** | - | ** | * | * | * | * | * |

Table 13.

# Regional Disease Summaries. Alternaria. Dark Leaf Spot.

\- nil or not recorded * slight ** moderate *** severe infections in most areas

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| York/Humberside | * | ** | ** | * | * | – | * | ** | * | * |
| East Midlands (Lincs) | * | *** | ** | * | * | * | * | * | * | * |
| E. Anglia (Beds, Norfolk, Suffolk) | ** | ** | ** | * | * | * | * | * | * | * |
| S. East (Kent) | * | * | * | ** | * | – | – | * | * | * |
| S. West (Glos) | ** | ** | * | * | * | ** | ** | * | * | * |
| W. Midlands (Hereford & Worcester) | ** | *** | ** | * | * | ** | ** | * | * | * |
| N. West (Lancs & Mersey) | * | ** | * | * | * | ** | * | * | * | * |
| Wales | * | *** | ** | *** | ** | * | * | * | * | * |

Table 14.

# Regional Disease Summaries. Powdery Mildew.

- nil or not recorded * slight ** moderate *** severe infections in most areas

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| York/Humberside | * | – | * | ** | ** | – | – | – | *** | *** |
| East Midlands (Lincs) | * | * | * | * | * | * | * | – | ** | *** |
| E. Anglia (Beds, Norfolk, Suffolk) | ** | ** | ** | ** | * | * | * | ** | ** | *** |
| S. East (Kent) | * | * | *** | ** | * | – | – | – | * | *** |
| S. West (Glos) | * | * | * | *** | * | ** | * | * | *** | *** |
| W. Midlands (Hereford & Worcester) | ** | * | * | * | * | * | * | * | ** | ** |
| N. West (Lancs & Mersey) | * | * | – | – | * | * | * | * | ** | ** |
| Wales | – | – | * | – | – | – | – | – | * | * |

**Which are the main areas at risk from individual diseases?**

The areas most at risk from ringspot over the last decade have been the Western side of the country, particularly the South West and Wales, and also Hereford and Worcester in the West Midlands, as well as Lancashire in the North West. The disease has occasionally been a problem in other areas, eg Lincolnshire in 1986 to 1988. Light leaf spot was fairly widespread throughout England and Wales in 1984, 1985 and 1986. It was generally most severe and frequent in Humberside and East Anglia, and less frequently in the North West, West Midland, South West and Wales - occasional epidemic years. The incidence of white blister was high nationally in 1983, 1985 and 1988. Disease incidence was very variable with some severe outbreaks in all areas. The North West and West Midlands seem to be most vulnerable to this disease. Alternaria (dark leaf spot) was severe in most areas in the early 1980s, but is now rarely a major problem. In some years it can be troublesome in the West Midlands and South West. Powdery mildew is another disease which is frequently severe throughout the main vegetable brassicae growing areas in some years, eg 1989 and 1990. It was generally most common in East Anglia and was common in some seasons in Humberside, Lincolnshire, the South East and South West.

**What time of the year do epidemics occur?**

Although there are seasonal variations, epidemics of particular diseases tend to arise at similar times of the year. Information compiled in ADAS intelligence reports highlight disease incidence and severity. Epidemic years for ringspot have usually been preceded by reported incidences of the disease from August onwards, with the disease becoming epidemic from October or November. Similarly, Alternaria infections in June and July in either oilseed rape or vegetable brassicae indicated probable epidemics in Brussels sprouts and other brassicae by early winter. Epidemic years for powdery mildew are usually preceded by light infections in crops during August and early September. White blister is less predictable with some infections seen in late summer but fail to develop further. In other years, the disease is not encountered until about November. Light leaf spot is frequently absent from leaves during the growing season, but can become epidemic on Brussels sprout buttons from October/November onwards.

## B. Effect of weather on disease epidemics

An attempt has been made to compare epidemic seasons with low disease years for each disease and to evaluate the meteorological data in specific localities. With the known epidemiological information for each disease, reasons for high or low disease incidences are proposed. The weather records in each locality is that nearest the main vegetable brassicae growing area.

Each disease will be discussed and summarised, with full weather data in graphic form in Appendices II to VI.

### Ringspot

Infection and disease development is dependent on high humidity (near 100%) and temperature of 15-20°C. Long periods of rainfall are also thought critical to the epidemic development of the disease; rain on four consecutive days being optimum. Comparisons were made in high and low years for ringspot in Hereford and Worcester (Meteorological Station, Elmdon), South West Wales (Aberporth), and Lancashire (Squires Gate). Critical data are summarised in Table 17, and Appendix II A-F.

Table 17. **Effect of weather on incidence of ringspot**

| Criteria | Epidemic Years | | | | | | Low Disease Years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1982 | | ELMDON | | | | 1984 | | | | | |
| Max temp: 15°C+ | April-September | | | | | | May-September | | | | | |
| Rain: 75 mm +/month | June, August, Nov | | | | | | September, November | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 21 | 9 | 19 | 13 | 18 | 80 | 9 | 8 | 10 | 16 | 18 | 61 |
| | 1984 | | ABERPORTH | | | | 1988 | | | | | |
| Max temp: 15°C+ | May-October | | | | | | May-September | | | | | |
| Rain: 75 mm +/month | Sep, Oct, Nov, Dec | | | | | | October | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 9 | 10 | 12 | 21 | 21 | 73 | 13 | 24 | 16 | 16 | 17 | 86 |

Table 17 (continued)

| Criteria | Epidemic Years | | | | | | Low Disease Years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1982 SQUIRES GATE | | | | | | 1986 | | | | | |
| Max temp: 15°C+ | May-October | | | | | | May-September | | | | | |
| Rain: 75 mm +/month | Jun, Aug, Oct, Nov, Dec | | | | | | Oct, Nov, Dec | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 15 | 8 | 24 | 16 | 22 | 85 | 11 | 16 | 16 | 7 | 22 | 72 |

**Suggested explanation**

Epidemic years: In 1982 at both Elmdon and Squires Gate, high rainfall and a high number of rain days in August with maximum temperatures above 15°C were ideal for epidemic ringspot development. At Aberporth in 1984 there was a late development of the disease due to high temperature (15°C+) in October together with high rainfall and a high number of rain days from September onwards.

Low disease years: At Elmdon in 1984 the dry summer was followed by only moderate rainfall in September. Substantial rain did not fall until November, when maximum temperatures were below 15°C. In July 1988 at Aberporth, the weather was damp, but total rainfall was below 75 mm for the month, with only low rainfall in the following two months. Maximum temperatures in October were below 15°C when there was high rainfall. In 1986 at Squires Gate there was no substantial rain until October, by which time maximum temperatures were low and therefore too late for epidemic ringspot development.

**Light Leaf Spot**

Rain splash and cold, wet conditions, with temperatures of 10-15°C are necessary for disease spread and development. Comparisons are made at two areas, South West Wales (Aberporth) and Humberside (Finningley). The data are summarised in Table 18, and Appendix III A-D

Table 18. **Effect of weather on incidence of light leaf spot**

| Criteria | Epidemic Years | | | | | | Low Disease Years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1987 ABERPORTH | | | | | | 1989 | | | | | |
| Max temp: 10°C+ | March-November | | | | | | March-November | | | | | |
| Max temp: 15°C+ | July-September | | | | | | May-September | | | | | |
| Rain: 75 mm +/month | Sept, Oct, Nov | | | | | | Oct, Dec | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 18 | 12 | 15 | 16 | 24 | 85 | 13 | 7 | 16 | 14 | 23 | 73 |
| | 1987 FINNINGLEY | | | | | | 1990 | | | | | |
| Max temp: 15°C+ | April-October | | | | | | March-October | | | | | |
| Max temp: 15°C | June-September | | | | | | May-October | | | | | |
| Rain: 75 mm +/month | Jun, July, Oct | | | | | | December | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 24 | 16 | 14 | 12 | 21 | 87 | 18 | 8 | 8 | 11 | 15 | 60 |

**Suggested Explanations**

Epidemic year: At both Aberporth and Finningley, 1987, the cold weather from October onwards and high rainfall with a high number of rain days were responsible for epidemic light leaf spot development.

Low disease years: At Aberporth in 1989 a dry summer and early autumn was followed by rain in late October, but probably too late for epidemic disease development as inoculum was probably too low. In 1990 at Finningly no substantial rain fell until December - too late to affect disease development.

**White Blister**

This sporadic disease, spread by wind and rainsplash, is favoured by periods of high humidity and temperatures of 10-20°C. Comparisons are made of Lincolnshire (Coningsby) and Gloucestershire (Brize Norton). The main data are summarised in Table 19, and Appendix IV A-D.

Table 19. **Effect of weather on incidence of white blister**

| Criteria | Epidemic Years | | | | | | Low Disease Years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1989 CONINGSBY | | | | | | 1987 | | | | | |
| Max temp: 15°C+ | May-October | | | | | | June-September | | | | | |
| Rain: 75 mm+/month | None | | | | | | Jun-Aug, Oct | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 10 | 9 | 9 | 12 | 19 | 59 | 20 | 15 | 10 | 12 | 16 | 73 |
| | 1988 BRIZE NORTON | | | | | | 1987 | | | | | |
| Max temp: 15°C+ | May-October | | | | | | April-September | | | | | |
| Rain: 75 mm +/month | July | | | | | | June, October | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 13 | 23 | 15 | 12 | 17 | 80 | 24 | 14 | 11 | 14 | 23 | 86 |

**Suggested explanations**

Epidemic years: At both sites temperature maxima were above 15°C longer (into October). Although total rainfall in October was low, the number of rain days were high. Also, high rainfall fell at Brize Norton in 1988.

Low disease years: At both sites these years were short summers. Temperature maxima above 15°C were only recorded between June and September. As substantial rain/rain days did not happen until October, infection levels were low in these two areas.

**Alternaria (dark) leaf spot**

This disease is encouraged by warm (17-23°C) wet weather, and can be found in crops from the end of July. Since the early 1980s the disease has been less frequently seen, possibly due to routine fungicide sprays to both oilseed rape and vegetable brassicae crops. Comparisons are made of three bad years in the early 1980s and three years later in the decade when the disease was low throughout the country. The areas were South West Wales (Aberporth), Hereford and Worcester (Elmdon) and Lincolnshire (Coningsby). The data are summarised in Table 20, and Appendix V A-F.

Table 20. **Effect of weather on incidence of Alternaria dark leaf spot**

| Criteria | Epidemic Years | | | | | | Low Disease Years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1984 ABERPORTH | | | | | | 1986 | | | | | |
| Max temp: 20°C+ | August | | | | | | None | | | | | |
| Rain: 75 mm +/month | September-December | | | | | | Aug, Oct-Dec | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 9 | 10 | 12 | 21 | 21 | 73 | 16 | 16 | 22 | 4 | 18 | 76 |
| | 1982 ELMDON | | | | | | 1985 | | | | | |
| Max temp: 20°C+ | June-August | | | | | | July | | | | | |
| Rain: 75 mm +/month | June, August, Nov | | | | | | June, December | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 21 | 9 | 19 | 13 | 18 | 80 | 20 | 12 | 23 | 6 | 6 | 67 |
| | 1982 CONINGSBY | | | | | | 1986 | | | | | |
| Max temp: 15°C+ | June-August | | | | | | July | | | | | |
| Rain: 75 mm +/month | Jun, Aug, Oct | | | | | | - | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 18 | 6 | 18 | 14 | 22 | 78 | 10 | 13 | 15 | 7 | 15 | 60 |

**Suggested explanation**

Epidemic years: High temperatures in August (20°C+ maximum) together with high rainfall (75 mm+) have consistently resulted in high disease incidences in three areas.

Low disease years: August temperatures below 20°C maxima seem to be critical, irrespective of summer rainfall. Low rainfall in September prevented epidemic development.

**Powdery Mildew**

Infection and disease development is favoured by warm (17-20°C) conditions with periods of high humidity. The disease is often found from the end of

July and can develop rapidly during the autumn. The disease is generally most severe in dry hot summers. Comparisons are made of three areas - Lincolnshire (Coningsby), Humberside (Finningley), and the South West, Gloucestershire (Brize Norton). The main data are summarised in Table 21 and Appendix VI A-F.

Table 21. **Effect of weather on incidence of powdery mildew**

| Criteria | Epidemic Years | | | | | | Low Disease Years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | | CONINGSBY | | | | 1986 | | | | | |
| Max temp: 20°C+ | June-September | | | | | | June, July | | | | | |
| Rain: 50 mm/month | March-December | | | | | | Jun, Jul, Sep, Oct | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 17 | 9 | 9 | 12 | 13 | 60 | 10 | 13 | 15 | 7 | 15 | 60 |
| | 1989 | | FINNINGLEY | | | | 1988 | | | | | |
| Max temp: 20°C+ | June-September | | | | | | August | | | | | |
| Rain: 50 mm/month | July-November | | | | | | Jun, Sept-Dec | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 13 | 8 | 12 | 9 | 18 | 60 | 11 | 24 | 14 | 11 | 15 | 75 |
| | 1989 | | BRIZE NORTON | | | | 1987 | | | | | |
| Max temp: 20°C+ | June-September | | | | | | July, August | | | | | |
| Rain: 50 mm/month | May-August | | | | | | July-September | | | | | |
| No. of rain days (Jun-Oct) | Jun | Jul | Aug | Sep | Oct | Total | Jun | Jul | Aug | Sep | Oct | Total |
| | 10 | 7 | 10 | 10 | 16 | 53 | 24 | 14 | 11 | 14 | 23 | 86 |

**Suggested explanation**

Epidemic years: Prolonged high temperatures (maximum 20°C+) between May and October, with low summer and autumn rainfall, have consistently resulted in epidemic years at all three areas.

Low disease years: Shorter summers, together with high summer rainfall, consistently resulted in low disease years.

There was no correlation between frost days and powdery mildew incidence in the following season (1).

## C. Disease development and weather data

Where disease progress curves from trials are available, attempts have been made to correlate such information with meteorological data from the nearest weather station. A selected number are illustrated in figures 1-5.

### Ringspot (figs 1, 2 and 3)

The trial in Devon, 1982 (fig 1), had rain on 15 consecutive days in early October with maximum temperatures above 15°C. From mid October to the end of November there were 40 rain days, with maximum temperatures of 15°C until mid November. The rains were probably too late to influence foliar infections, but contributed to the epidemic on buttons. Similarly, in the trial in south Wales, 1990 (fig 2), substantial rain on 10 out of 12 days at the end of October, with temperature maxima above 15°C resulted in severe button infection, but foliar ringspot was low. In a trial in South Wales in 1983 (fig 3) rain on 16 out of 22 days in early September, with temperature maxima between 15-20°C, resulted in moderate leaf infection. With further rain on 15 out of 16 days in early October, the disease became epidemic. However, the following weather was dry and cold resulting in a low incidence of button infection.

### Light leaf spot (fig 4)

This trial in South Wales in 1981 had rain on 43 days between 10 September and the end of October, with temperature maxima above 10°C. This resulted in severe button infection from late October. The low level of ringspot infection on buttons was probably due to low temperature.

### Powdery mildew (fig 5)

This trial in Gloucester 1989 had a maximum temperature above 17°C throughout the summer and autumn until at least late September. High temperature and occasional wet days in August resulted in slow early disease development. Heavier rain in mid September probably resulted in higher humidities when the disease became epidemic.

There are no trial details available with disease progress for either white blister or Alternaria dark leaf spot.

Fig. 1

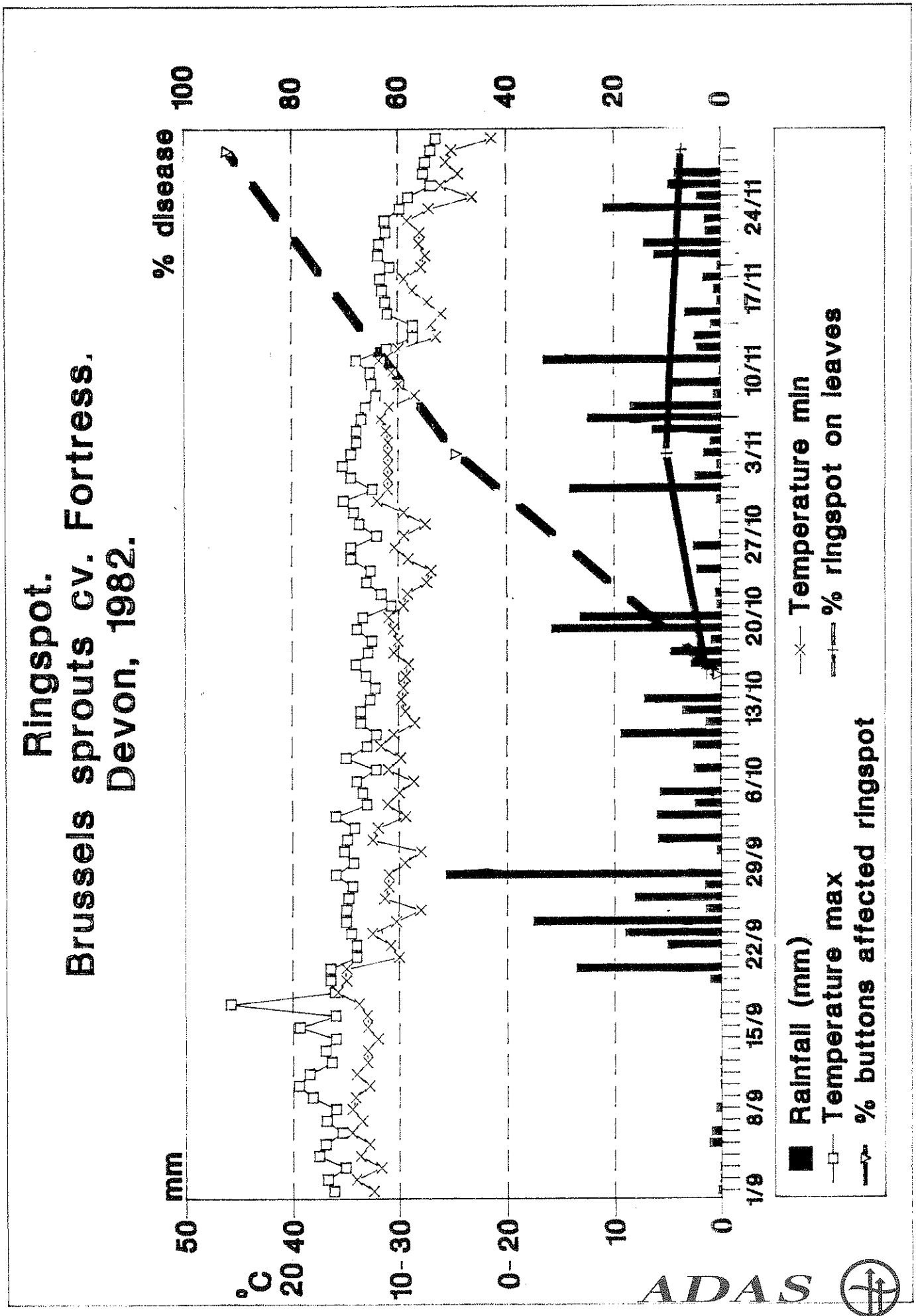

Ringspot.
Brussels sprouts cv. Fortress.
Devon, 1982.
% disease
mm
°C
Rainfall (mm)
Temperature max
% buttons affected ringspot
Temperature min
% ringspot on leaves
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11
ADAS

Fig. 2

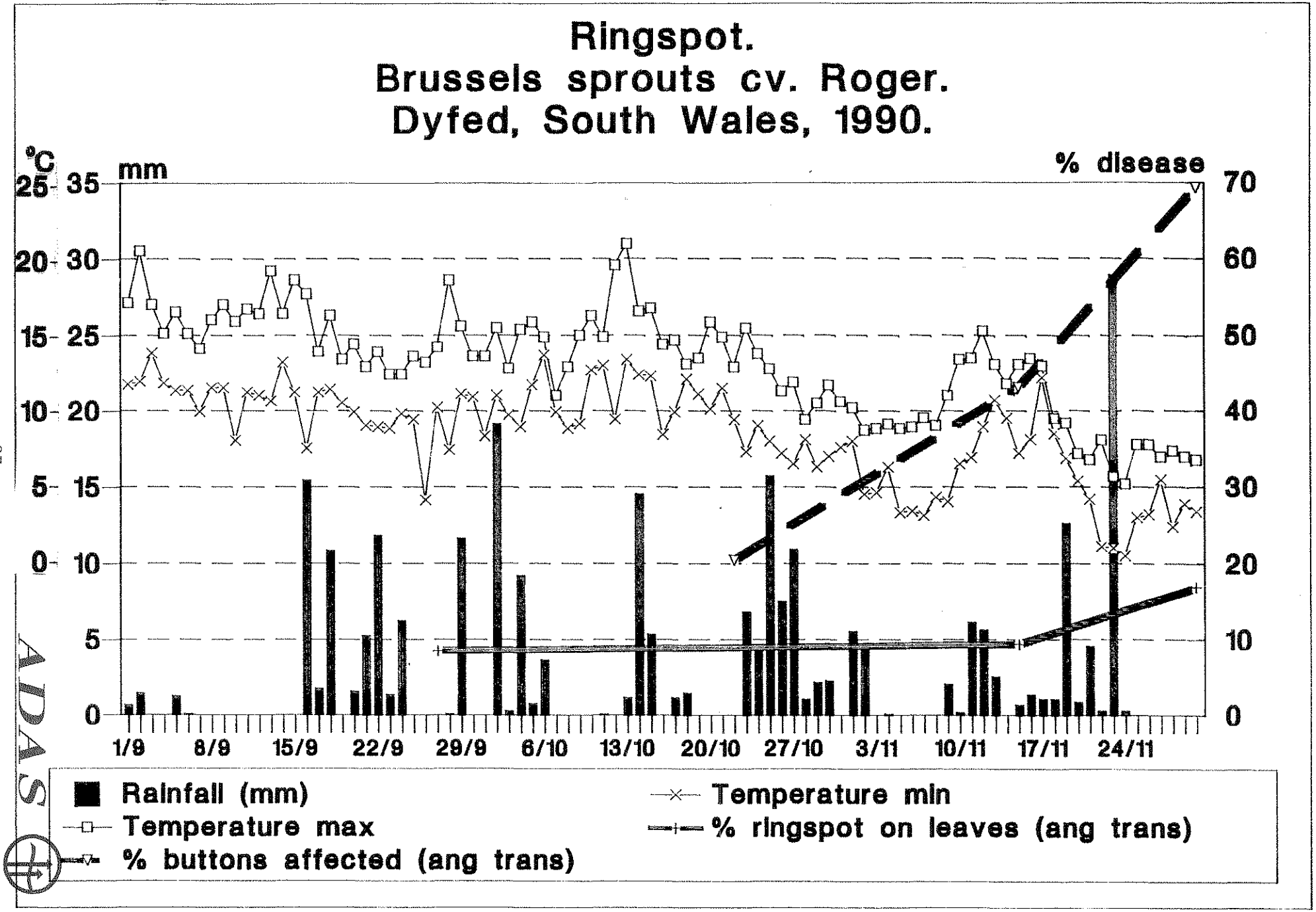

Ringspot.
Brussels sprouts cv. Roger.
Dyfed, South Wales, 1990.
°C
mm
% disease
25 35 20 30 15 25 10 20 5 15 0 10 5 0
70 60 50 40 30 20 10 0
1/9 8/9 15/9 22/9 29/9 6/10 13/10 20/10 27/10 3/11 10/11 17/11 24/11
Rainfall (mm)
Temperature max
% buttons affected (ang trans)
Temperature min
% ringspot on leaves (ang trans)

Fig. 3

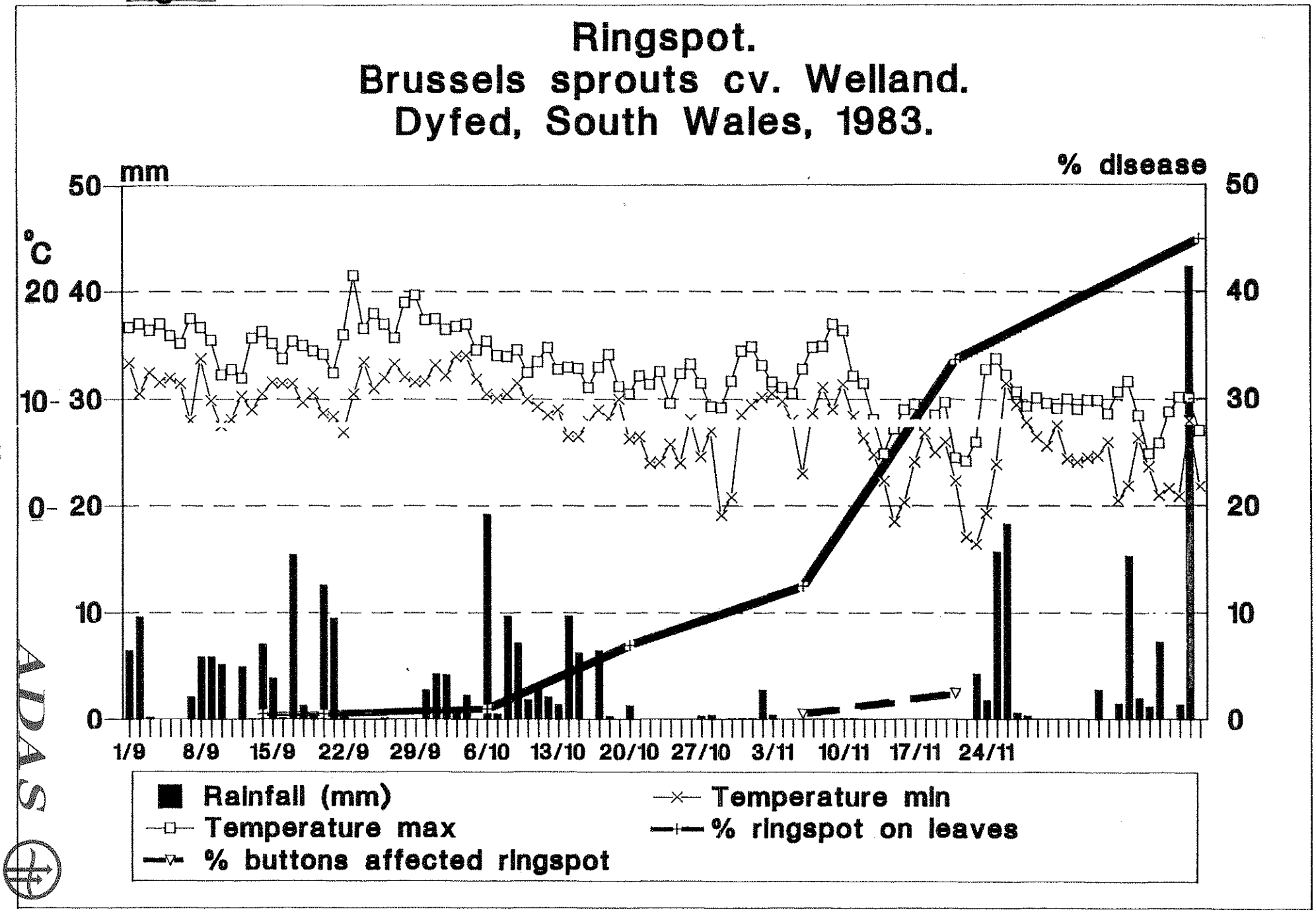

Ringspot.
Brussels sprouts cv. Welland.
Dyfed, South Wales, 1983.
mm
% disease
°C
50
40
30
20
10
0
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11
Rainfall (mm)
Temperature max
% buttons affected ringspot
Temperature min
% ringspot on leaves

Fig. 4

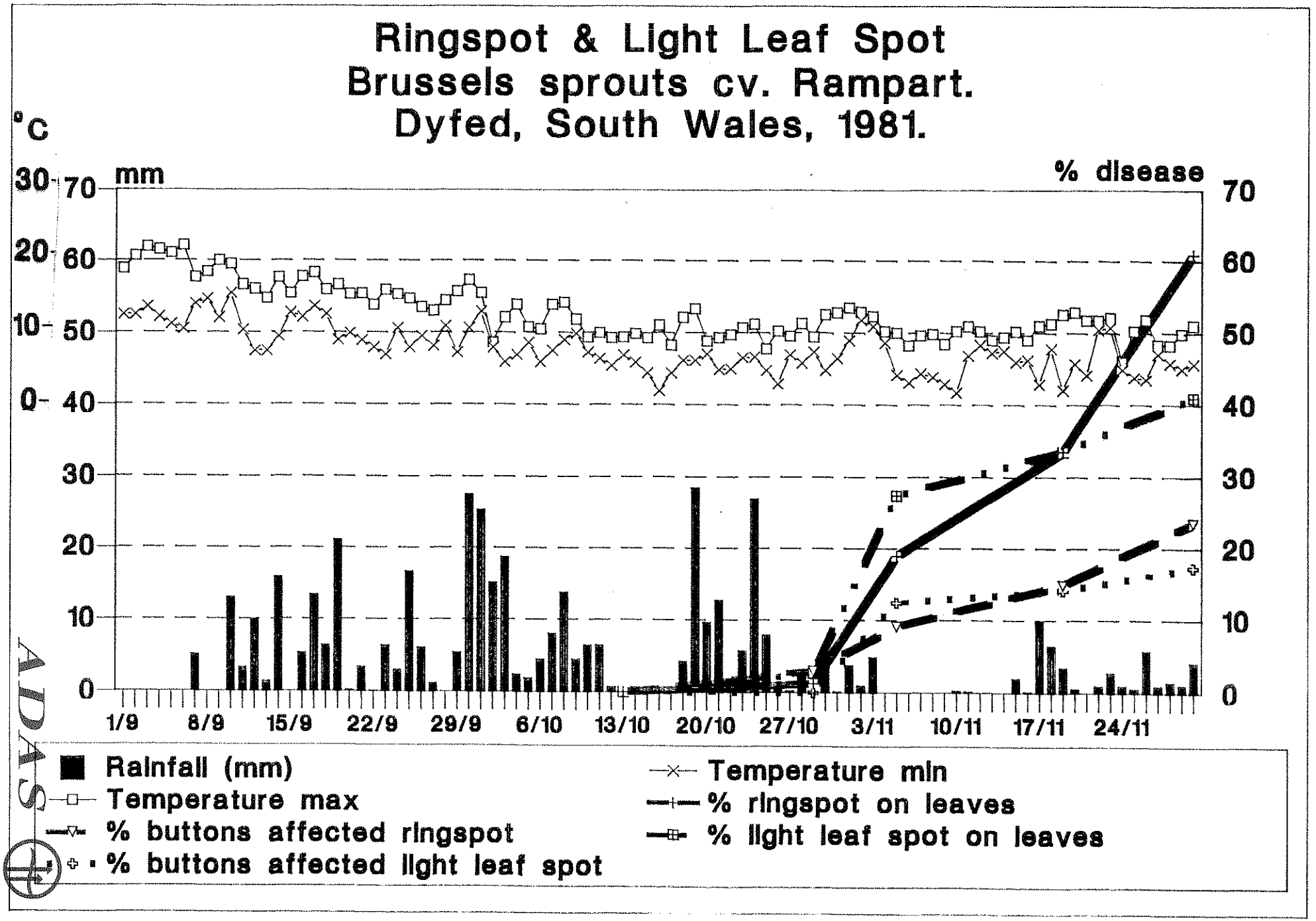
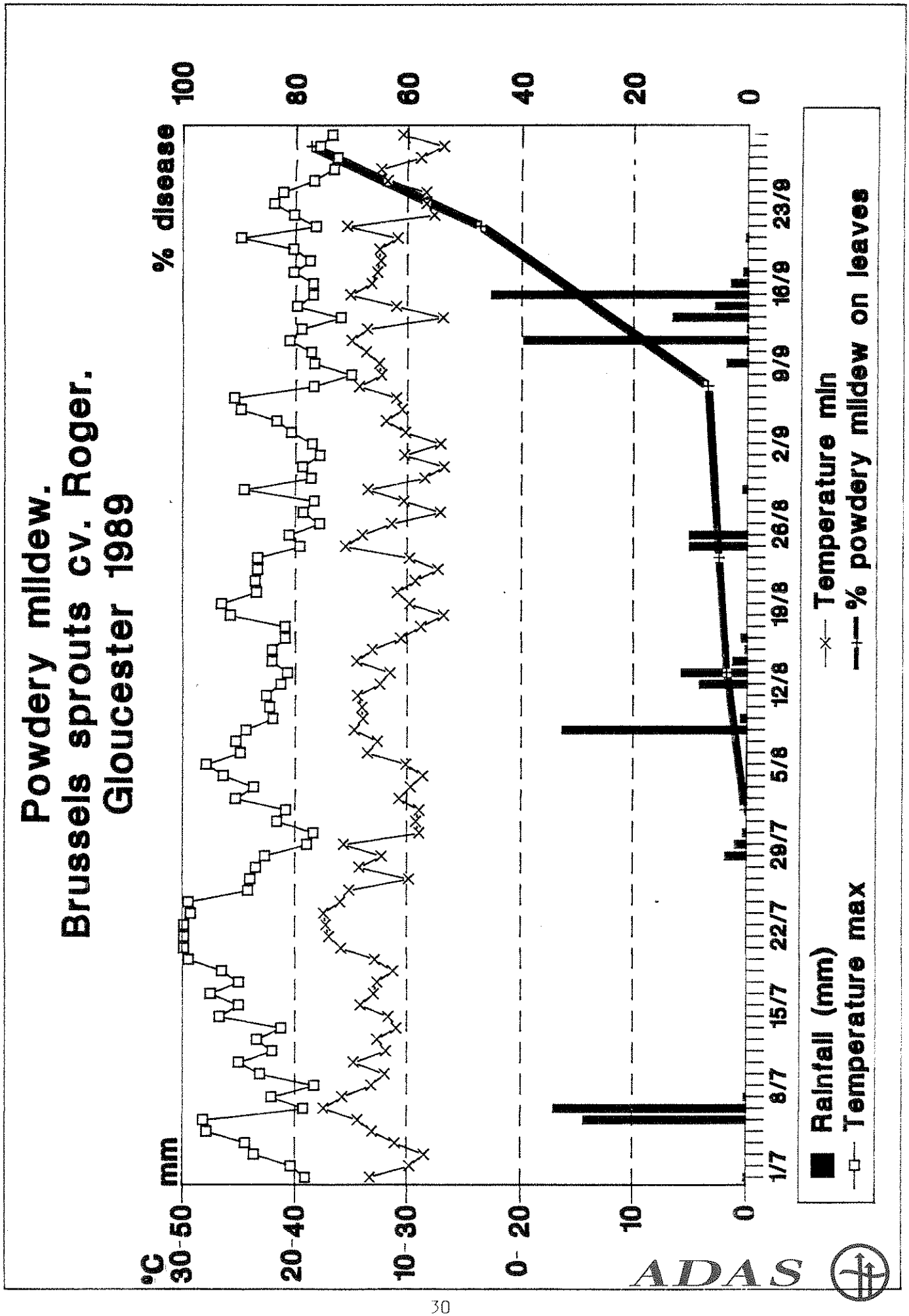

Ringspot & Light Leaf Spot
Brussels sprouts cv. Rampart.
Dyfed, South Wales, 1981.
°C
mm
% disease
30
20
10
0
70
60
50
40
30
20
10
0
1/9
8/9
15/9
22/9
29/9
6/10
13/10
20/10
27/10
3/11
10/11
17/11
24/11
Rainfall (mm)
Temperature max
% buttons affected ringspot
% buttons affected light leaf spot
Temperature min
% ringspot on leaves
% light leaf spot on leaves

Fig. 5


Powdery mildew.
Brussels sprouts cv. Roger.
Gloucester 1989
°C
mm
% disease
30-50
20-40
10-30
0-20
100
80
60
40
20
0
10
0
1/7
8/7
15/7
22/7
29/7
5/8
12/8
19/8
26/8
2/9
9/9
16/9
23/9
Rainfall (mm)
Temperature max
Temperature min
% powdery mildew on leaves
ADAS

## Conclusions

1. **Ringspot** was quite common nationally between 1984 and 1986, and again in 1990. The disease was widespread, sometimes severe, in the Western half of the country - North West, West Midlands, South West and Wales. The disease was usually prevalent from August/September in epidemic years.

2. **Light leaf spot** has been generally most severe in Humberside and East Anglia and sporadically in the North West and Wales. The disease was prevalent nationally in 1985 and to a lesser extent in 1984 and 1988. It was frequently absent on leaves during the growing season, becoming epidemic from November onwards, especially on Brussels sprouts.

3. **White blister** was fairly common nationally in 1983, 1985 and 1988, with the disease very sporadic, with some severe outbreaks in all areas. The disease has been most common during the last decade in the North West and West Midlands, and parts of the South West and East Anglia. The disease was most frequently encountered from late autumn, but was occasionally seen in late summer.

4. **Alternaria dark leaf spot** was nationally common, occasionally severe in 1982 and 1983, but since then has declined considerably. The disease was most severe in Lincolnshire, the West Midlands and Wales in the early 1980s, but is now only occasionally troublesome mainly in the West Midlands and part of the South West. The disease was commonly found from July onwards in epidemic years.

5. **Powdery mildew** was quite common nationally in 1984 and again in 1989 and 1990. It is a disease of the eastern side of the country, being most frequently seen in East Anglia and occasionally in Humberside and Lincolnshire. In epidemic years the disease could be detected in crops during August or September, becoming severe by October or November.,

6. For **ringspot, light leaf spot** and **white blister** there is reasonably good correlation between disease incidence and weather - temperature, rainfall and rain days.

7. Where disease progress information was available from trials there was good correlation between known epidemiological requirements of ringspot, light leaf spot and powdery mildew.

## Recommendations for Further Work

1. More detailed work on the biology and epidemiology of specific diseases. Work in progress at HRI (Wellesbourne) should continue and be supported by the industry if necessary.

2. Specific breeding for resistance to foliar diseases should be encouraged. Standardised disease resistance testing should be developed and in addition variety trials should continue to be monitored for field tolerance to the various diseases. Such work should be funded by government and industry to ultimately reduce pesticide usage without losing quality.

3. Considerable progress in spray timing of fungicides has occurred during the last decade. The work, mainly by ADAS on Brussels sprouts, has resulted in more accurate and reduced sprays being applied to Brussels sprouts, especially for ringspot control. Such work should be extended to other brassicas and work on spring cabbage is in progress sponsored by HDC.

4. There is a need to develop forecasting methods for the various brassica diseases. These should evolve from the epidemiological work already in progress and resulted in target spraying for specific diseases. Infection criteria for white blister and Alternaria are being evaluated at HRI (Wellesbourne). Work on ringspot and light leaf spot should continue with high priority.

5. As fungicides become more commonly used for controlling the major diseases, growers must be aware that present minor diseases could become a major problem in the future. Consideration should be given to a survey - every 5 years - to monitor disease severity in the various vegetable brassica crops and the incidence of fungicide-resistant strains. Monitoring of MBC resistance in ringspot and light leaf spot is crrently in progress, funded by HDC.

6. As new fungicides become available, these should be screened for efficacy against the various brassica leaf diseases. Such testing will probably have to be sponsored by growers or grower organisations as the major agrochemical companies are frequently reluctant to undertake such work for what is considered to be minor uses.

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## References


1. Asher, M. J. C. and Williams, G. E. (1991) Forecasting the national incidence of sugar-beet powdery mildew from weather data in Britain. Plant Pathology 40, 100-107.

2. Davies, J. M. L., Ann, D. M., Dobson, S. C., Gladders, P., Melville, S. C., McPherson, G. M., Popham, M. D., Price, R. I., and Wafford, J. D. M. (1986) Fungicide spray timing trials on Brussels sprouts. Aspects of Applied Biology 12, 1-12.

3. Ellis, M. B. (1968) Alternaria brassicae. CMI Descriptions of Pathogenic Fungi and Bacteria No. 162

4. Ellis, M. B. (1968) Alternaria brassicicola. CMI Descriptions of Pathogenic Fungi and Bacteria No. 163

5. Evans, E. J., Gladders, P., Davies, J. M. L., Hardwick, N. V., Hawkins, J. H., Jones, D. R. and Simkin, M. B. (1984) Current status of diseases and disease control of winter oilseed rape in the UK. Aspects of Biology 6, 323-334.

6. Gladders, P. (1984) Present and potential disease interactions between oilseed rape and vegetable brassicas. Proceedings of the 1984 British Crop Protection Conference - Pests and Diseases, 791-798.

7. Gladders, P., McPherson, G. M., Wafford, J. D., Davies, J. M. L., Jones, O. W., Ann, D. M., Clarkson, J. D. S., Jones, D. R., Melville, S. C., and Griffin, G. W. (1984) Interactions between oilseed rape and vegetable brassicas. Aspects of Applied Biology 6, 361-370.

8. Hortill, W. F. T. (1975) Epidemiology and control of ringspot in cabbages and cauliflowers. Proceedings of 30th New Zealand Weed and Pest Conference, 91-95

9. Humpherson-Jones, F. M. (1983b) The occurrence of Alternaria brassicicola, Alternaria brassicae and Leptosphaeria maculans in brassica seed crops in south east England between 1976 and 1980. Plant Pathology, 32, 33-39.

10. Humpherson-Jones, F. M. and Hocart, M. J. (1983) Alternaria disease of brassica seed crops. Report for the National Vegetable Research Station for 1982, p. 63.

11. Humpherson-Jones, F. M. and Maude, R. B. (1982) Studies on the epidemiology of Alternaria brassicicola in Brassica oleracea seed production crops. Annals of Applied Biology, 100, 61-71.

12. Humpherson-Jones, F. M. and Phelps, K. (1989) Climatic factors influencing spore production in Alternaria brassicae and Alternaria brassicicola. Annals of Applied Biology 114, 449-458.

13. Muskerji, K. G. (1975) Albugo candida. CMI Descriptions of Pathogenic Fungi and Bacteria No. 460

14. Purnell, T. J., Sivanesan, A. (1970). Erysiphe cruciferarum. CMI Description of Pathogenic Fungi and Bacteria No. 251

15. Punithalingam, E., Holliday, P. (1975) Mycosphaerella brassicicola. CMI Descriptions of Pathogenic Fungi and Bacteria No. 468

16. Staunton, W. P. (1967) Studies on light leaf spot. Irish Journal of Agricultural Research 6, 203-211

17. Sutton, B. C., Gibson, I. A. S. (1977) Cylindrosporium concentricum. CMI Description of Pathogenic Fungi and Bacteria No. 536

18. Wafford, J. D., Gladders, P., McPherson, G. M. (1986) The incidence and severity of Brussels sprout diseases and the influence of oilseed rape. Aspects of Applied Biology 12, 1-17.

## Appendix I

**Incidence of the commonest diseases of Brussels sprouts in England and Wales in 1983 expressed as % plants with affected leaves (L) and % buttons affected (B)**

| Area | Number of crops examined | Albugo candida | | Alternaria spp | | Erysiphe cruciferarum | | Mycosphaerella brassicicola | | Peronospora parasitica | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | B | L | B | L | B | L | B | L | B |
| Cleveland | 1 | 24 | 1.0 | 16 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| Lancashire | 5 | 52 | 19.3 | 18 | 0 | 0 | 0 | 45 | 18.8 | 0 | 0 |
| N. Humberside/ N. Yorks. | 23 | 0 | 0 | 40 | 2.5 | 20 | 0.7 | 0 | 0 | 41 | 1.7 |
| S. Humberside | 12 | 0 | 0 | 12 | 0 | 42 | 1.9 | 0 | 0 | 44 | 1.0 |
| Lincolnshire | 19 | 0.4 | 0 | 86 | 11.4 | 4 | 0 | 0 | 0 | 71 | 0 |
| Norfolk/Suffolk | 14 | 24 | 0 | 61 | 0.8 | 33 | 0 | 7 | 0 | 54 | 0.01 |
| Bedfordshire | 11 | 20 | 4.3 | 55 | 0.1 | 53 | 6.6 | 0 | 0 | 28 | 0 |
| Staffs/Hereford | 6 | 3 | 0 | 22 | 6.7 | 7 | 2.2 | 14 | 0 | 37 | 0.6 |
| Worcs/Warwick/ S. Hereford | 13 | 31 | 5.5 | 9 | 0.01 | 7 | 0 | 31 | 3.4 | 31 | 0 |
| Kent | 17 | 47 | 0.3 | 88 | 0.1 | 82 | 7.6 | 23 | 0 | 29 | 0.01 |
| Oxon/Hants/Berks | 7 | 17 | 2.6 | 25 | 6.3 | 11 | 0.1 | 42 | 0.9 | 62 | 0.05 |
| Gloucestershire | 5 | 84 | 1.4 | 2 | 0 | 29 | 2.2 | 6 | 0 | 1 | 0 |
| Devon/Cornwall | 4 | 41 | 3.8 | 0 | 0 | 0 | 0 | 70 | 0.8 | 20 | 0 |
| N. Wales | 2 | 90 | 21.0 | 30 | 0 | 12 | 0 | 64 | 4.0 | 4 | 0 |
| Mean % affected | (139 crops) | 21.2 | 2.2 | 45.0 | 2.7 | 28.5 | 1.6 | 13.9 | 1.1 | 39.8 | 0.4 |
| % Crops affected | | 36 | 23 | 81 | 49 | 52 | 20 | 29 | 12 | 61 | 12 |

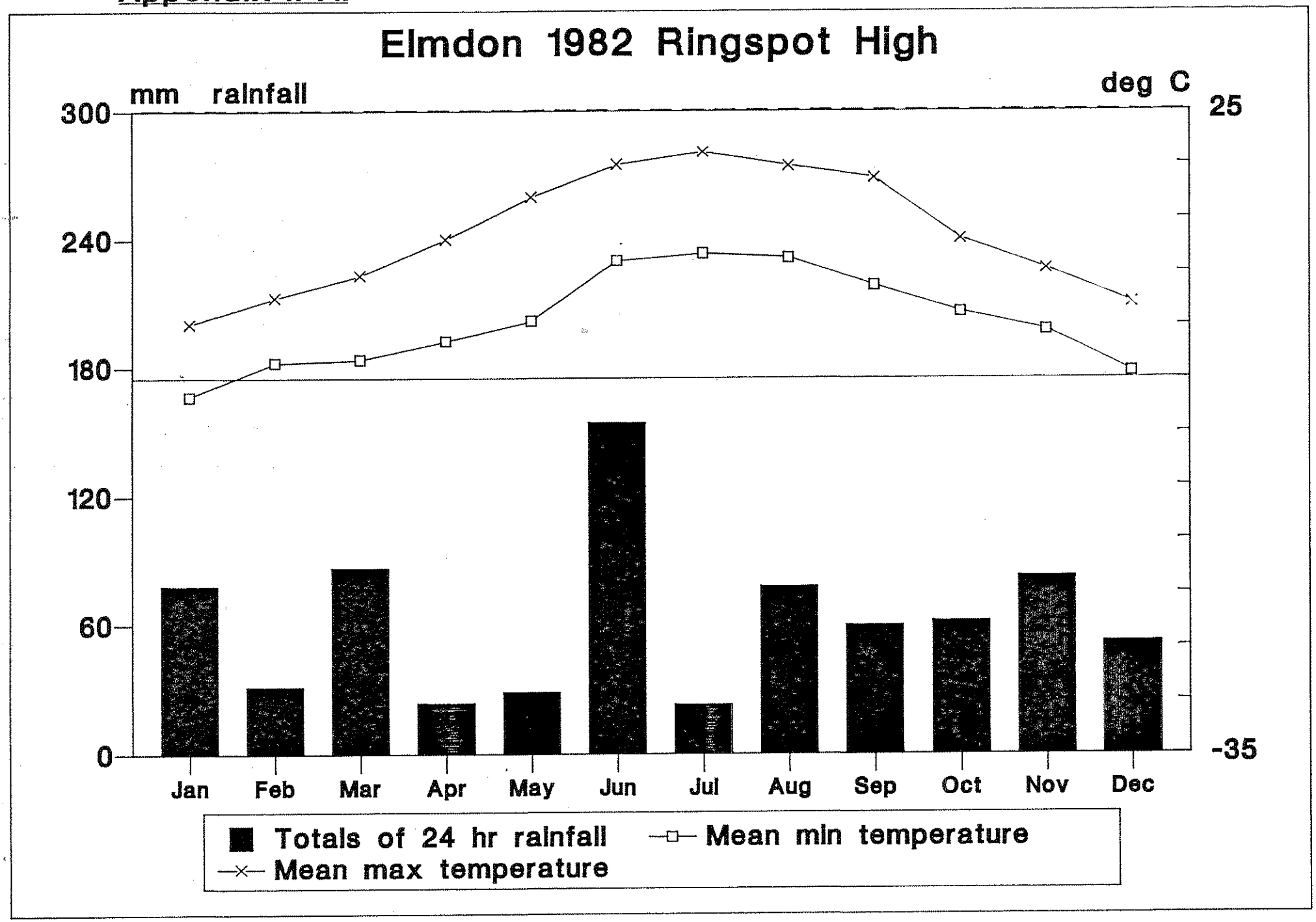
**Incidence of the commonest diseases of Brussels sprouts in England and Wales in 1984 expressed as % plants with affected leaves (L) and % buttons affected (B)**

| Area | Number of crops examined | Albugo candida | | Alternaria spp | | Erysiphe cruciferarum | | Mycosphaerella brassicicola | | Peronospora parasitica | | Pyrenopeziza brassicae | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | B | L | B | L | B | L | B | L | B | L | B |
| North East | 2 | 0.0 | 0.0 | 0.0 | 0.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 54.5 |
| North West | 27 | 34.3 | 2.6 | 21.4 | 2.0 | 1.7 | 0.0 | 31.3 | 1.8 | 10.8 | 0.3 | 27.6 | 6.2 |
| Yorks & Humbs | 22 | 0.0 | 0.0 | 23.0 | 0.4 | 53.0 | 0.2 | 0.0 | 0.0 | 37.0 | 0.04 | 37.0 | 10.6 |
| Lincolnshire | 15 | 1.0 | 0.03 | 7.0 | 3.1 | 24.0 | 4.6 | 0.0 | 0.0 | 5.0 | 0.04 | 11.0 | 2.6 |
| E. Anglia | 16 | 10.0 | 0.4 | 27.0 | 0.3 | 55.0 | 0.3 | 18.0 | 0.07 | 22.0 | 0.03 | 38.0 | 7.8 |
| Bedfordshire | 11 | 1.0 | 0.0 | 16.0 | 0.0 | 59.0 | 0.02 | 0.0 | 0.0 | 15.0 | 0.03 | 2.0 | 0.5 |
| Midlands | 16 | 0.6 | 0.1 | 21.3 | 0.03 | 7.6 | 0.02 | 18.7 | 0.04 | 51.7 | 0.2 | 0.3 | 0.02 |
| Kent | 10 | 7.0 | 1.0 | 18.0 | 9.1 | 61.0 | 12.4 | 0.0 | 0.0 | 16.0 | 0.1 | 8.0 | 0.1 |
| South | 8 | 19.0 | 3.7 | 12.0 | 0.04 | 51.0 | 1.2 | 36.0 | 1.5 | 56.0 | 0.3 | 0.0 | 0.0 |
| South West | 10 | 2.4 | 0.2 | 3.6 | 0.0 | 45.0 | 1.7 | 46.6 | 4.0 | 0.6 | 0.0 | 0.0 | 0.0 |
| Mean | (137 crops) | 10.0 | 0.86 | 17.9 | 1.49 | 35.0 | 1.68 | 16.0 | 0.75 | 22.8 | 0.13 | 17.7 | 4.95 |
| % Crops affected | | 22.6 | 19.7 | 50.4 | 29.9 | 55.5 | 21.3 | 32.8 | 17.5 | 46.0 | 9.5 | 40.9 | 41.6 |

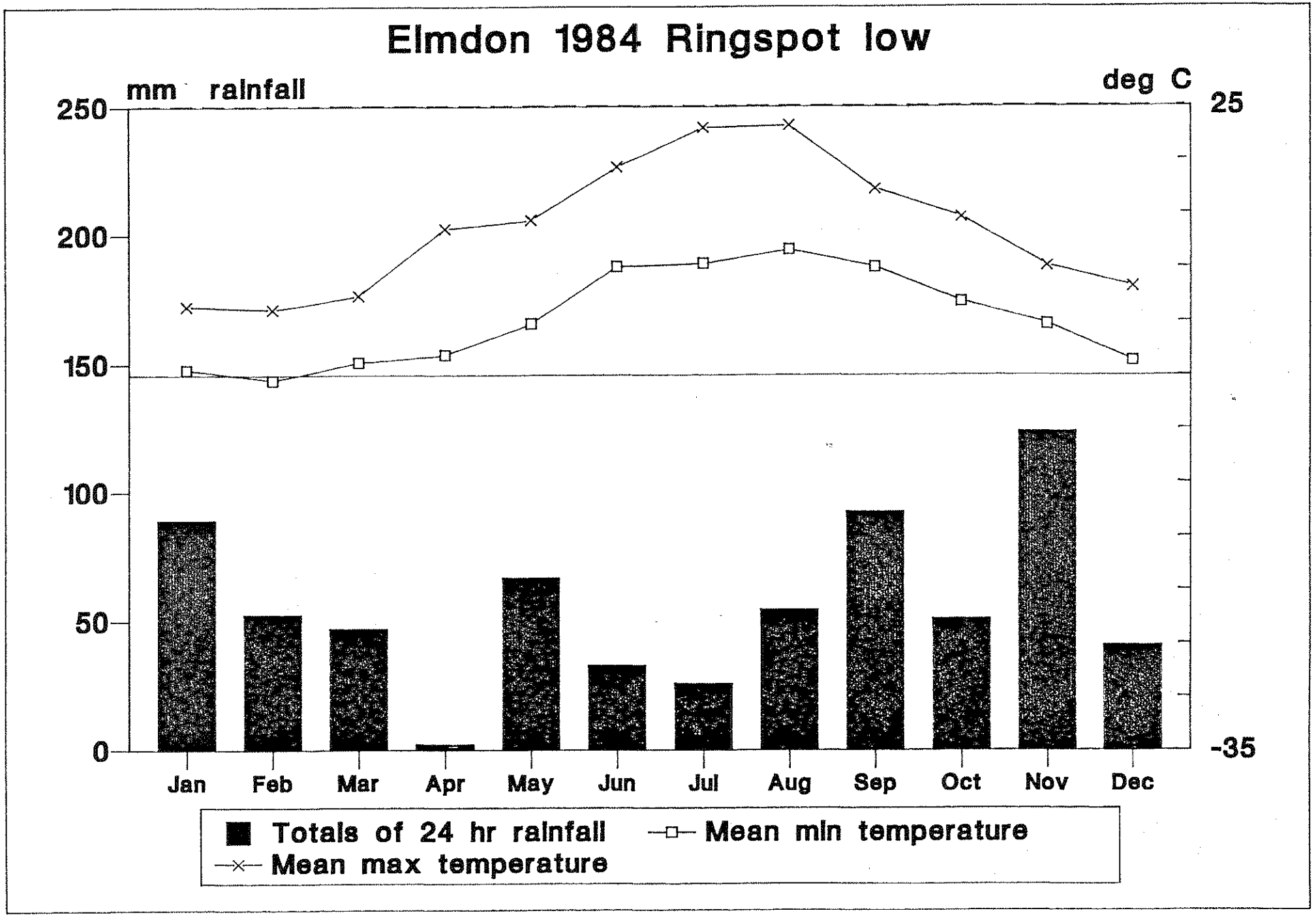
**Incidence of the commonest diseases of Brussels sprouts in England and Wales in 1985 expressed as % plants with affected leaves (L) and % buttons affected (B)**

| Area | Number of crops examined | Albugo candida | | Alternaria spp | | Erysiphe cruciferarum | | Mycosphaerella brassicicola | | Peronospora parasitica | | Pyrenopeziza brassicae | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | B | L | B | L | B | L | B | L | B | L | B |
| North East | 2 | 6.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 52.0 | 2.0 | 0.0 | 0.0 | 26.0 | 5.0 |
| North West | 13 | 24.9 | 0.82 | 3.7 | 0.02 | 0.0 | 0.0 | 29.7 | 4.82 | 0.6 | 0.0 | 48.9 | 2.18 |
| Yorks & Humbs | 48 | 0.2 | 0.01 | 2.5 | 0.19 | 44.9 | 2.13 | 0.2 | 0.03 | 13.1 | 0.02 | 12.5 | 3.1 |
| Lincolnshire | 22 | 1.1 | 0.29 | 9.5 | 0.09 | 2.3 | 0.18 | 4.4 | 0.09 | 14.86 | 1.05 | 14.31 | 3.43 |
| E. Anglia | 14 | 3.1 | 0.02 | 20.0 | 0.31 | 26.6 | 0.06 | 11.4 | 0.14 | 7.1 | 0.0 | 6.9 | 0.18 |
| Bedfordshire | 11 | 1.1 | 0.03 | 25.4 | 0.07 | 0.0 | 0.0 | 0.0 | 0.0 | 18.2 | 0.0 | 31.9 | 0.20 |
| Midlands | 23 | 15.3 | 1.68 | 8.7 | 0.66 | 31.3 | 0.03 | 1.2 | 0.0 | 17.0 | 0.0 | 13.9 | 6.56 |
| Kent | 13 | 8.6 | 1.56 | 15.0 | 0.01 | 24.6 | 0.71 | 2.46 | 0.0 | 3.4 | 0.0 | 18.6 | 4.4 |
| South | 13 | 12.9 | 1.70 | 16.2 | 0.04 | 5.8 | 4.8 | 31.8 | 5.84 | 8.3 | 0.09 | 22.0 | 9.77 |
| South West | 7 | 21.9 | 5.29 | 0.6 | 0.0 | 7.1 | 0.71 | 89.3 | 21.36 | 0.0 | 0.0 | 10.9 | 7.22 |
| Mean | (166 crops) | 8.0 | 0.8 | 9.0 | 0.2 | 23.0 | 0.9 | 11.0 | 1.8 | 11.7 | 0.2 | 18.0 | 3.9 |
| % Crops affected | | 21.1 | 15.7 | 34.3 | 18.1 | 31.9 | 18.7 | 22.3 | 10.8 | 32.5 | 6.0 | 50.6 | 48.8 |

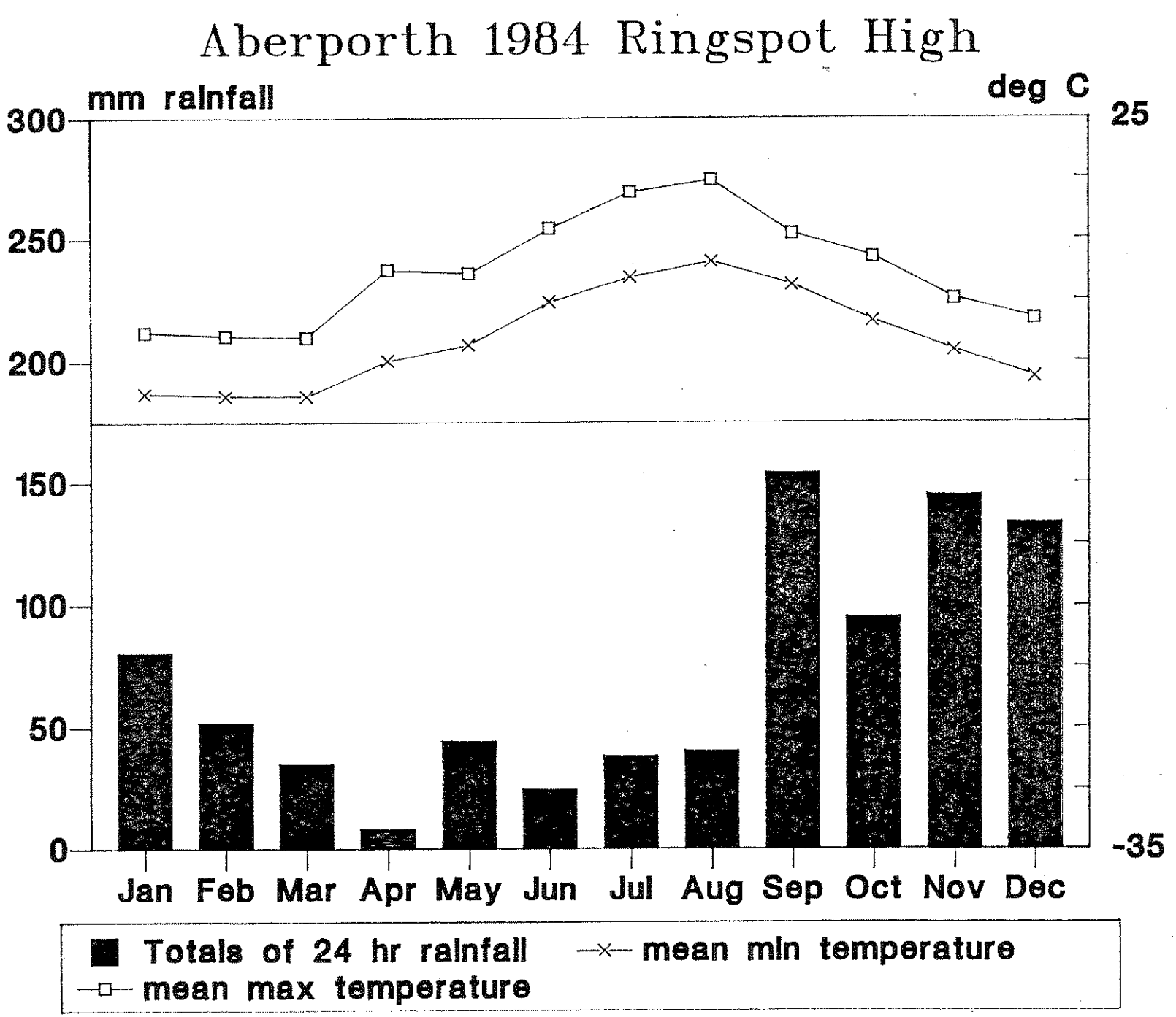
Appendix II A.



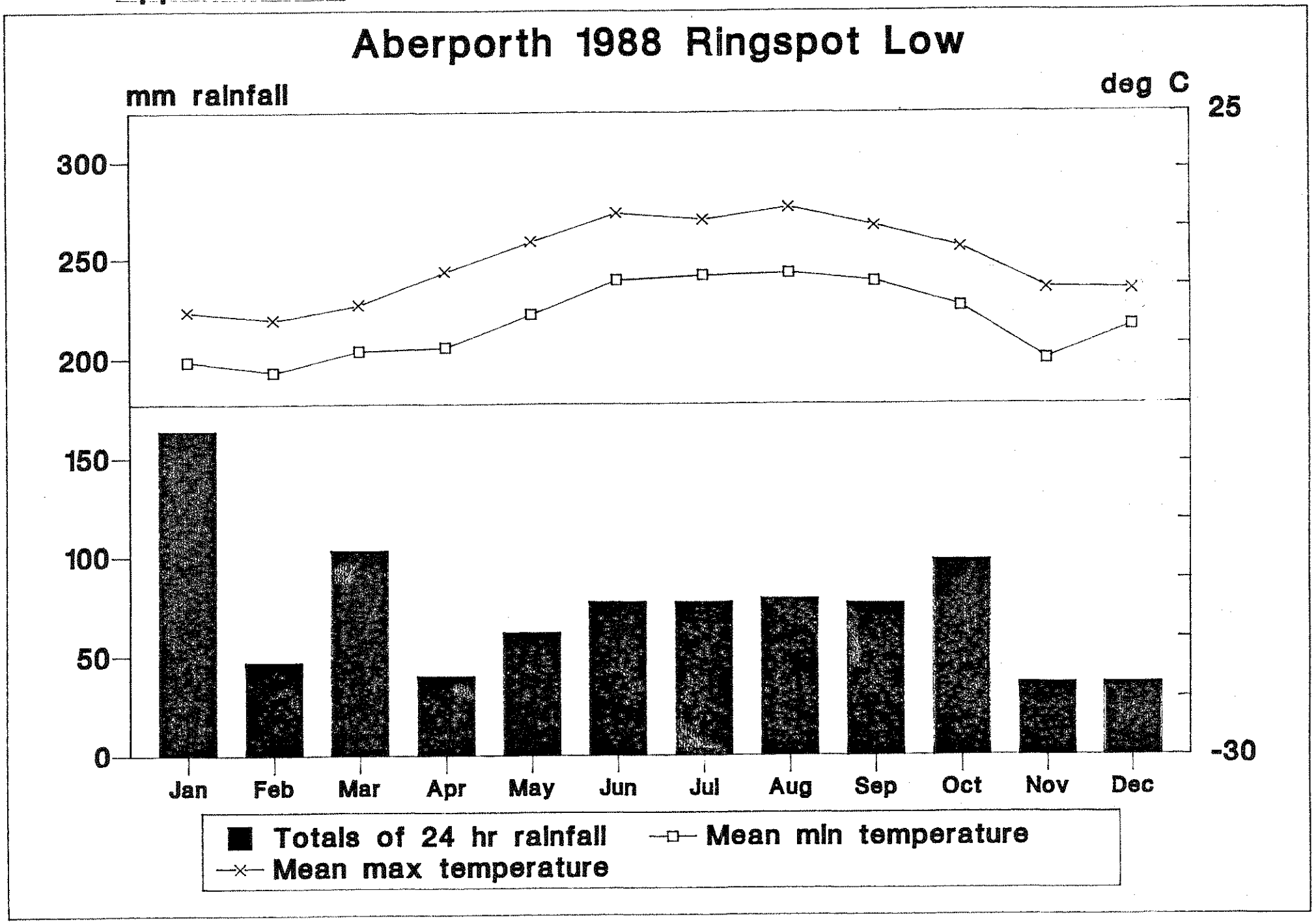
Appendix II B.



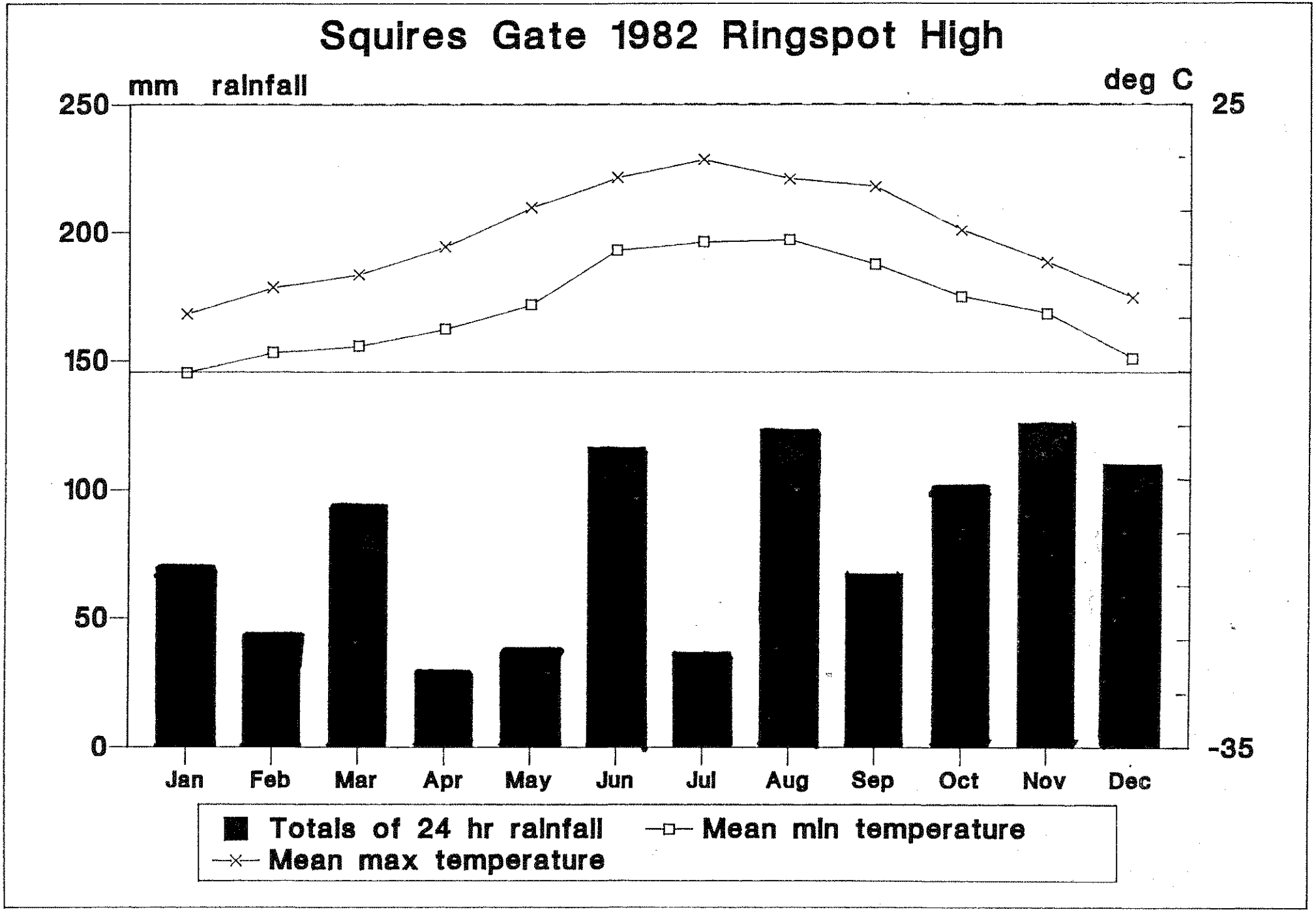
## Appendix II C.



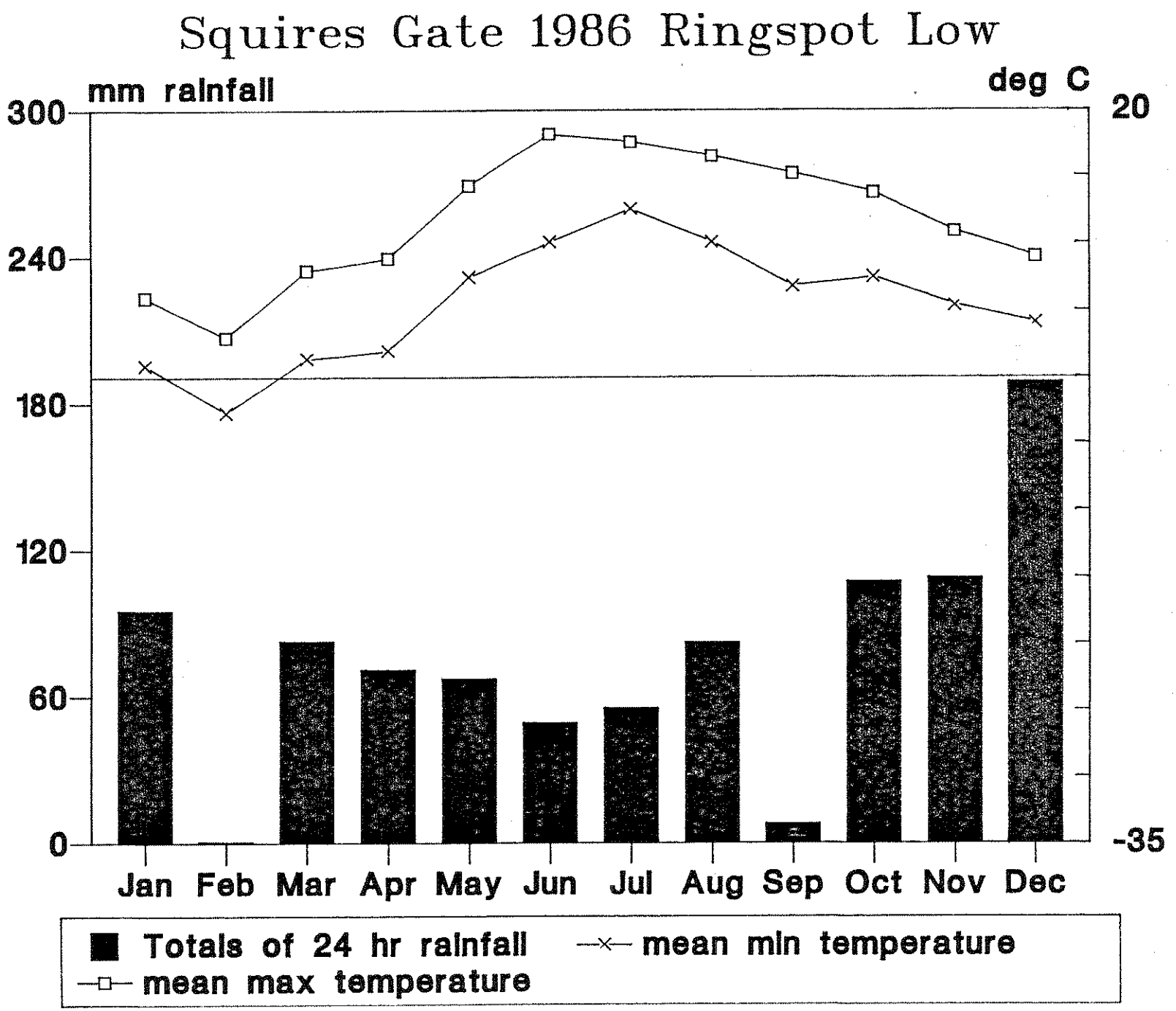
Appendix II D.



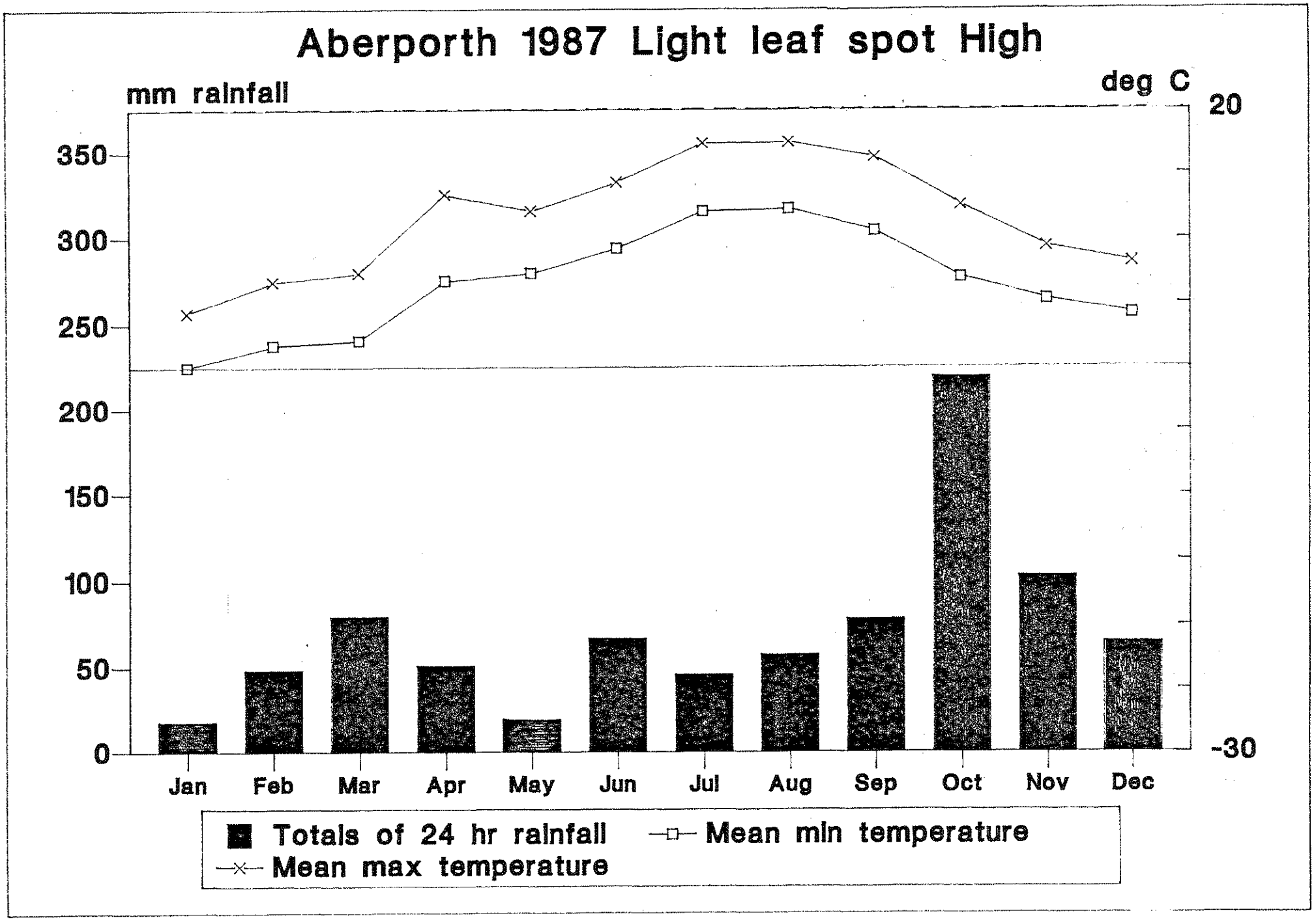
Appendix II E.



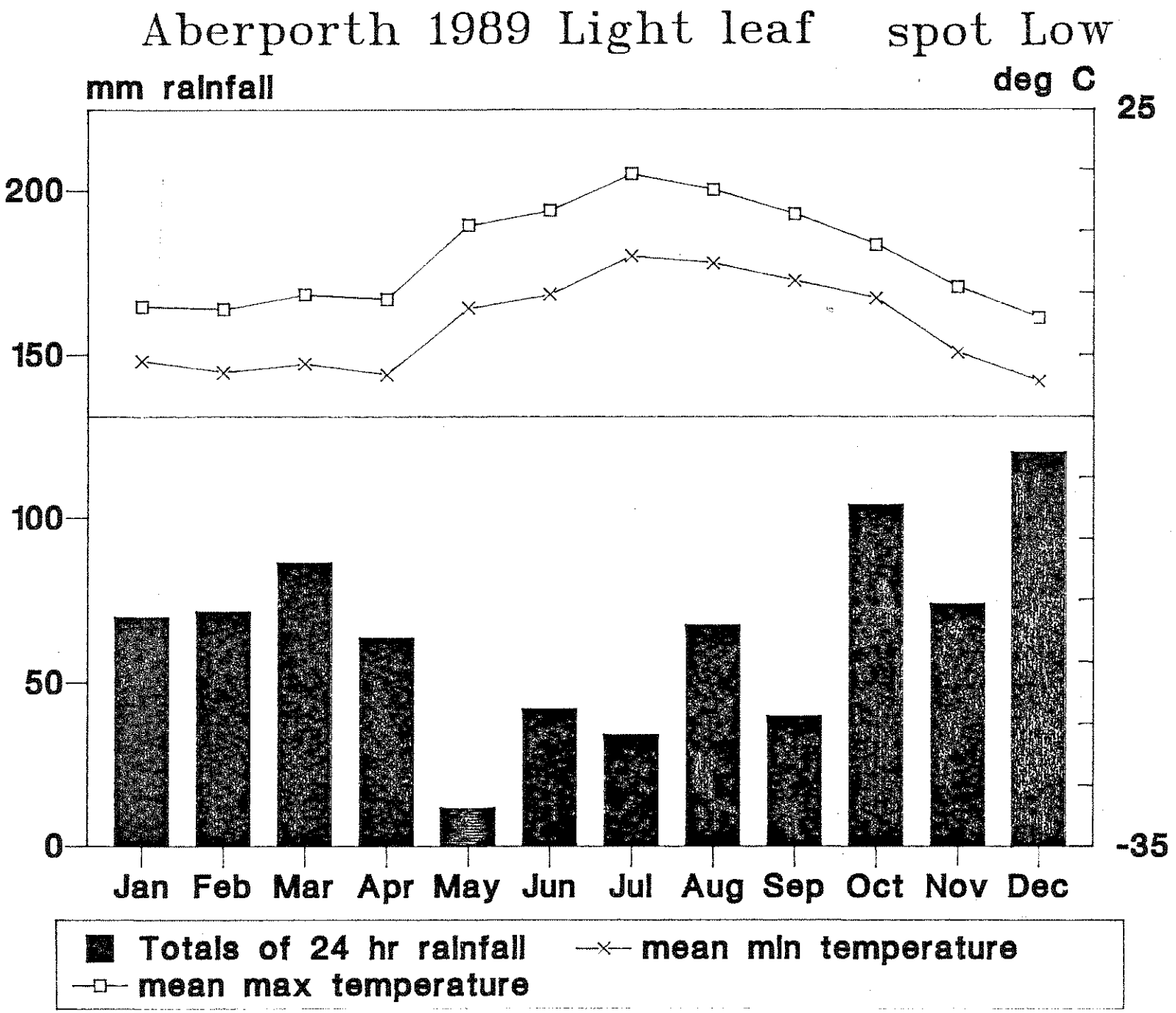
## Appendix II F.



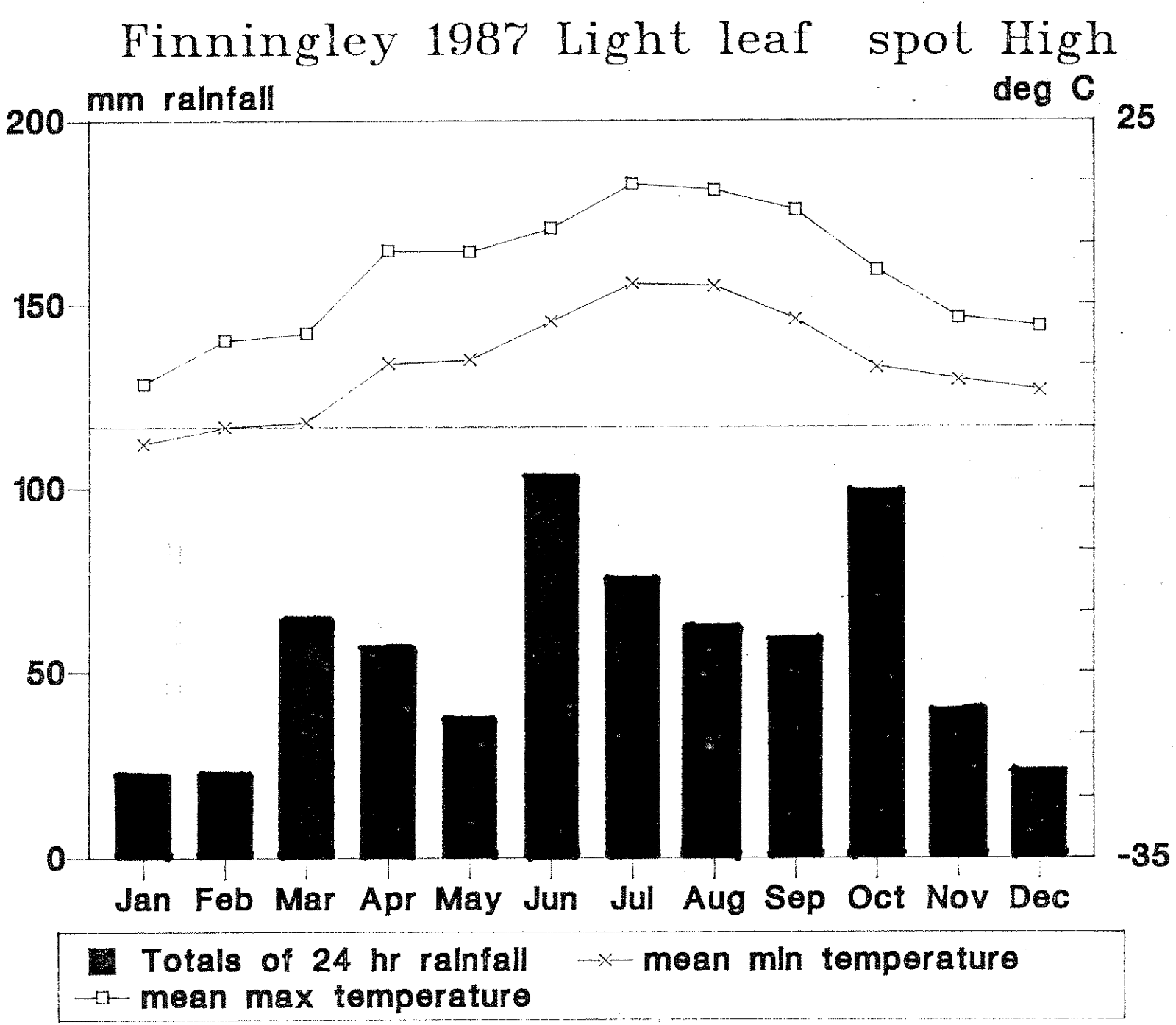
Appendix III A.



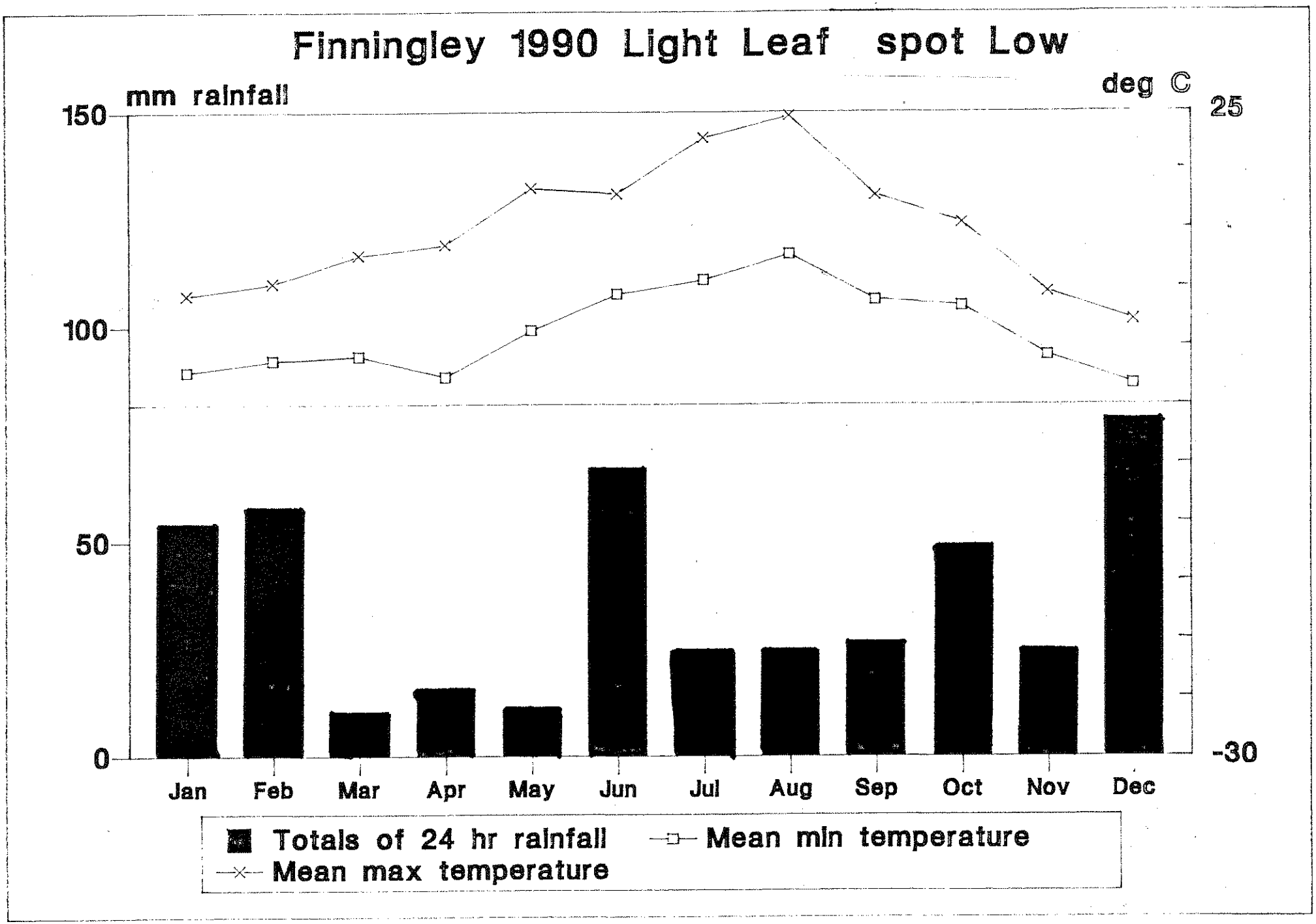
**Appendix III B.**



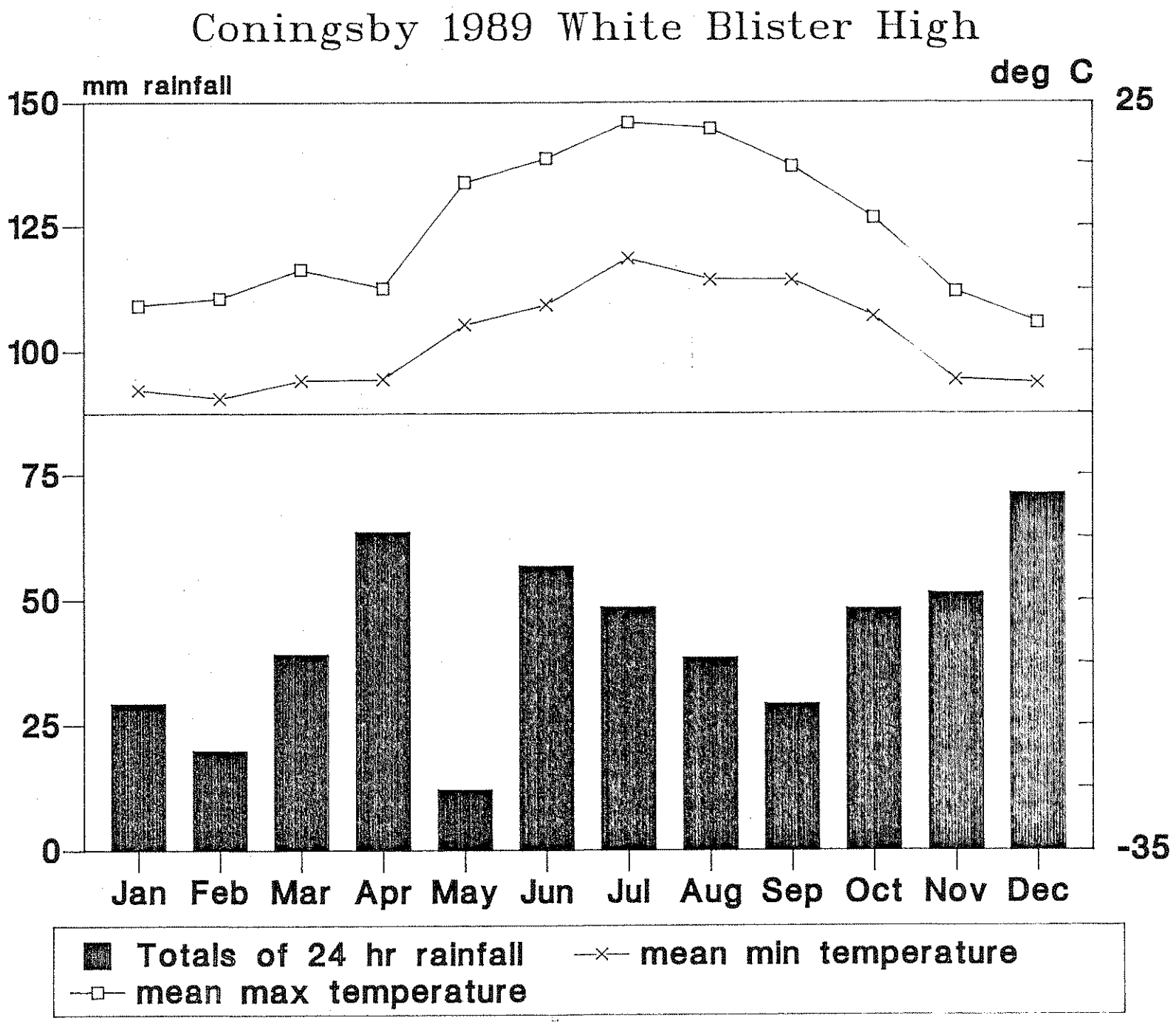
**Appendix III C.**



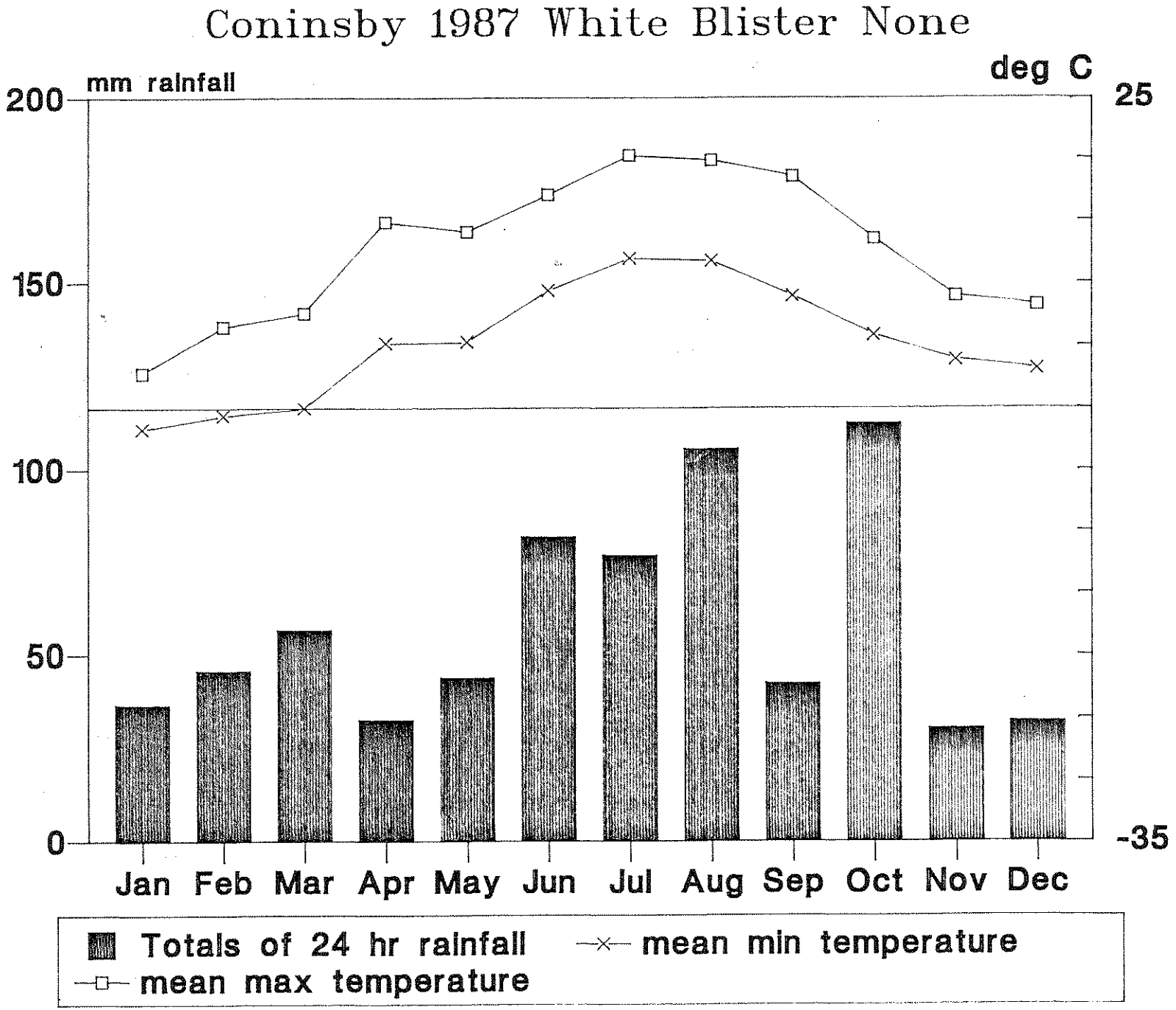
Appendix III D.



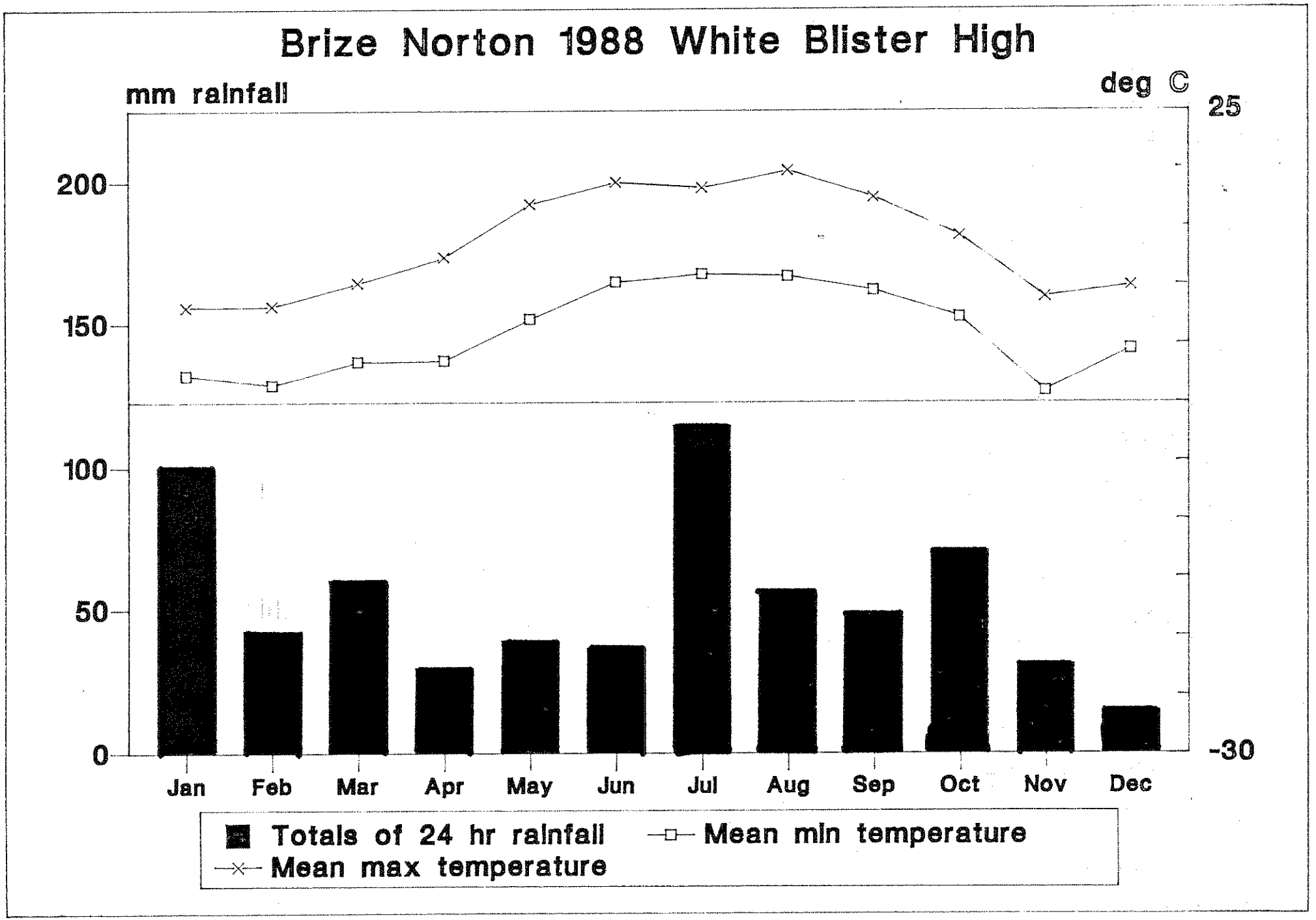
## Appendix IV A.



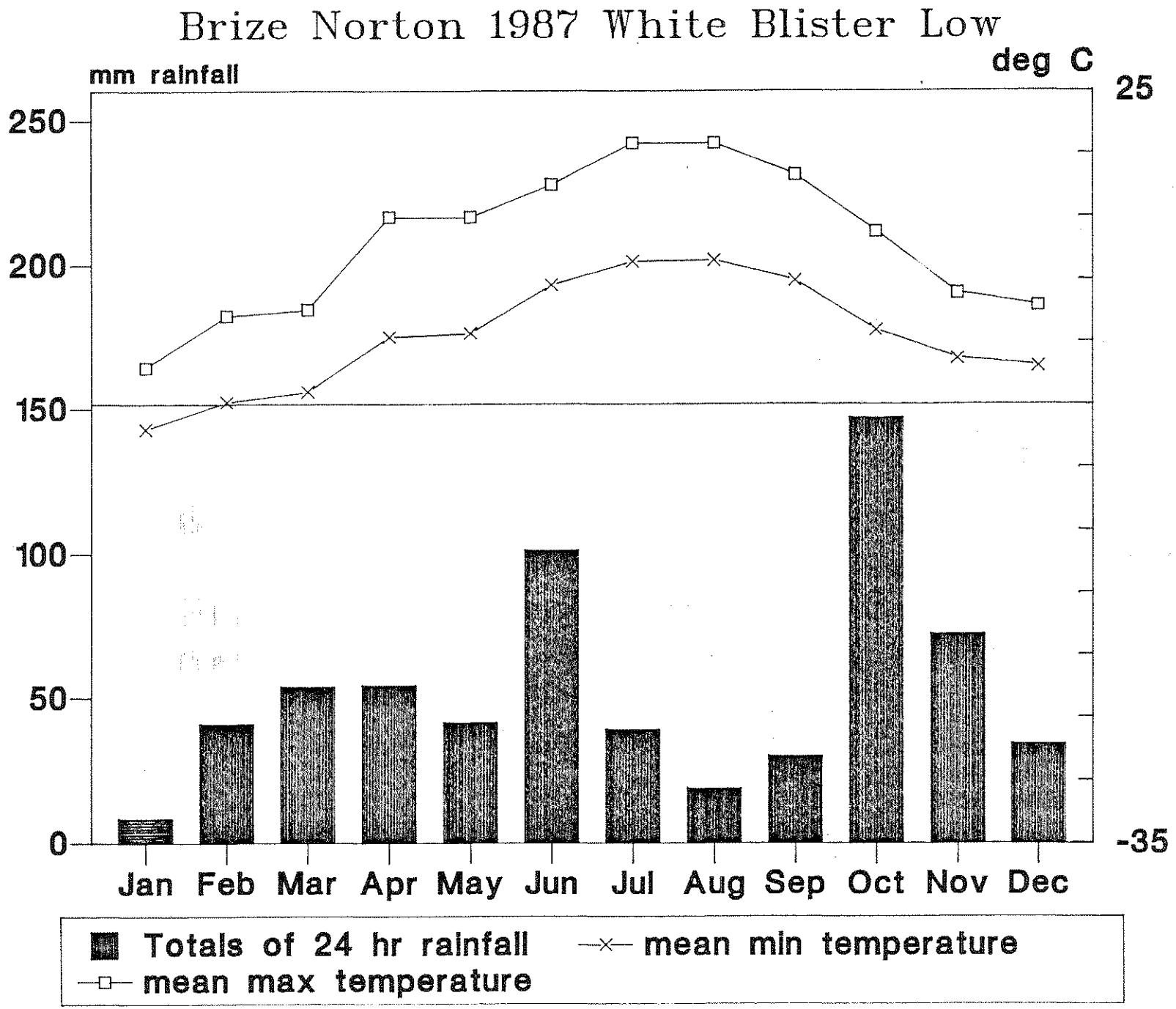
## Appendix IV B.



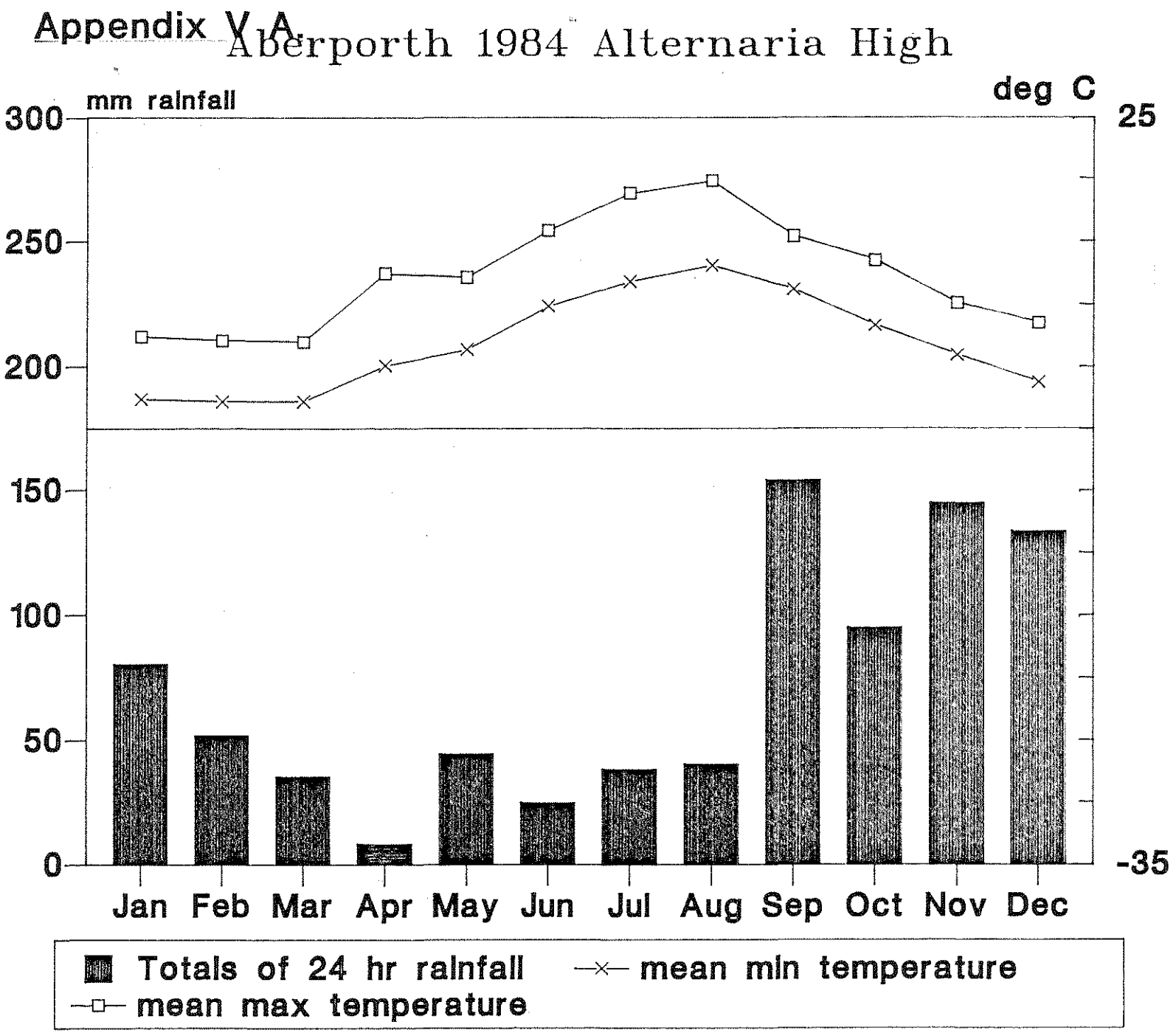
Appendix IV C.



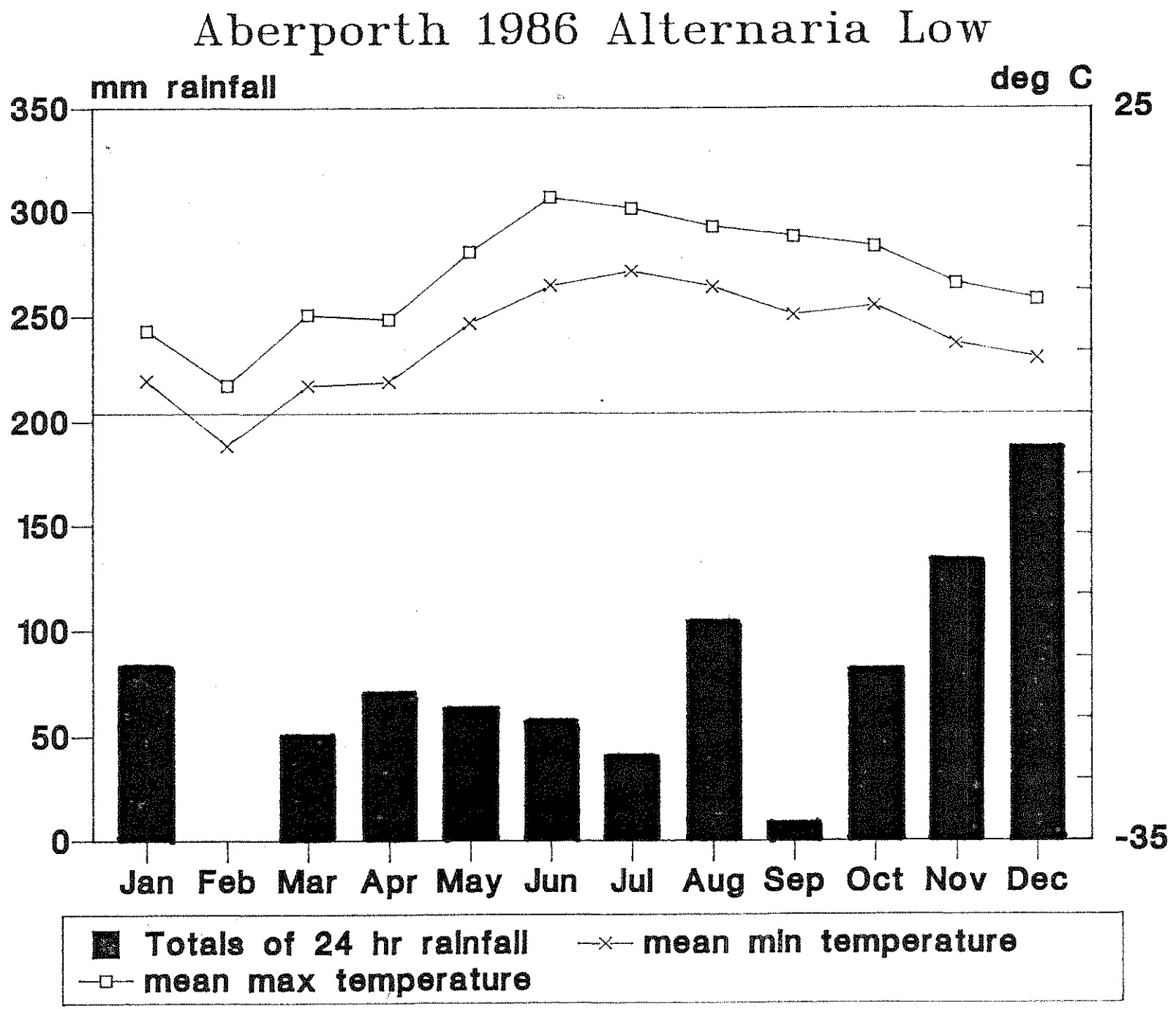
Appendix IV D.



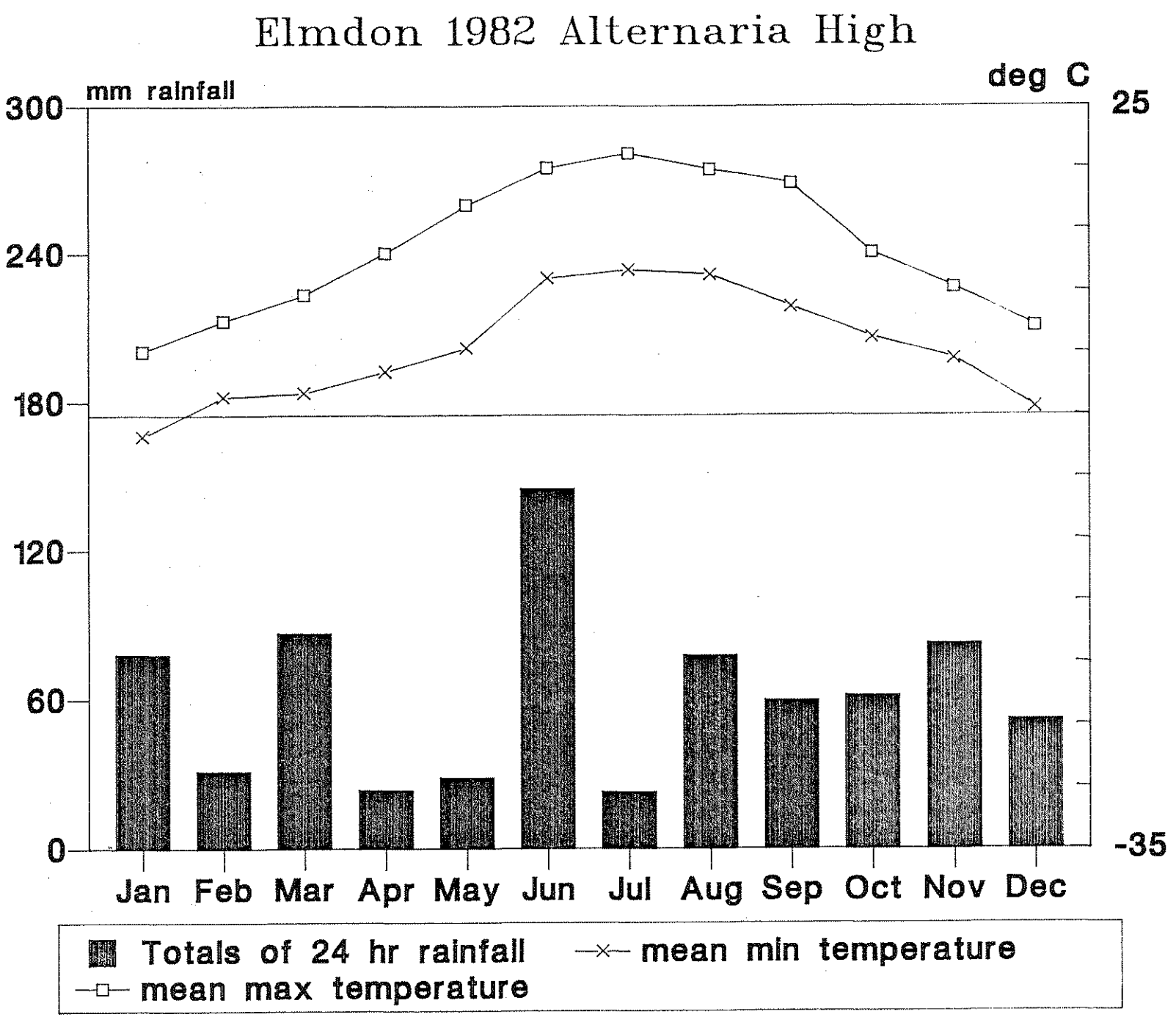
Appendix V A


Aberporth 1984 Alternaria High
mm rainfall
deg C
300
250
200
150
100
50
0
25
-35
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Totals of 24 hr rainfall
mean min temperature
mean max temperature

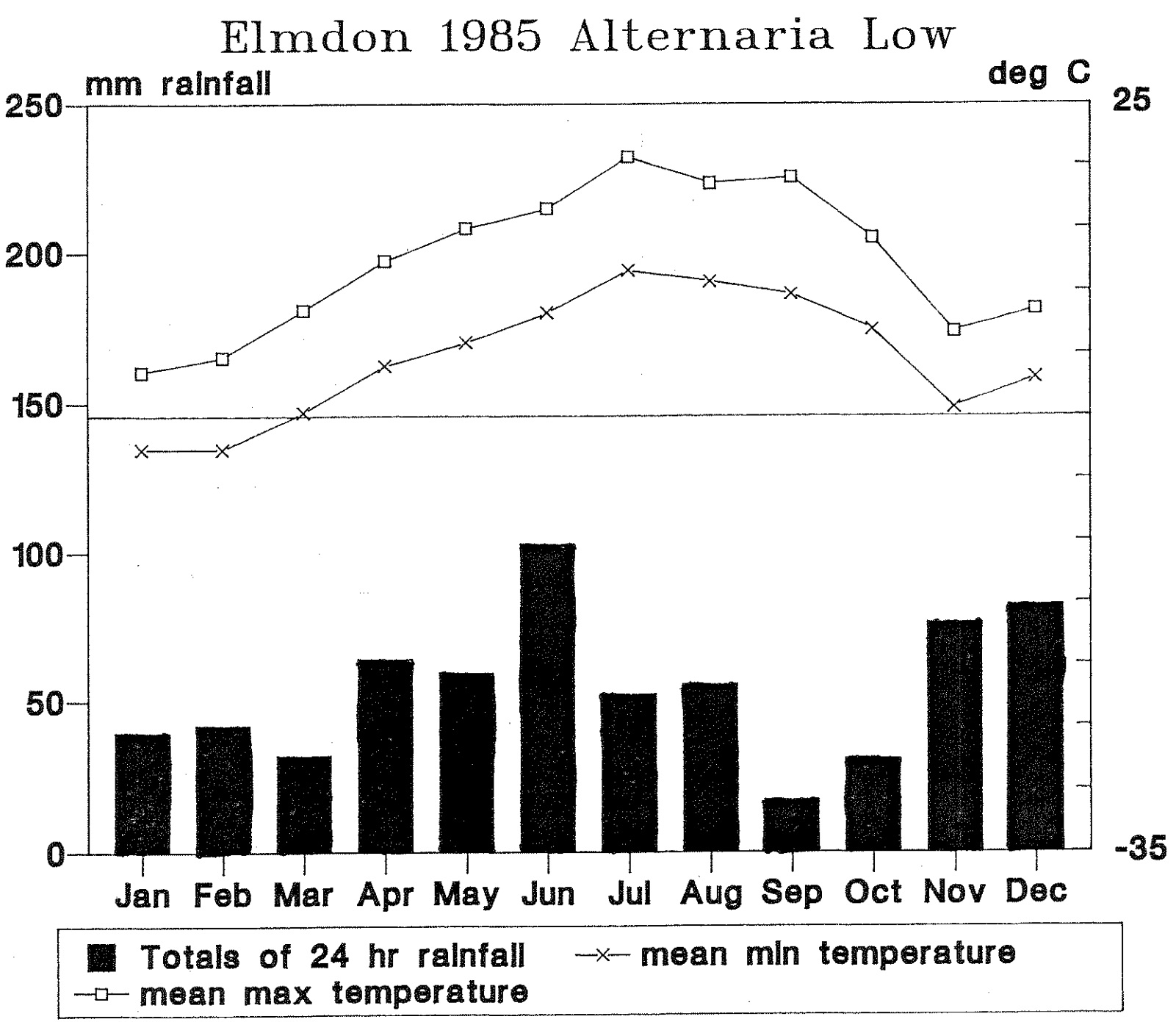
Appendix V B.


Aberporth 1986 Alternaria Low
mm rainfall
deg C
350
300
250
200
150
100
50
0
25
-35
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Totals of 24 hr rainfall
mean min temperature
mean max temperature

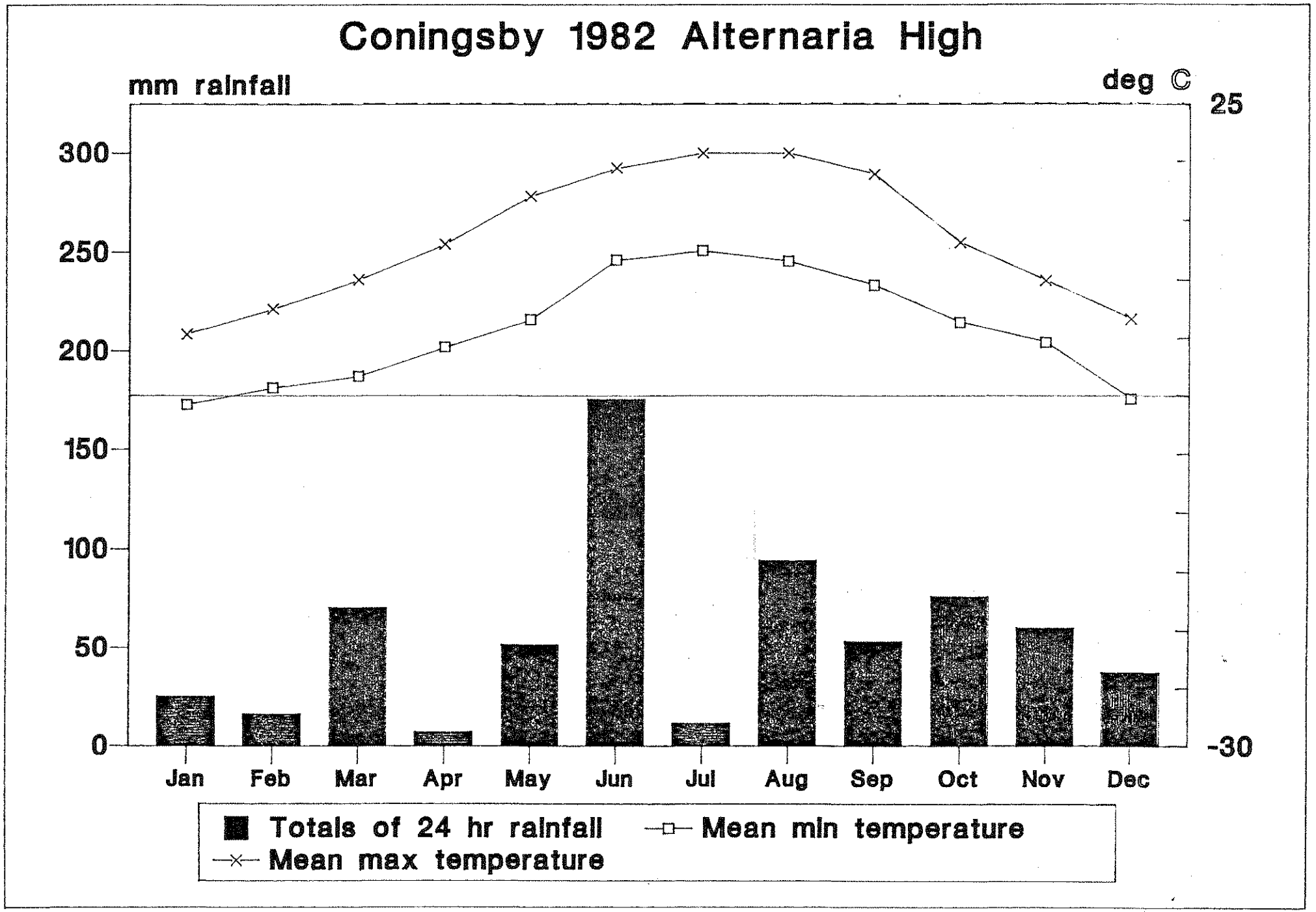
## Appendix V C.


Elmdon 1982 Alternaria High
mm rainfall
deg C
300
240
180
120
60
0
25
-35
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Totals of 24 hr rainfall
mean min temperature
mean max temperature

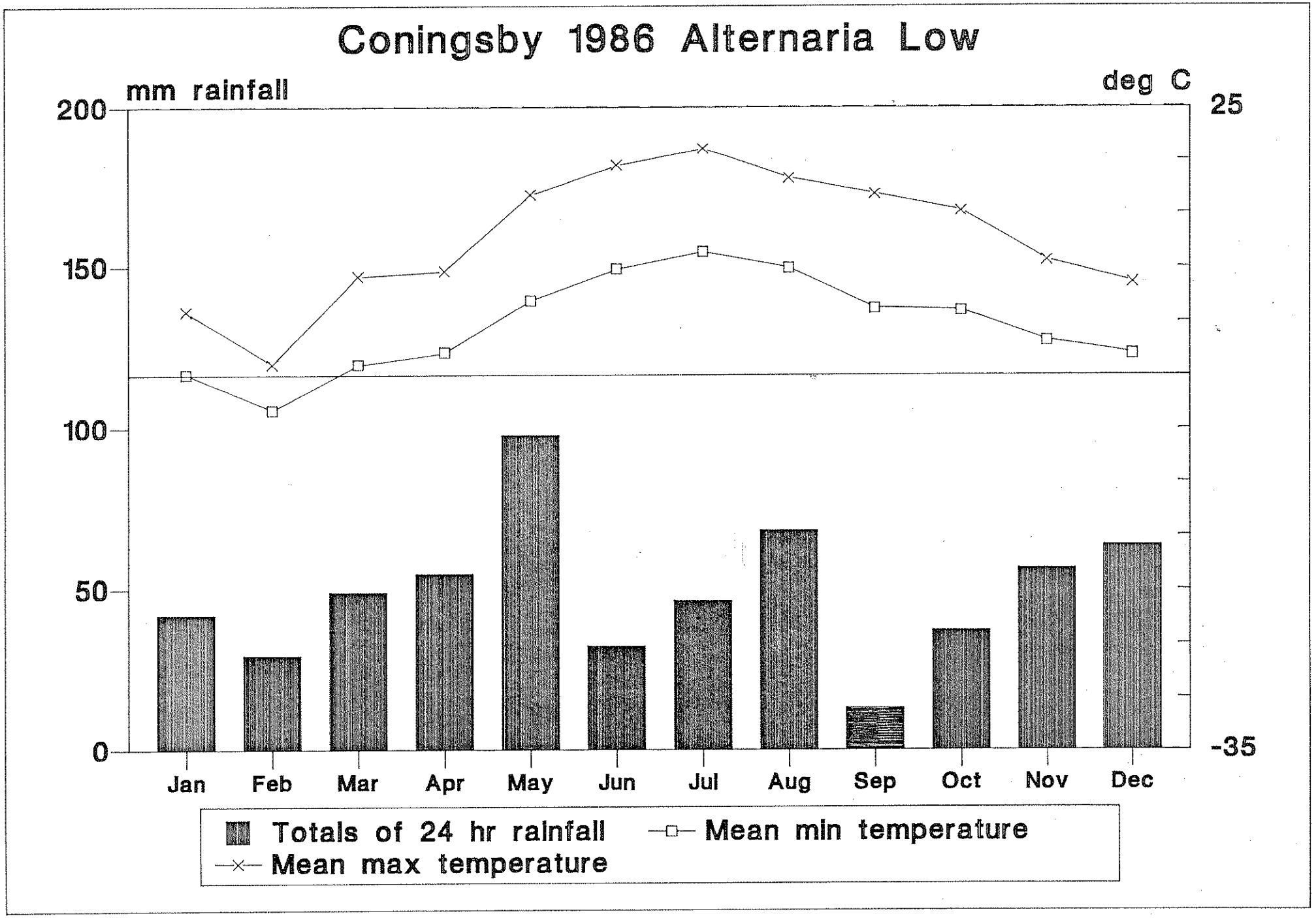
Appendix V D.


Elmdon 1985 Alternaria Low
mm rainfall
deg C
250
200
150
100
50
0
25
-35
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Totals of 24 hr rainfall
mean min temperature
mean max temperature

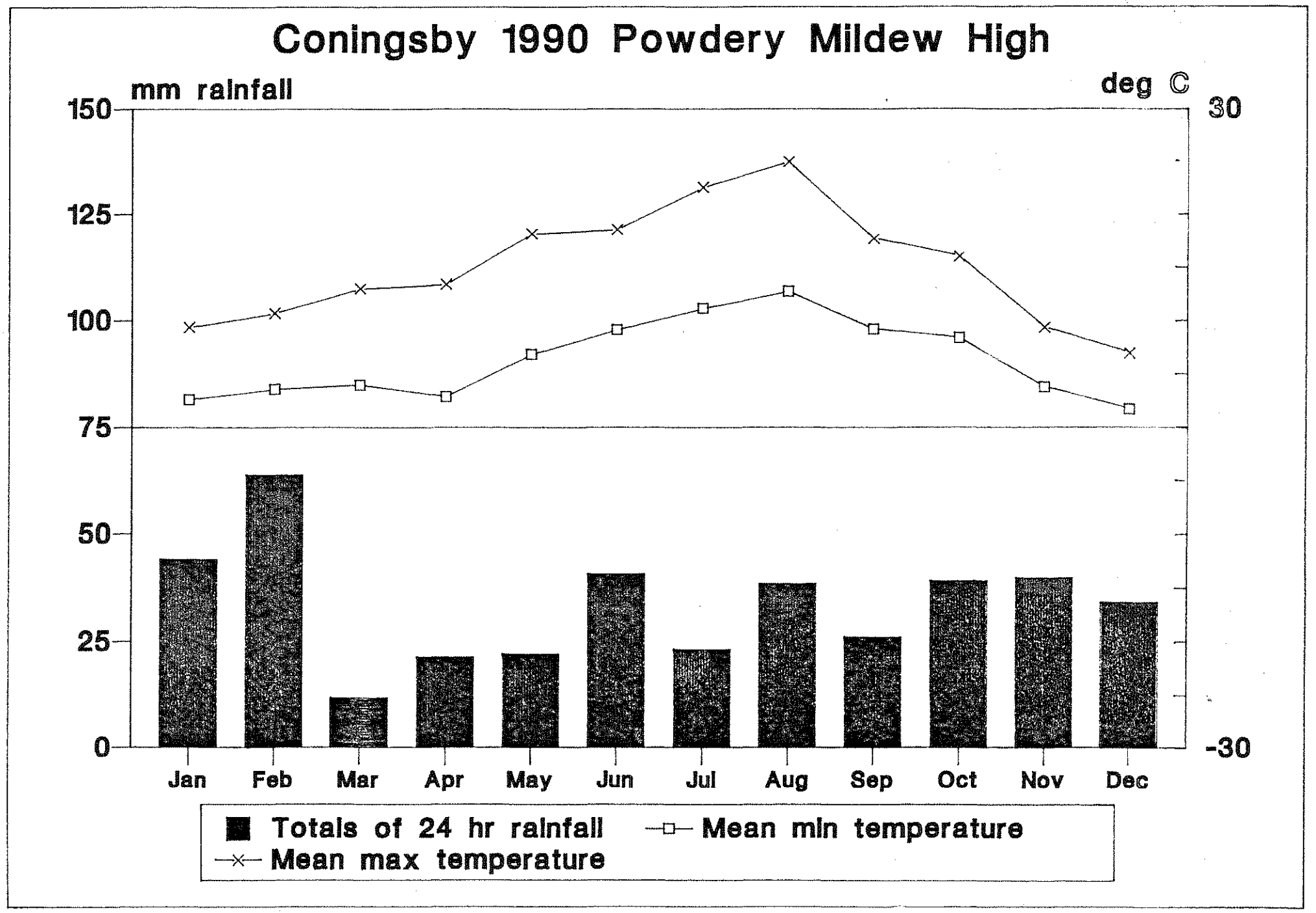
Appendix V E.


Coningsby 1982 Alternaria High
mm rainfall
deg C
300
250
200
150
100
50
0
25
-30
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Totals of 24 hr rainfall
Mean min temperature
Mean max temperature

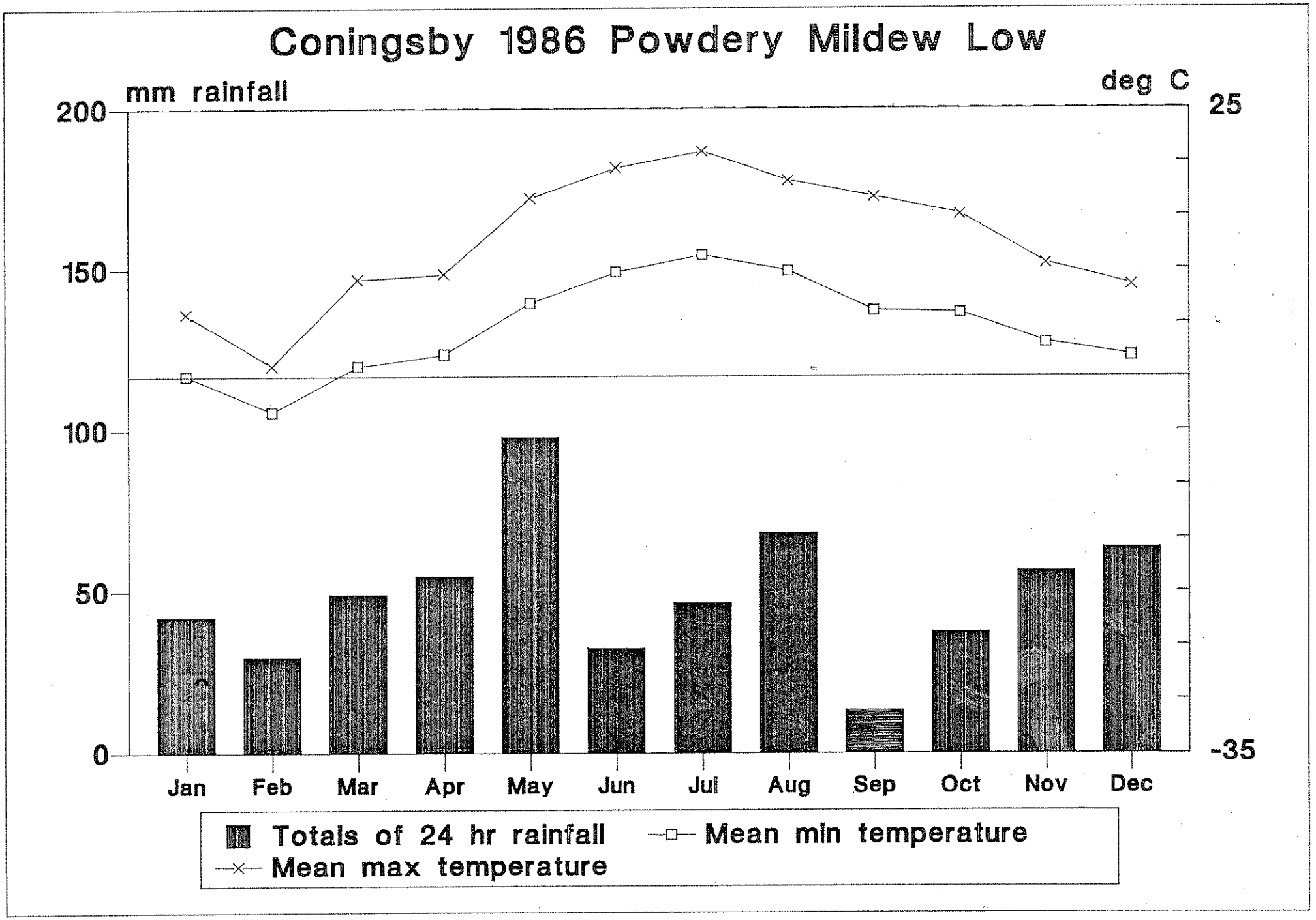
Appendix V F.


Coningsby 1986 Alternaria Low
mm rainfall
deg C
200
150
100
50
0
25
-35
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Totals of 24 hr rainfall
Mean min temperature
Mean max temperature

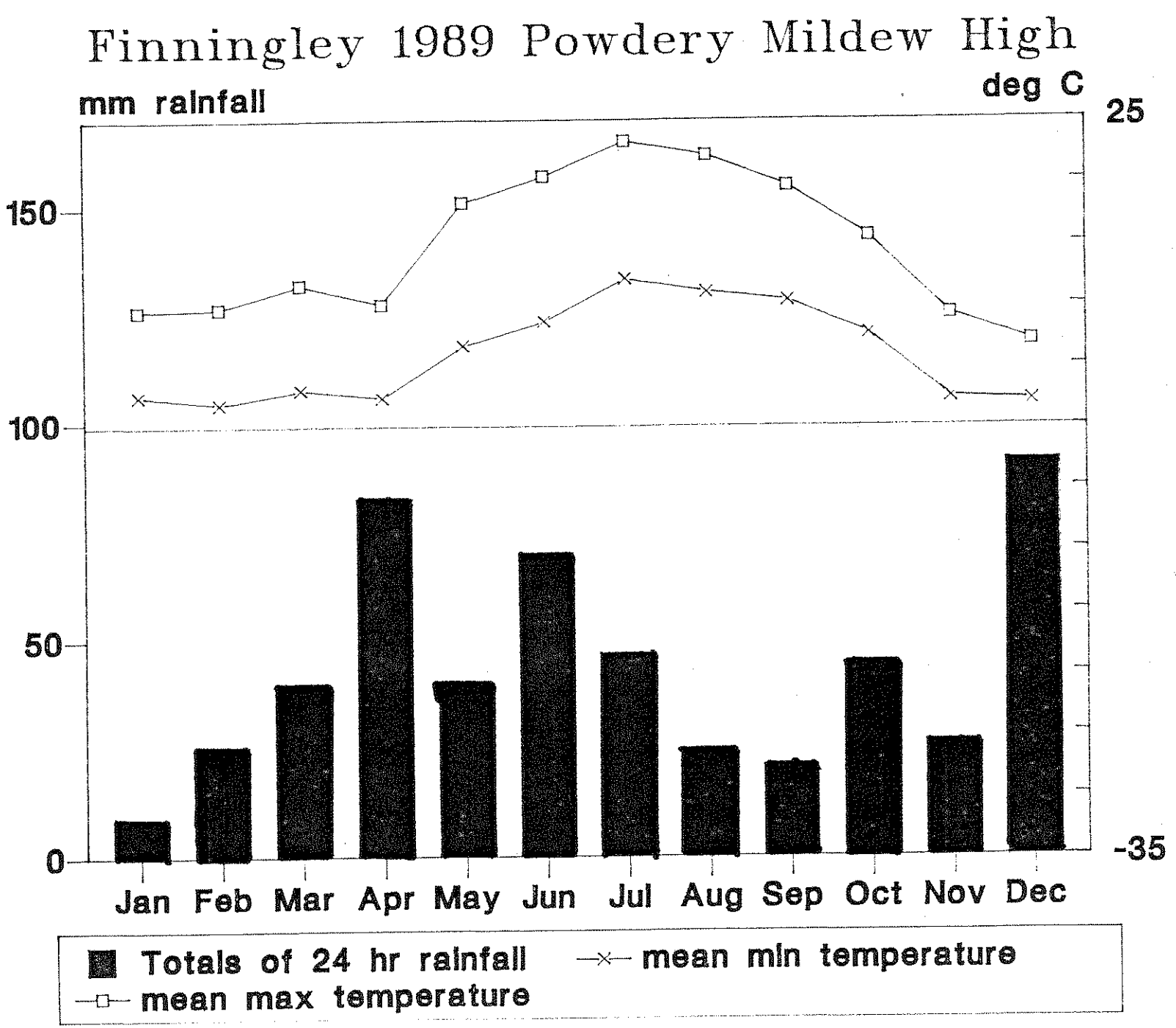
Appendix VI A.



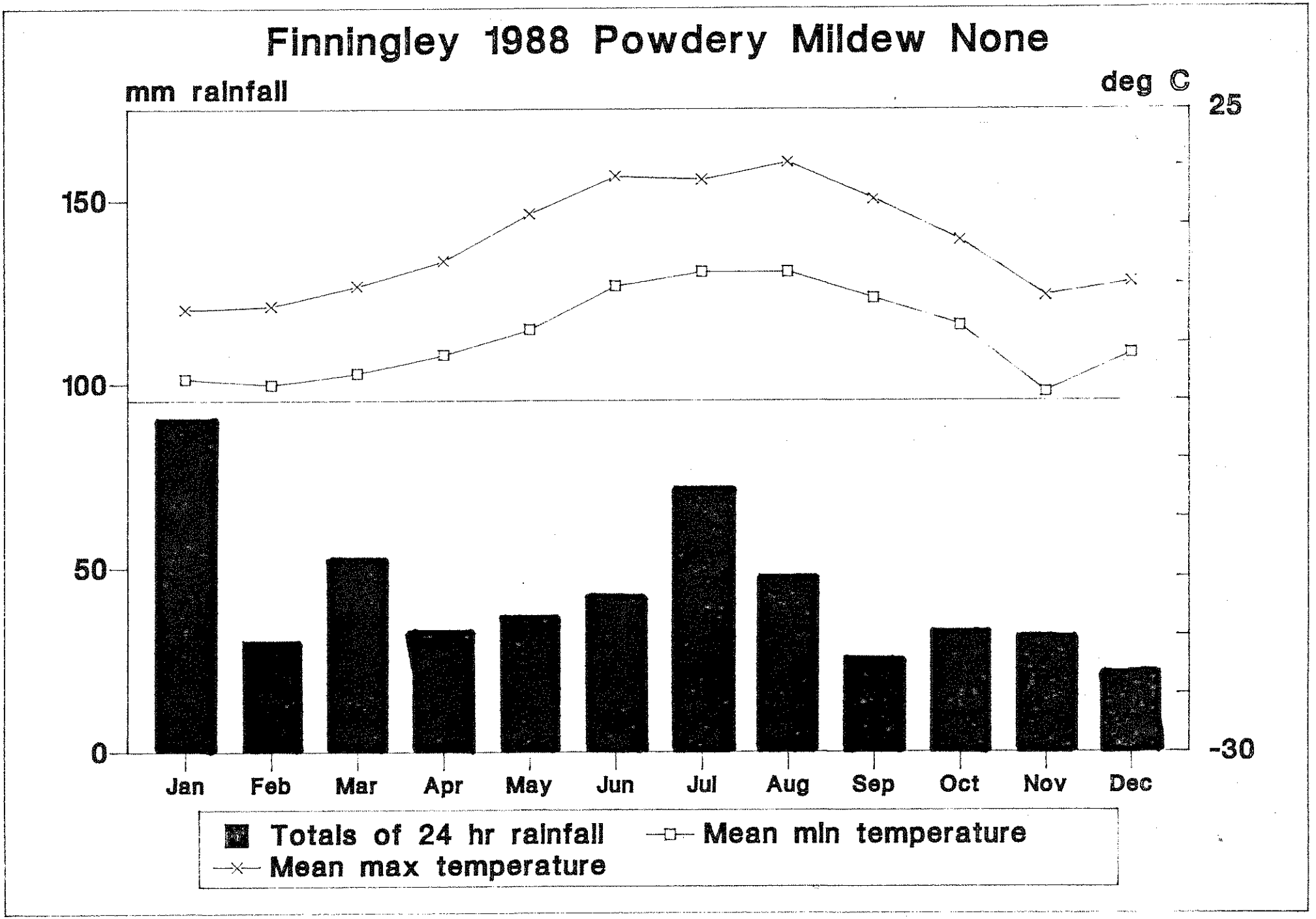
Appendix VI B.



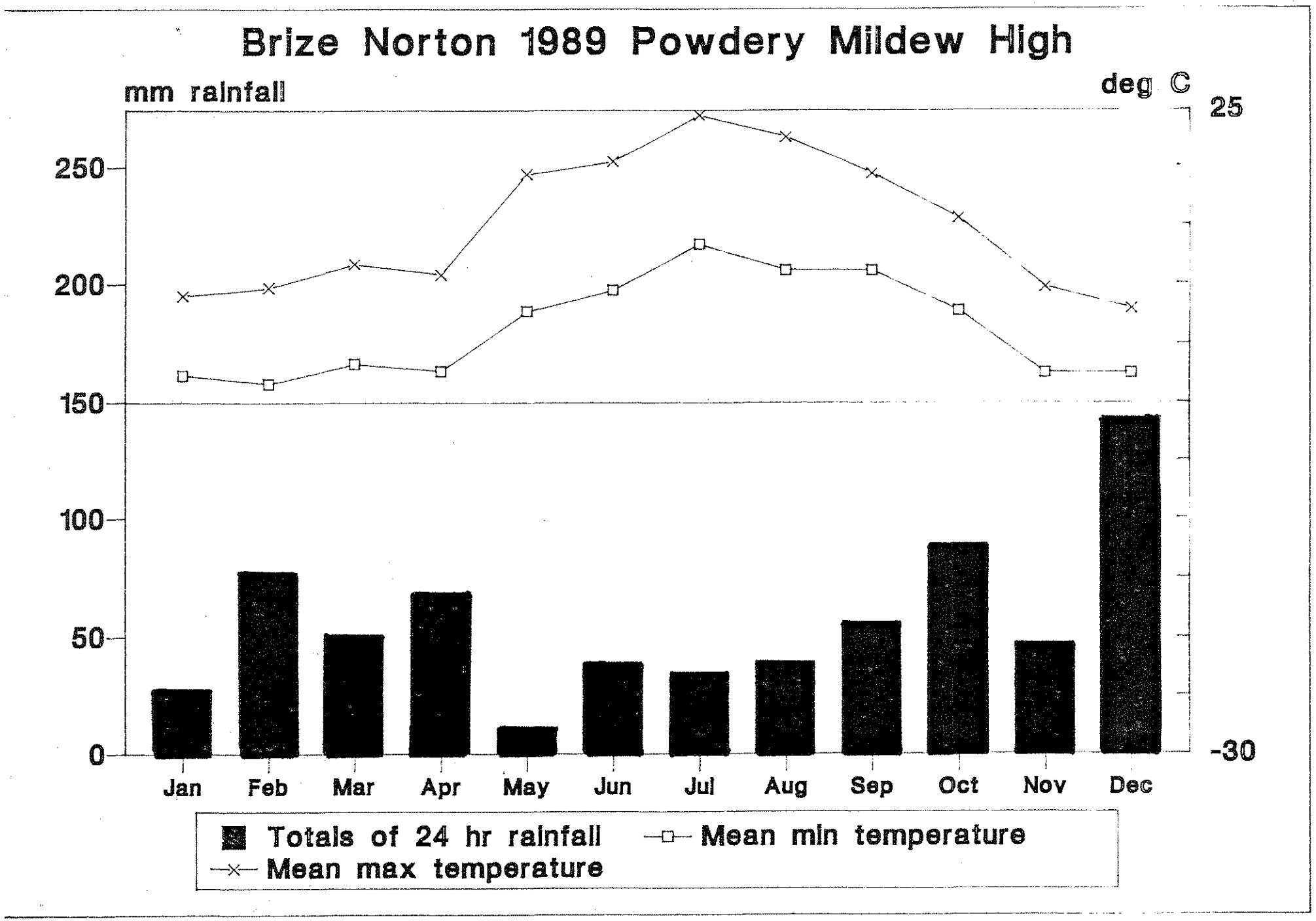
Appendix VI C.



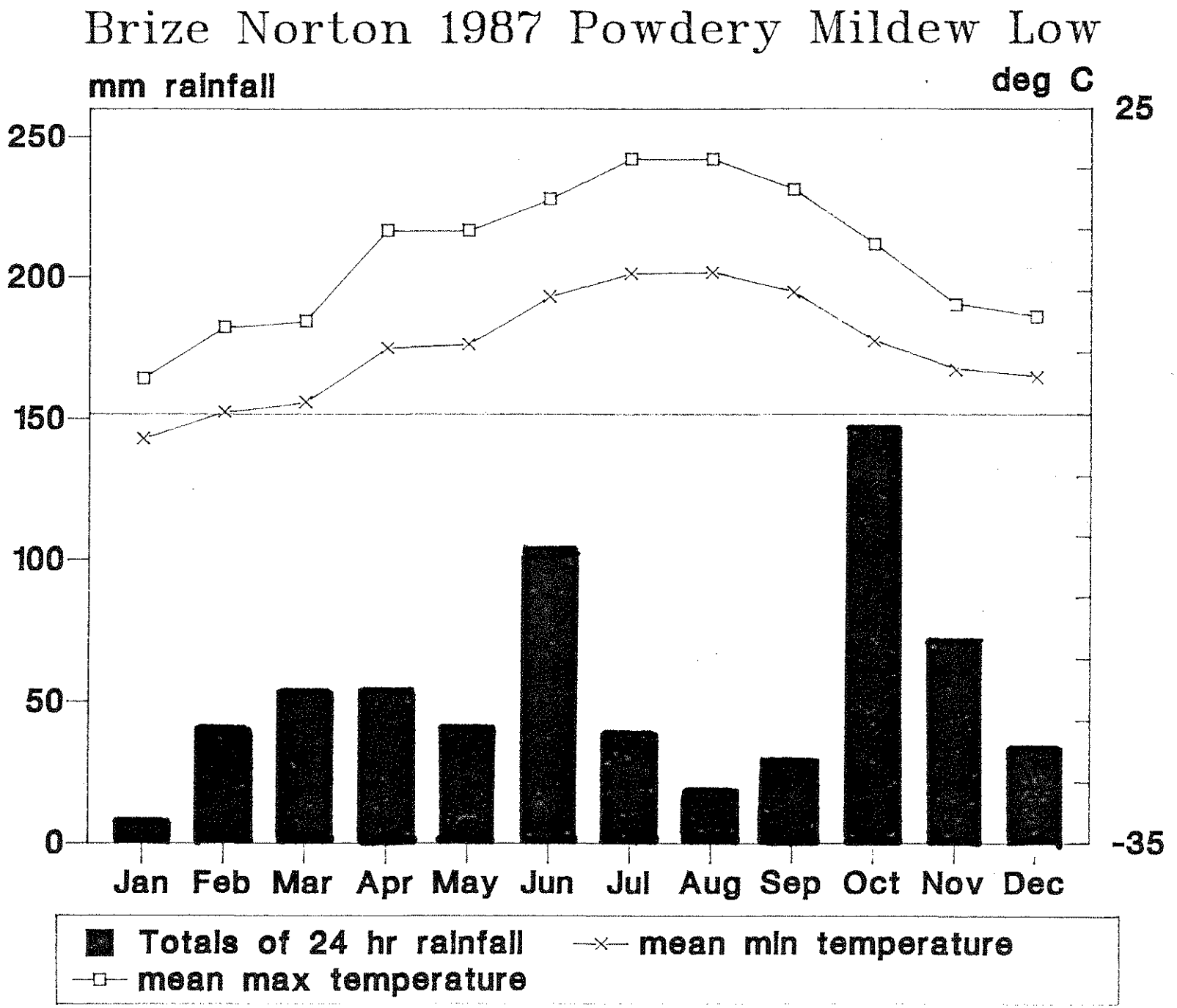
Appendix VI D.



Appendix VI E.



Appendix VI F.



PPENDIX VII

**NCIDENCE OF FOLIAR DISEASES IN VEGETABLE BRASSICAE**

egion: Location of Crops: Nearest Met Station (if known):

| EAR | CROPS | | | RINGSPOT | | | | | LIGHT LEAF SPOT | | | | | WHITE BLISTER | | | | | POWDERY MILDEW | | | | | OTHERS SPECIFY | | | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Brussels sprouts | Cauli | Cabbage | 0 | 1 | 2 | 3 | A ± | 0 | 1 | 2 | 3 | A ± | 0 | 1 | 2 | 3 | A ± | 0 | 1 | 2 | 3 | A ± | 0 | 1 | 2 | 3 | A ± | |
| 981 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 982 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 983 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 984 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 985 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 986 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 987 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 988 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 989 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 990 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Key:**
0 = Not seen or reported
1 = Slight infections reported or seen
2 = Some moderate infections
3 = Severe outbreaks/generally severe in area

A = Average incidence for the disease
+ = Above average disease incidence
- = Below average disease incidence