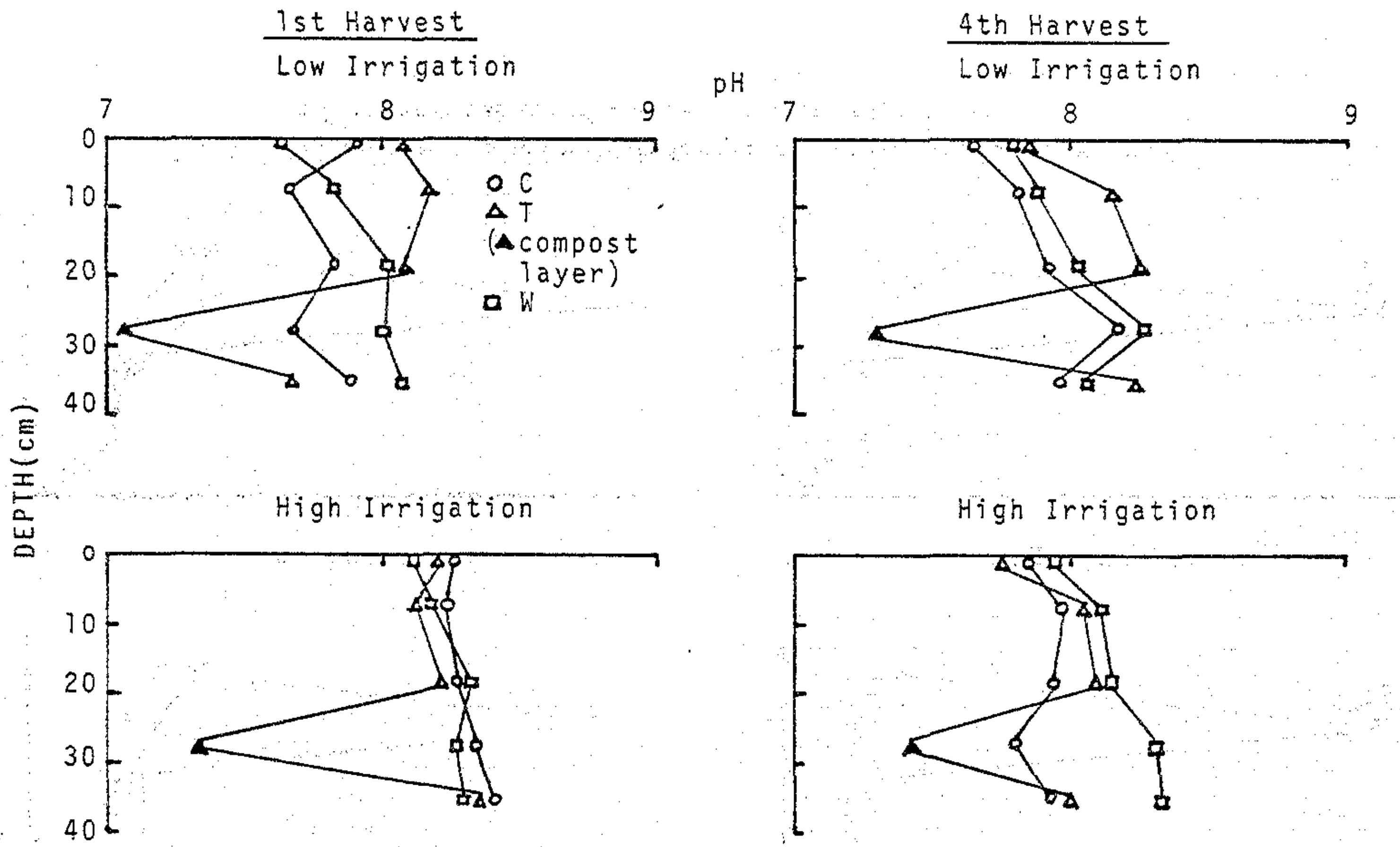


Fig. 4. Values of pH in saturation extracts of soil samples from different depths at 1st and 4th harvests of alfalfa

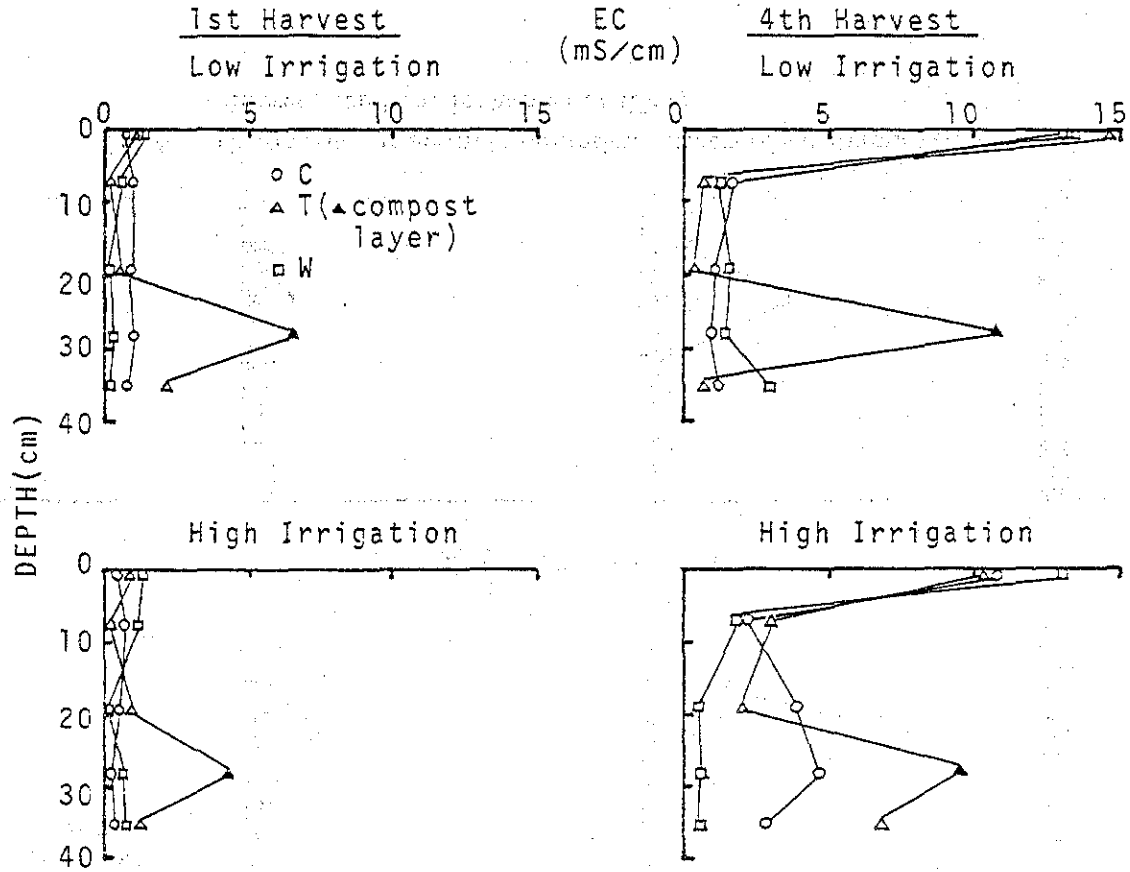


Fig. 5. Values of EC in saturation extracts of soil samples from different depths at 1st and 4th harvests of alfalfa

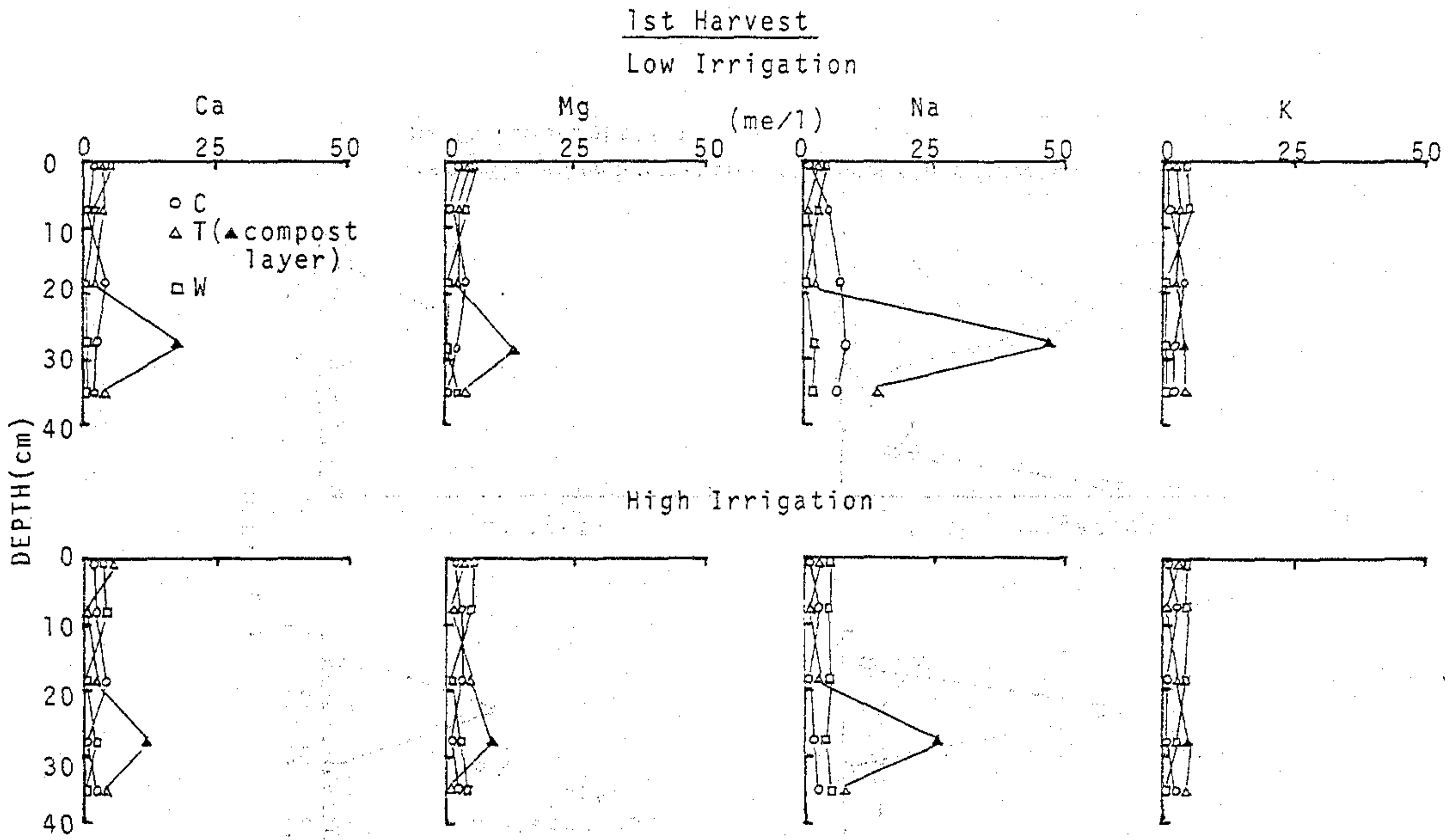


Fig. 6. Cation concentrations in saturation extracts of soil samples from different depths at 1st harvest of alfalfa

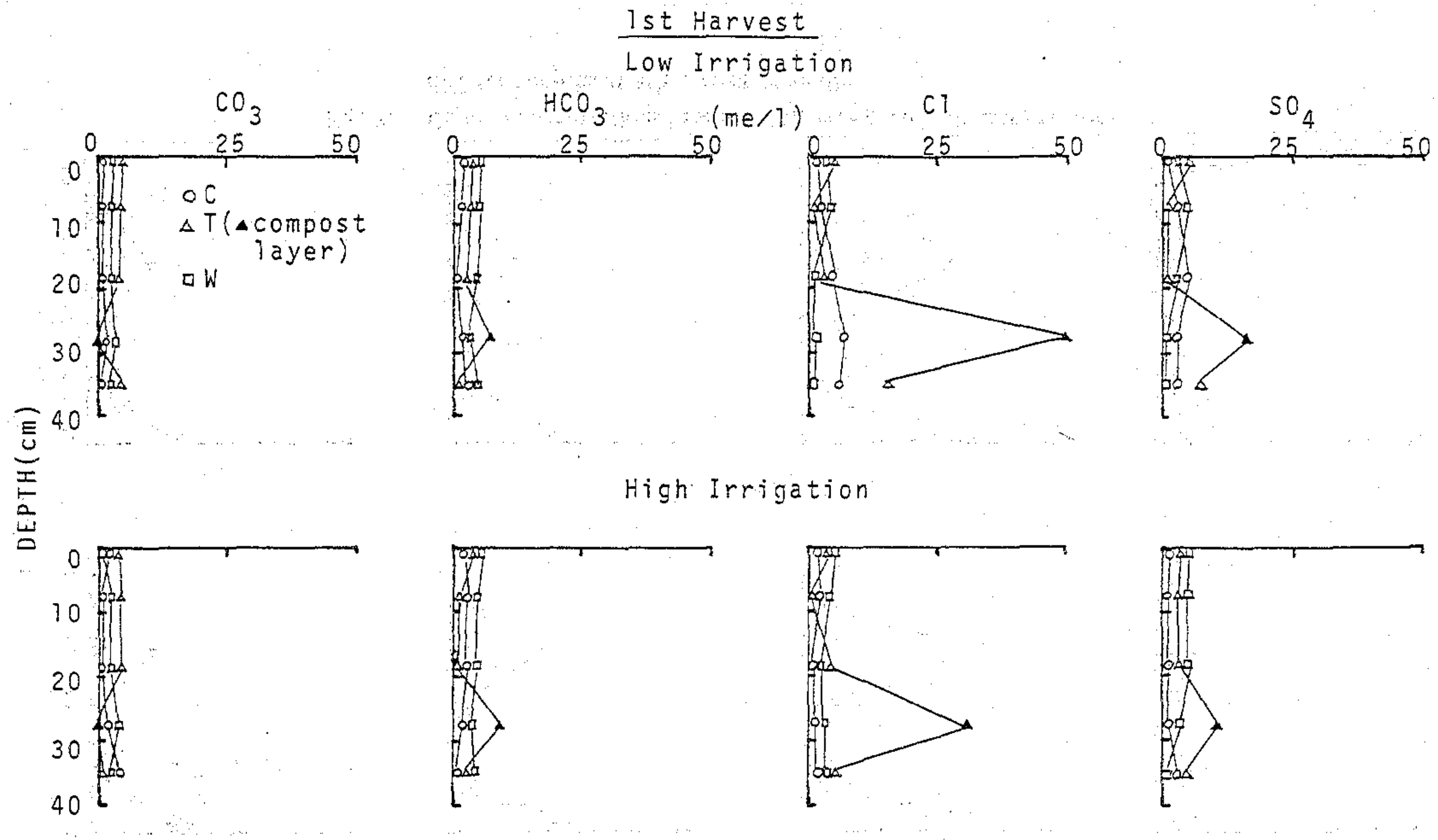


Fig. 7. Anion concentrations in saturation extracts of soil samples from different depths at 1st harvest of alfalfa

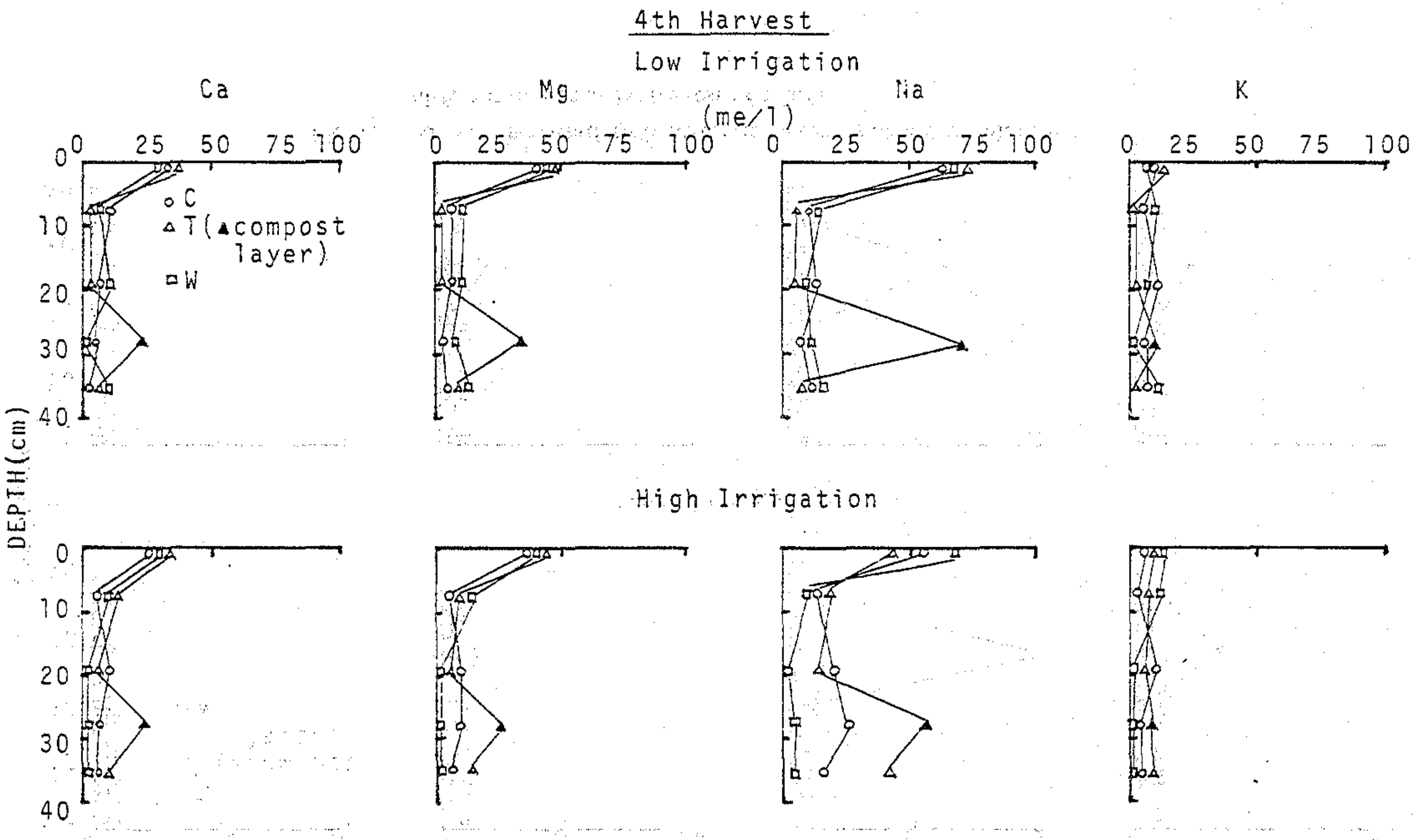


Fig. 8. Cation concentrations in saturation extracts of soil samples from different depths at 4th harvest of alfalfa

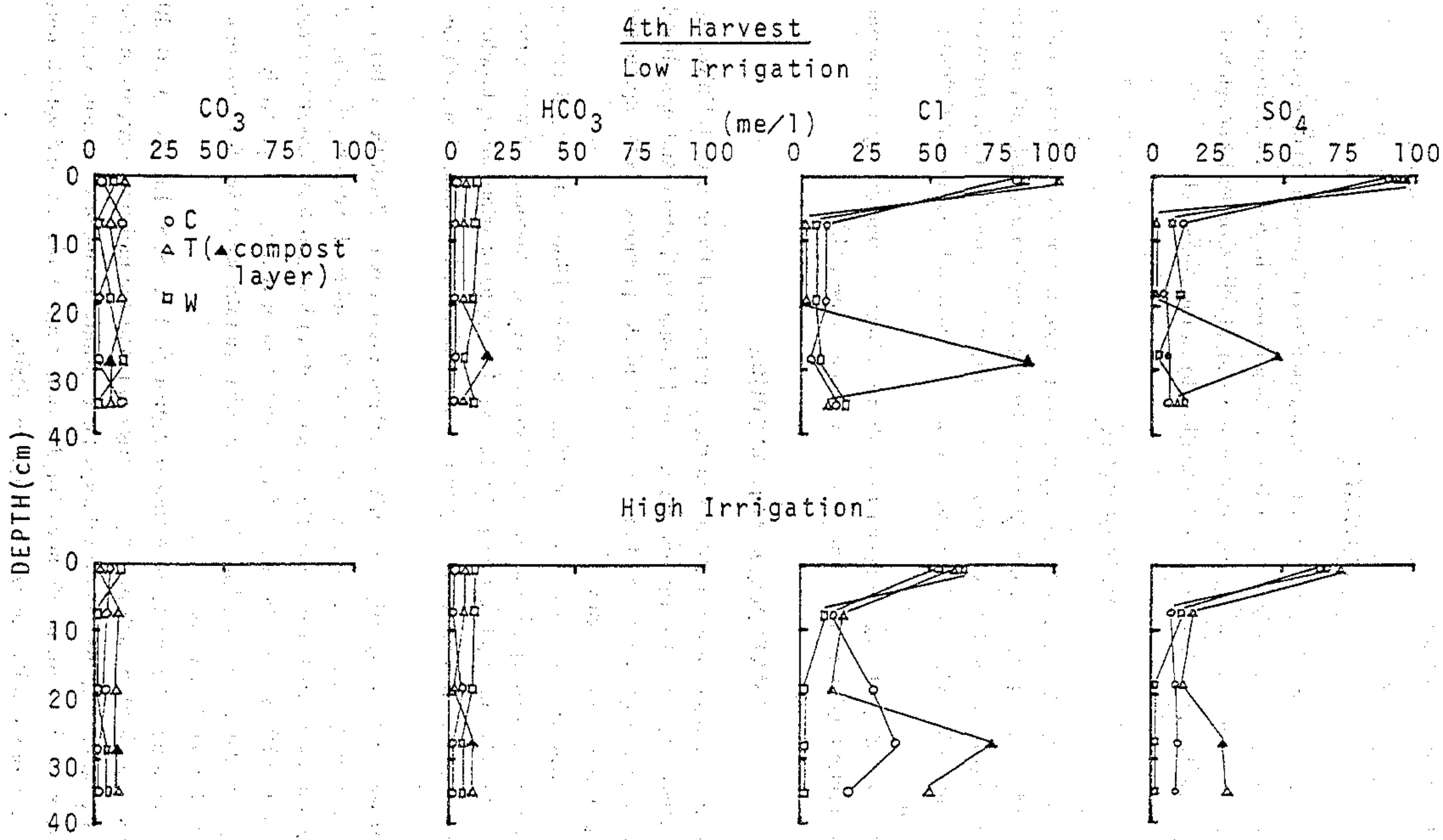


Fig. 9. Anion concentrations in saturation extracts of soil samples from different depths at 4th harvest of alfalfa

(2) Effects of Compost Layer in Subsurface Soil on the Yield of Wheat (*Triticum aestivum* L.) Irrigated with Sweet Water

ABSTRACT

Thick layer application of bark compost in subsurface soil (T-treatment) increased the grain yield of wheat under high irrigation conditions. Such increase in yields results from the remarkably high moisture retention in the root zone to supply the crop with enough water during the dry periods and to prevent water infiltration down the sandy soil.

INTRODUCTION

Wheat is grown in UAE in Al Oha agricultural farm in an area of about 1200 ha under irrigation and the cultivar grown is called Mexipak. The area may be increased in the future but generally the yields per hectare were low in the range of 1 – 2 ton/ha. There are many reasons behind such low yields but the major ones are : soil and water salinity and shortage of irrigation water.

Hence the present study was designed to study the effect of compost layer on water preservation and retention in the root zone of the crop to increase yield.

MATERIALS AND METHODS

The present experiment was carried out in the Experimental Farm of UAE University at Al Oha in 1986/1987. The treatments, experimental deisng, replications and agricultural practices used were exactly similar to those described in the previous alfalfa experiment with few exceptions mentioned below.

Mexipak cultivar of wheat was sown on 25th November 1986, with a seed rate of 150 kg/ha and at an interrow spacing of 50 cm. At sowing the experimental area was fertilized with 300 kg/ha of compound fertilizer (14:14:14), 150 kg/ha of triple superphosphate and 100 kg/ha of potassium sulfate. 100 kg of urea was added on 17th Dec. 1986, 7th Jan. and 8th Feb. 1987.

Each plot was irrigated by drip system with 20 mm every day until 4th December and then with 15 mm every two or three days up to 29th December. Treatment of different levels of irrigation was started from 30th December. Plots in low and high irrigation levels were irrigated until 11th March, 1987 with 15 mm every four or two days, respectively.

The crop was harvested on 22nd March. Air dried samples were used for determination of yields and mineral contents.

Soil samples were collected from different deptsh (0–1, 1–8, 8–15, 15–20, 20–30 cm from the soil surface) in each plot before irrigation, and the moisture contents of the samples were measured. The pH and EC values, soluble cations, anions in saturation extracts of soil samples were determined. Methods for determination of pH, EC and soluble ions were the same as those described in previous paper on alfalfa.

RESULTS AND DISCUSSION

The results showed that the grain yield of wheat were significantly higher in the T-treatment under high irrigation than under low irrigation (Fig. 1). On the average the grain yield under T-treatment were 4 ton/ha compared to 2.2 ton/ha in the control. The effects of the W-treatment on the grain yield under high and low irrigation levels were not significant.

Differences in tops, roots and ear were also shown under high irrigation in all the three treatments. Such differences were not shown under low irrigation.

The moisture contents of compost layers in T-treatment were higher than those of equivalent layers in the other two treatments under both irrigation levels (Fig. 2 and 3).

The pH and EC values of saturation extract are shown in Fig. 4. No major differences were shown except that the pH values of the compost layers in T-treatment were rather low. Relatively high EC values were shown in the compost layer of T-treatment under both irrigation levels.

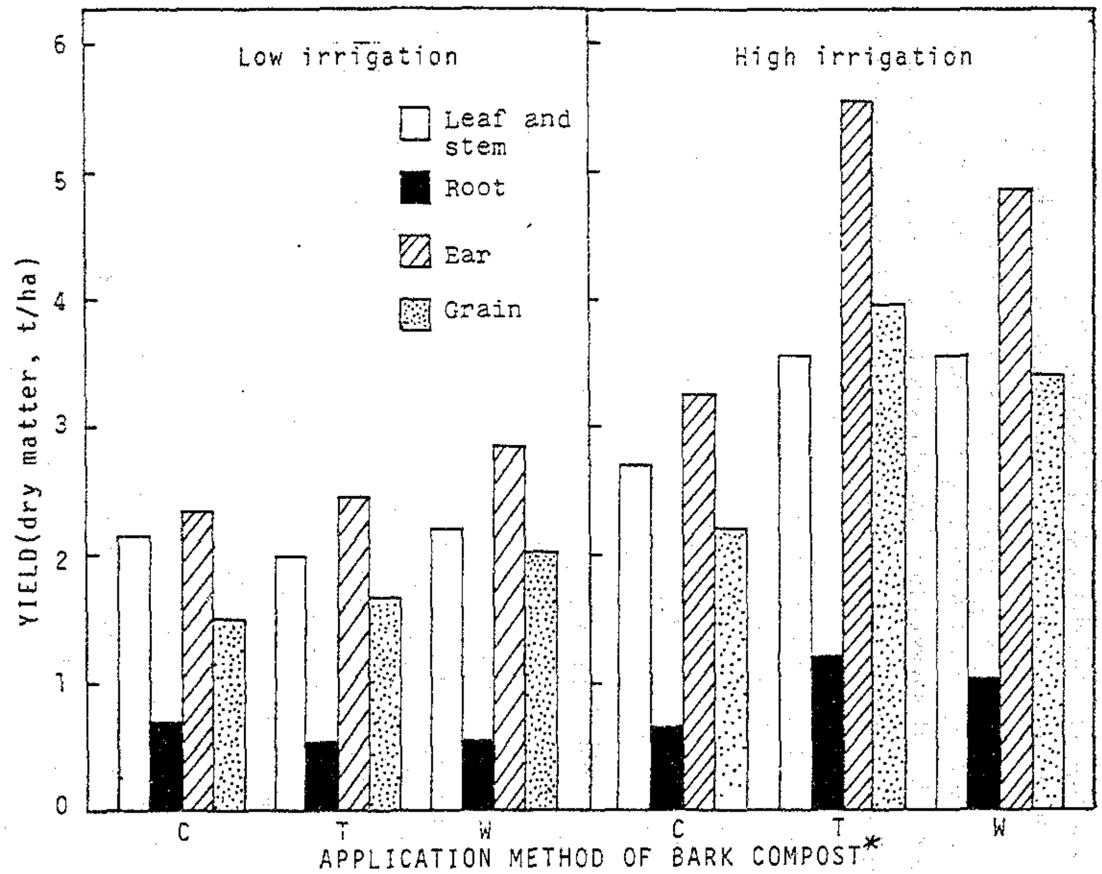


Fig. 1. Relationships between yields of wheat and application methods of bark compost under irrigation of sweet water

* C : Control, T : Thick Layer Application, W : Whole Layer Application

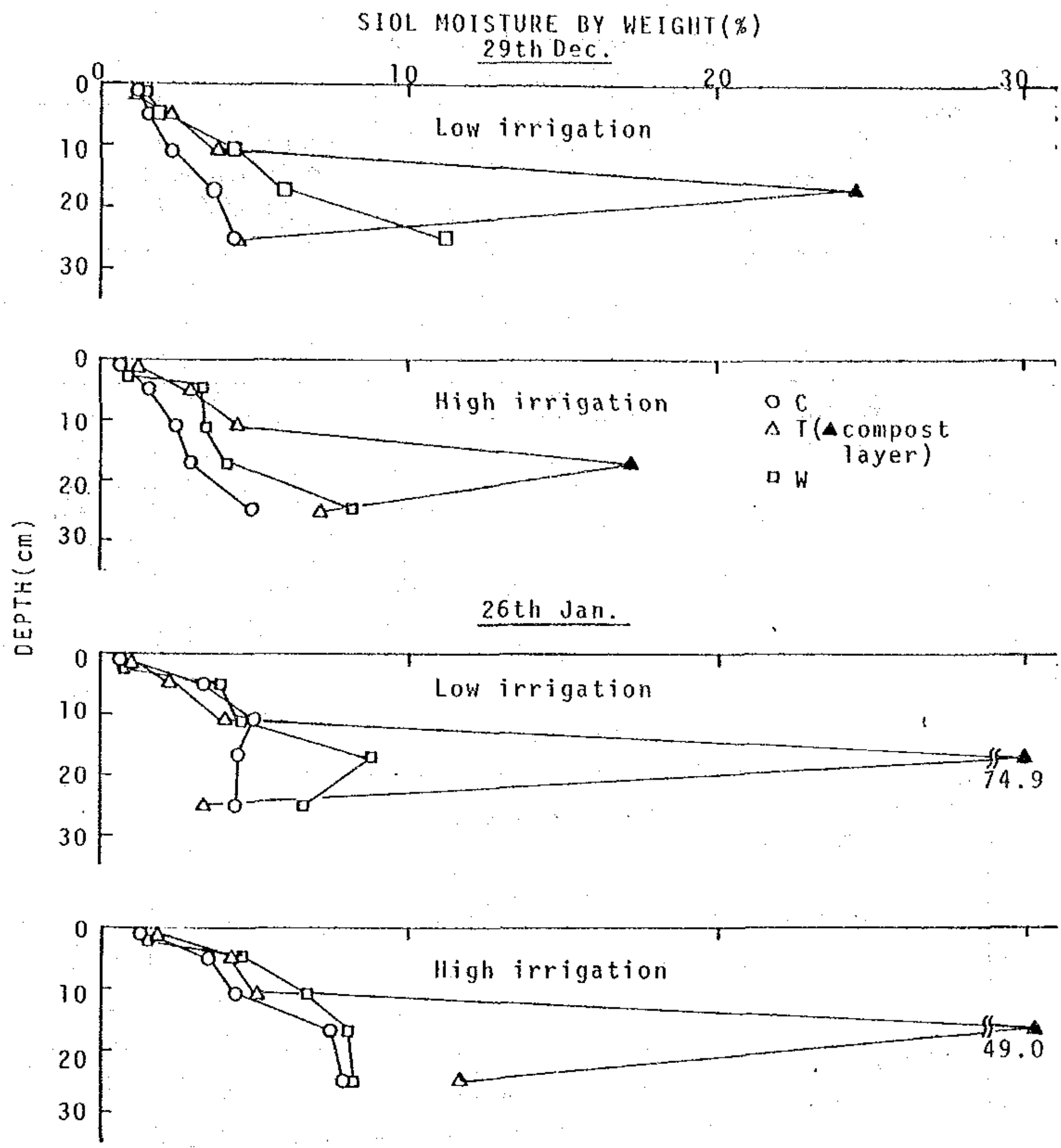


Fig. 2. **Monthly changes in soil moistures of different depths from surface as a function of application methods of bark compost and amounts of irrigation (1)**

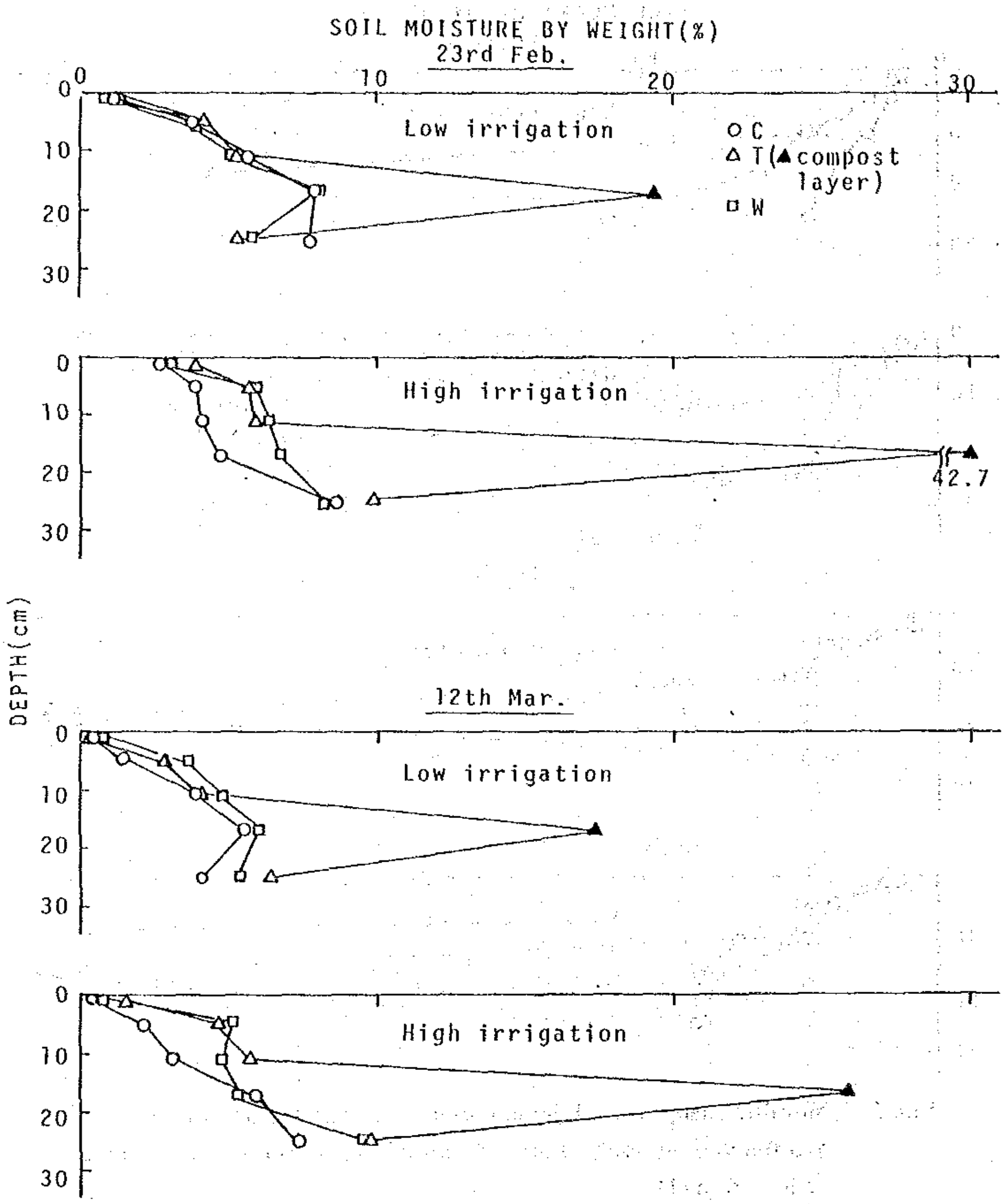


Fig. 3. Monthly changes in soil moistures of different depths from surface as a function of application methods of bark compost and amounts of irrigation (2)

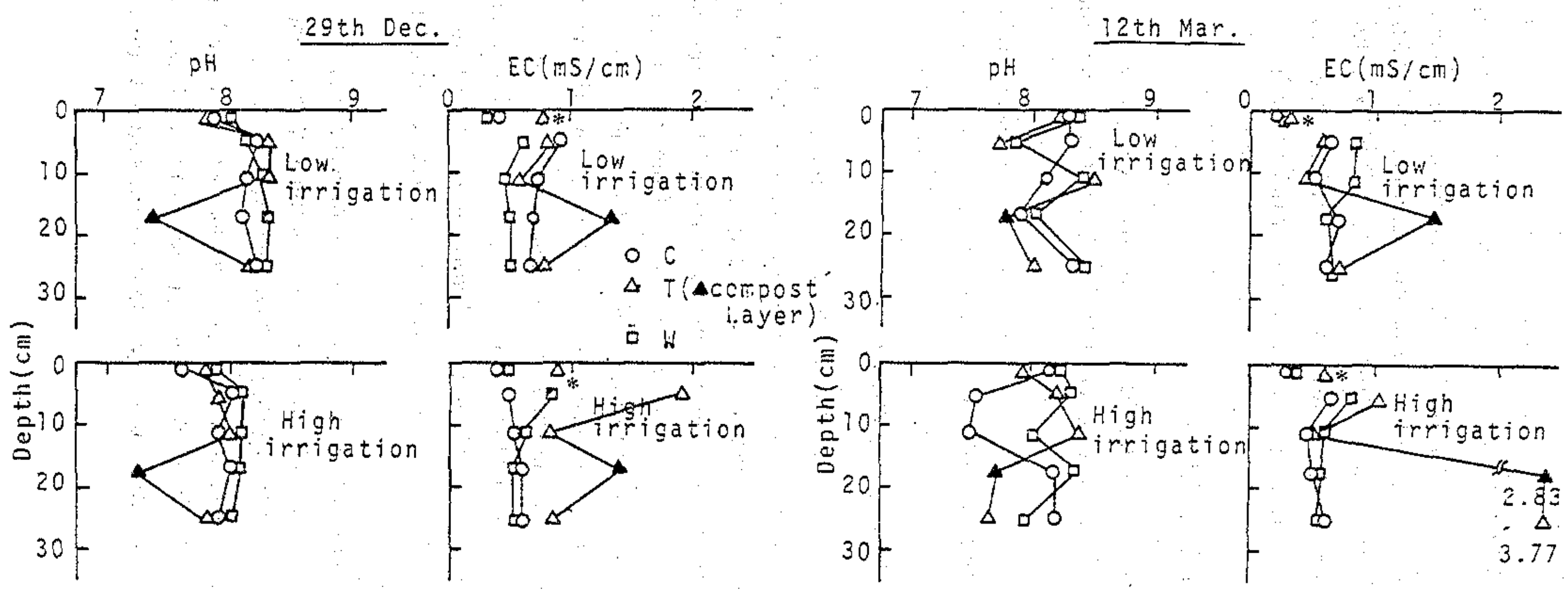


Fig. 4. Values of pH and EC in saturation extracts of soil samples from different depths as influenced by application methods of bark compost and amounts of irrigation

* Ten times value of scale

(3) Effects of Compost Layer in Subsurfaces Soil on the Yield of Squash (*Cucurbita pepo*) Irrigated with Sweec Water

ABSTRACT

Thick layer application of bark compost in 10 cm and 20 cm from the soil surface increased the fresh weight of squash tops compared to the control, although the fruits yield was not increased by the treatments. Since compost layer retained more water in the root zone of the crop, it was mainly considered that the high moisture content in the root zone contributed mainly for vegetative growth but not for propagative growth of squash.

INTRODUCTION

Squash (*Cucurbita pepo*) is widely cultivated, next to tomato areawise, in Al Ain region. Therefore, saving water is one of the most important subjects to keep stable production of squash in this area.

The present study is to investigate the effect of compost layer in subsurface soil on the growth and yield of squash under the conditions of UAE.

MATERIALS AND METHODS

A field experiment was conducted in a sandy loam soil at Agricultural Experimental Station, Kuwaitat. The experiment was laid out in a completely randomized design with three replications. The treatments were ; two kinds of thick layer application in subsurface soil (T-10 and T-20 treatments) and control. The compost layer in T-10 and T-20 treatments was laid down the soil in form of sheets to a depth of 10 and 20 cm from the soil surface. The plot size was 10 m^2 and the amount of compost applied was 30 tons/ha. Sowing was done on 14th September 1986. The distance between rows was 150 cm and the distance between plants was 50 cm. Two seeds per hole and total 36 seeds per plot were used.

Compound fertilizer (14:14:14) was applied as basal dressing at a rate of 107 kg/ha. Top dressing was applied three times ; 100 kg/ha of compound fertilizer (14:14:14) on 24th October, 100 kg/ha of liquid fertilier (19:6:6) on 1st November and 100 kg/ha of liquid fertilizer (20:20:20) on 10th November.

Each plot was irrigated by drip system with approximately 8.5 mm every day.

The first harvest was conducted for one replication on 25th October. The second was done for remaining two replications during 28th October to 31st December.

Fresh weight of squash was measured in each harvest. Soil samples were collected from different depths (0–1, 1–10, 10–20, 20–30 cm from the soil surface) at each plot. Soil moisture contents, pH and EC of saturation extract were measured for the samples collected.

RESULTS AND DISCUSSION

Fresh weight and length of plant were significantly higher in T-20 treatment than the other two treatments in the first harvest (Table 1). However there were no significant differences in the number of leaves, flowers and fruits among three treatments. The fresh weight of tops and roots were higher in T-10 and T-20 treatments than the control in the second harvest (Table 2). But the effects of the compost layer were not obvious on the yields of gruits. In other wards, the compost layer was effective for the vegetative growth, but not for propagative growth.

Soil moisture in the compost layers of both T-10 and T-20 treatments were remarkably higher compared with the equivalent layers in control at every sampling (Fig. 1). Irrigation water would transfer downwards through soil layers and the compost layer retained more water than the equivalent layer of the control treatment. It was mainly considered that the moisture retained by the compost layer influenced increase of the top weight of squash.

Values of pH and EC of saturation extract during the experiment are shown in Figures 2 and 3. The pH values in the compost layers were lower than the other layers in T-10 and T-20 treatments. This would be due to elution of humic and fulvic acids from the compost as mentioned in the previous paper. The EC values at the soil surface in each treatment were severely high. This was due to accumulation of salt from irrigation water.

Table 1. The growth of squash in 1st harvest as influenced by compost layers

Treatment	Fresh weight of top* (g/plant)	Length of top (cm)	Fresh weight of top (t/ha)	Number per plant		
				Leaf	Flower	Fruit
Control	277±28	60.3±3.3	10.0	16 ±0.7	13.6±0.9	2.6±0.5
T-10	410±147	65.8±8.0	14.8	17 ±1.6	13.4±0.9	2.8±0.8
T-20	477±76	72.9±2.2	23.9	19 ±2.1	15.2±1.3	2.8±0.4

* Values of one replication

Table 2. Fresh weights of squash in 2nd harvest as influenced by compost layers

Treatment	Fresh weight(t/ha)*1			Fresh weight	
	Top	Root	Fruit	Top (kg/plant)	Root (g/plant)
Control	62.3(100)*2	0.60(100)*2	57.3	1.73±0.88	16.8±4.6
T-10	82.4(132)	0.81(135)	58.8	2.29±1.51	22.6±10.0
T-20	70.6(113)	0.81(135)	60.0	1.96±0.96	22.4±11.9

*1 Mean values of two replications

*2 Index for 100 of control

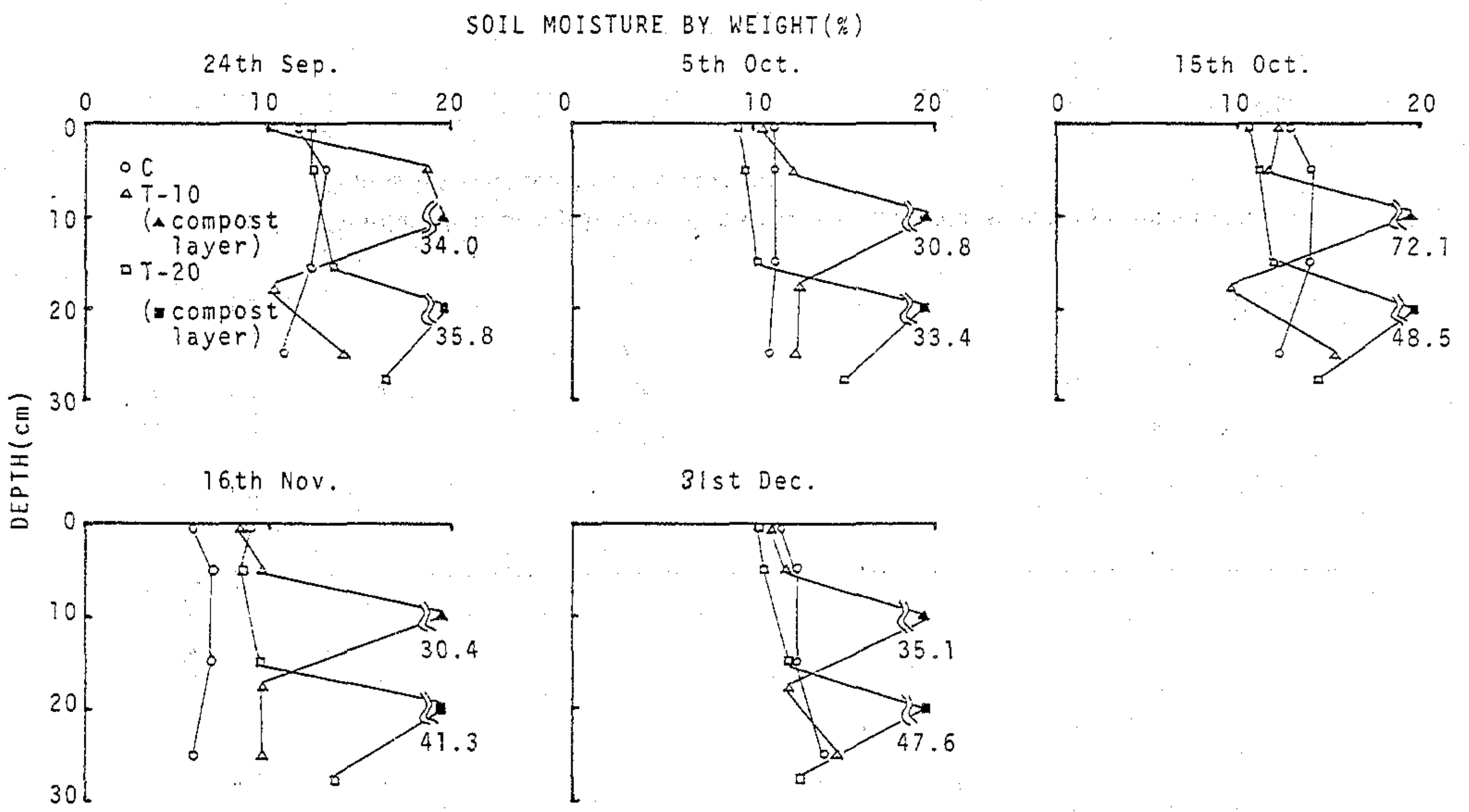


Fig. 1. Monthly changes in soil moisture in different depths from surface as influenced by compost layers

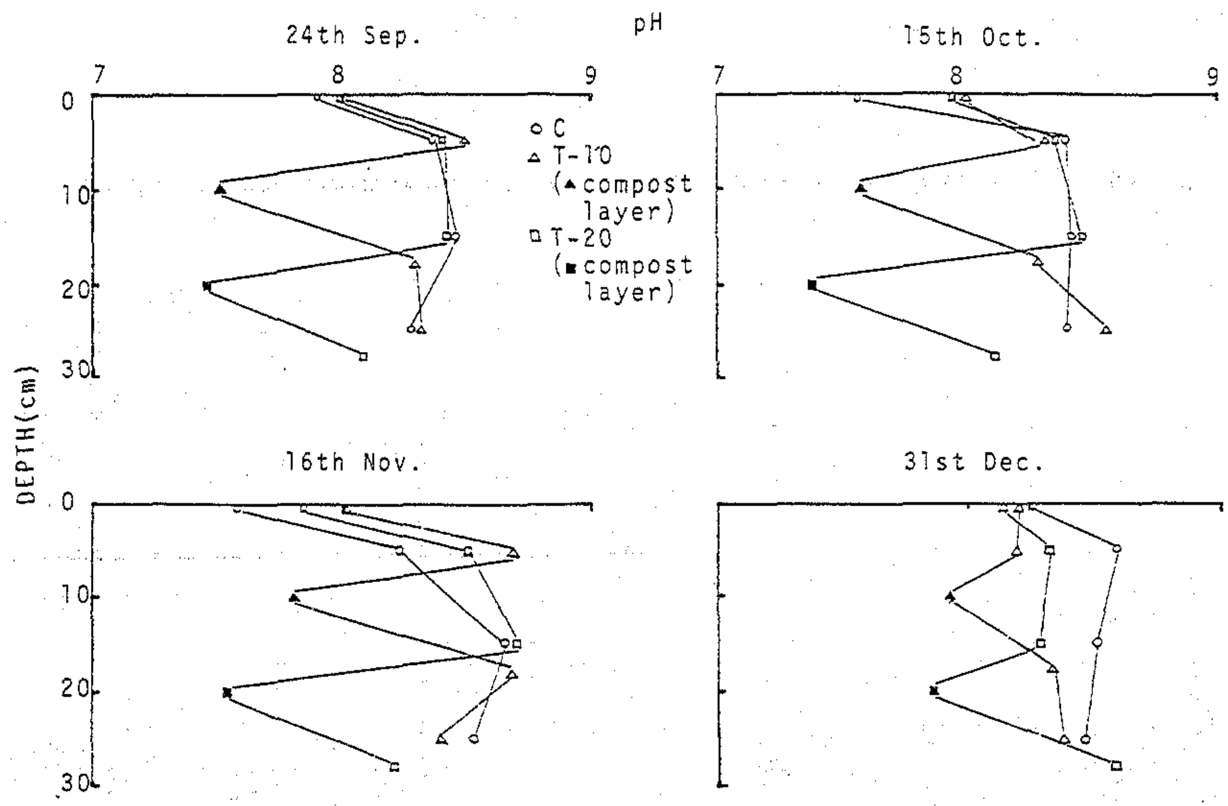


Fig. 2. Monthly changes in pH values of saturation extracts of soil samples from different depths as influenced by compost layers

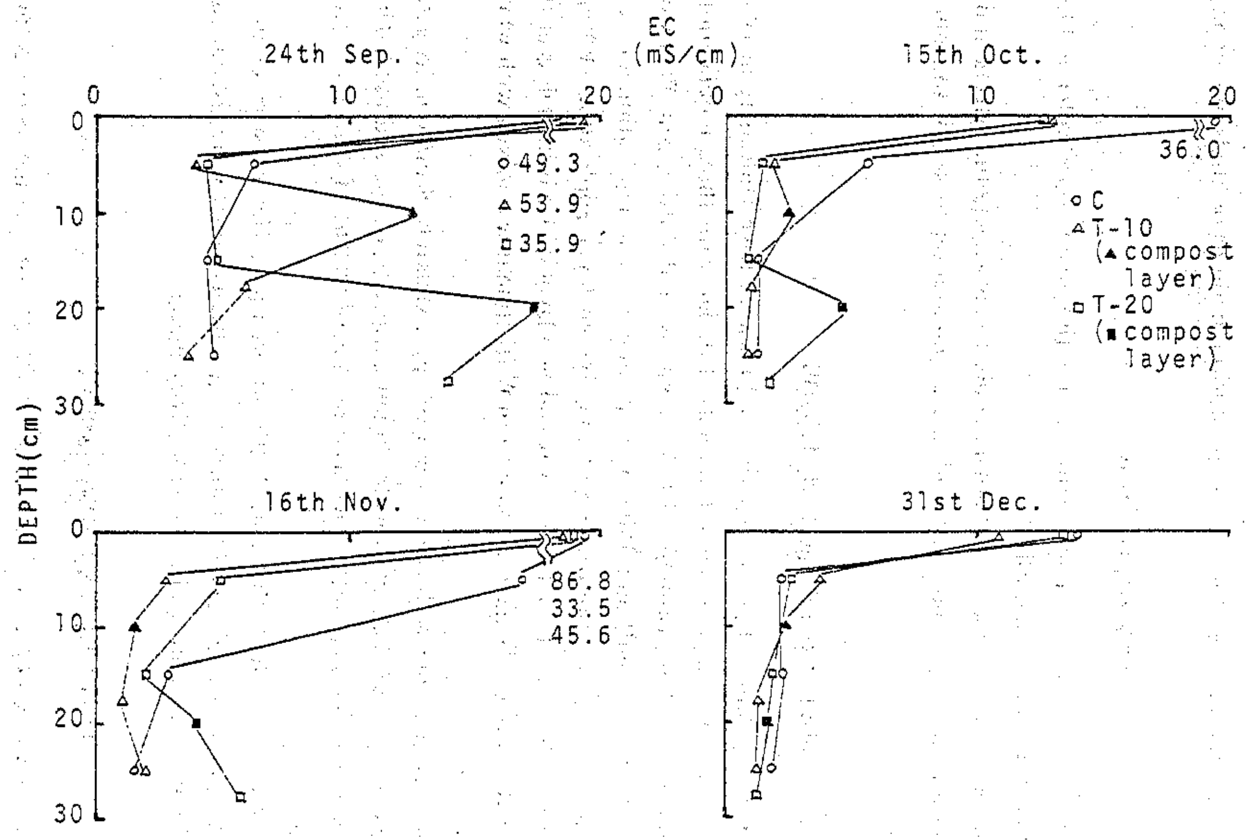


Fig. 3. Monthly changes in EC values in saturation extracts of soil samples from different depths as influenced by compost layers

(4) Effects of Application Methods of Compost on Water Preservation and Salinity in Sandy Soil under Irrigation of Saline Water

ABSTRACT

Thick layer application of compost retained more water in the compost layer compared with the equivalent layer of whole layer application and control. However, the EC values of saturation extract were not influenced by either application methods or kinds of compost.

INTRODUCTION

It is considered that the soil organic matter is effective to increase water holding capacity and to minimize the salinity hazard.

This experiment was conducted as a preliminary study to investigate the effects of different kinds of compost on water retention and salt accumuration in sandy soil under saline water irrigation.

MATERIALS AND METHODS

This experiment was conducted at the Experimental Farm of UAE University in 1986. The experiment was laid out in a completely randomized design with three reqplications. Three kinds of compost were Bark compost, Al Ain compost and Potting soil. Pots were filled with 23 kg of sand (dune sand) and 350 g of each compost. The application methods were ; Thick layer application in subsurface soil (T), Whole layer application (W) and Control (C). The compost layer in T- treatment was laid as a layer of 1 cm thickness at the depth of 10 cm from the surface. While the compost in W-treatment was mixed with whole layer of the soil in the pot.

Each treated pot was irrigated with saline water of approximately 8 mS/cm. Irrigated volume was equivalent to 70% of maximum water holding capacity of the soil used. Then the same saline water was added periodically to keep the initial weight of each pot during 29 June to 26 August.

Soil samples were collected from different depths of each pot. The moisture contents of the samples were measured. The pH and EC values of saturation extract were also measured with glass-electrode pH meter and electrical conductivity meter.

RESULTS AND DISCUSSION

Fig. 1 shows soil moisture contents in different depths. Moisture contents in compost layers of T-treatment were significantly higher than the equivalent layers of the other two treatments.

The pH and EC values of saturation extract of samples were shown in Fig. 2. The pH value ranged from 7.4 to 8.2 and no major differences were shown among three kinds of different compost. Generally the lower layers showed higher pH values than the upper layers, although the compost layers showed rather lower pH values depending on the quality of the compost. High EC values at the soil surface were shown for all the treatments. Relatively high EC values were also shown in the compost layers of T-treatment compared with those of the equivalent layers of the other two treatments.

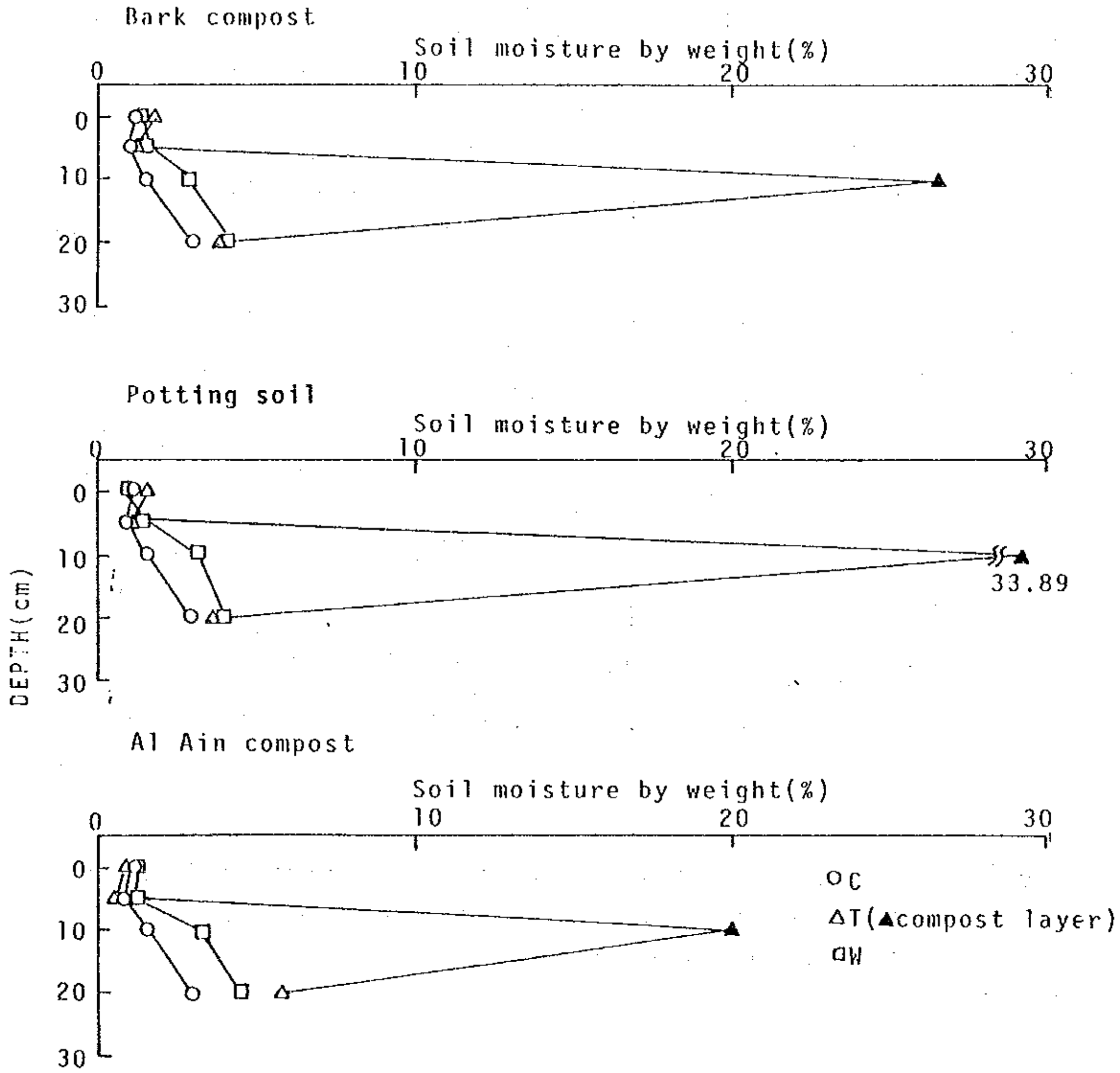


Fig. 1. **Soil moistures in different depths from surface as influenced by application methods of compost used**

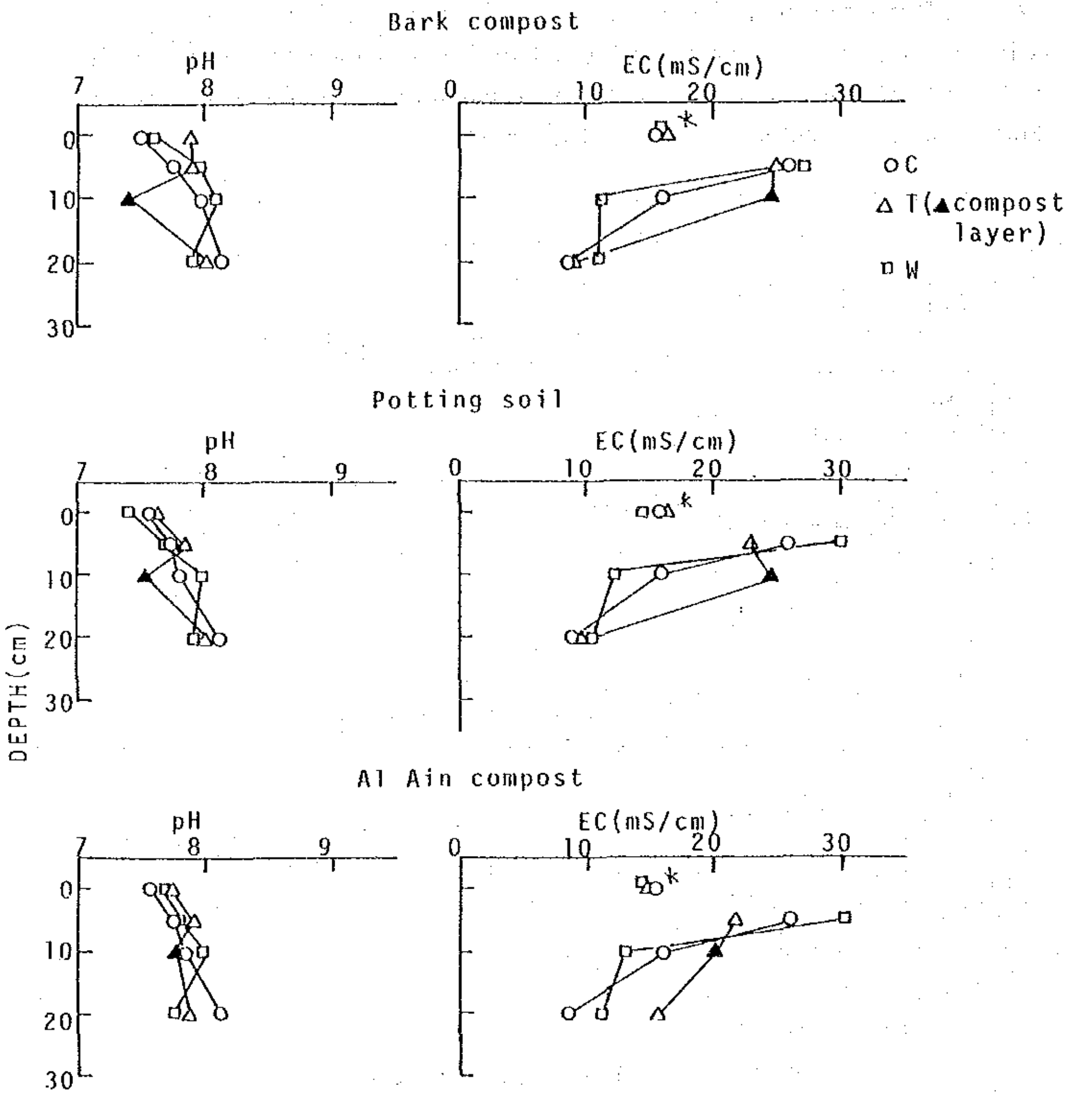


Fig. 2. **Values of pH and EC in saturation extracts of soil samples from different depths as influenced by application methods of compost used**
*** Ten times value of scale**

Theme B-2 : Studies on Cultivation Methods in UAE

(1) Growth Analysis of Alfalfa

ABSTRACT

Dry matter production and growth analysis were studied for alfalfa (cultivar: OMANI). The following three kinds of plot were established in the field: a) the uncut plot with standard irrigation; b) the cut plot with standard irrigation; c) the cut plot with high irrigation. The uncut plot was used for the analysis of growth parameters, and both cut plots were used for the analysis of dry matter production under the condition of the local standard cultivation. Alfalfa seeds were sown on 14 December 1986 and sampled regularly from 14 January 1987 to 29 July 1987 in the uncut plot, but harvested monthly in both cutting plots.

Plant weight increased steadily till 29 July after the seeding in the uncut plot. It increased more slowly till late February followed by the rapid increase till early June. Total dry weight and shoot weight were 1721.55 g/m^2 and 635.04 g/m^2 in maximum, respectively. LAI increased to 5.5 in middle of May followed by the decrease to 2.5 in July. CGR was high, 12.78 – 14.43 $g/m^2/day$, throughout to early February, followed by the decrease to 3.05 $g/m^2/day$ in early March. After that it increased again and had a peak of 13.70 $g/m^2/day$. NAR also had a peak of 3.08 $g/m^2/day$ in early April.

For the cut plots, the monthly yield increased till June – July but decreased considerably in August. LAI was also high, 3.32 to 4.73, in May to July but decreased considerably in August. The cumulative yield from March to August was 1679.61 g/m^2 and 1824.24 g/m^2 in the plots with standard irrigation and with high irrigation, respectively.

In analyzing the productive structure using the stratified clip method, a major part of leaves distributed at the layers of 30 – 50 cm in May to June in both cut plots.

INTRODUCTION

Many trials have been carried out towards increasing food production in the dry lands of the Middle East. The ways to increase the crop production are two-fold, the expansion of the cultivated area and the increase in the yield per unit area. The former have been too difficult to be conducted because of limited amount of water for irrigation. The latter have been considered as the only way to attain this objective in consideration of present poor yield levels. There are some possibilities to increase it by the improvement of the cultivation techniques and methods.

The first step in this direction is to examine matter production and its processes in the fields of the dry lands. Few studies, however, have been conducted in this area.

This paper reported on the dry matter production and its process in alfalfa, which was cultivated by the local standard techniques.

MATERIALS AND METHODS

The study was conducted in the Experimental Farm, Faculty of Agriculture of UAE University, located near Al Ain city, UAE from 1986 to 1987. The cultivar used was OMANI. Seeds of alfalfa were broadcasted onto the field at the rate of 40 kg/ha on 14 December 1986. The basal fertilizer was applied at the rate of 45 kg/ha of N, 113 kg/ha of P_2O_5, 67 kg/ha of K_2O and 2 tons/10 a of Al Ain compost. Top dressing was also applied monthly, just after the time of cutting in the cut plots after 24 March 1987. Its rate was 45 kg/ha of N, 45 kg/ha of P_2O_5 and 13 kg/ha of K_2O in March and April but 23 kg/ha of N, 23 kg/ha of P_2O_5 and 7 kg/ha of K_2O in May and June. No top dressing was applied in July.

The following three kinds of plot were set: the uncut plot with standard irrigation (B5), the cut plot with standard irrigation (B6), the cut plot with high irrigation (B4). The uncut plot was used for the analysis of growth parameters and both cut plots were used for the analysis of the dry matter production and its process of alfalfa (cultivar: OMANI) under the condition of the local standard cultivation. All three plots were 24.7 × 33.0 m in size. No replications were planned because of the inconvenience of plumbling for the irrigation system and the manageable limit. The sprinkler irrigation system was used and the positions of nozzles are shown in Fig. 1. The plots were irrigated at the rate of 4.8 mm/day after the seeding to 19 January 1987, at the rate of 5.0 mm per two days from 20 January to 13 February, and at the rate of 10.0 mm per two days from 14 February to 22 March. The amount of irrigation water was different between the standard irrigation plots (B5 and B6) and the high irrigated plot (B4) after that. The standard plots had the rate of 15.0 mm per two days till 16 april, 15.0 mm/day from 17 April to 3 May, and 20.0 mm/day after that. In constrast, the high plot had the rate of 15.0 mm/day till 16 April, 30.0 mm/day from 17 April to 3 May, and 40.0 mm/day after that. Several insecticides and pesticides such as "Rannate", "Benlate" and "Jimandaisen" were applied to the plots during the study period.

For the uncut plot, alfalfa plants were sampled regularly, every two weeks, from 14 January (one month after the seeding) to 29 July 1987. Two additional samples were also made on 12 August and 15 September. Three quadrats (each size was 30 x 30 cm in principle) were set up on each sampling date, from which all alfalfa plants were sampled after the measurement of plant number. Samples were recorded for individual plant height and stem number, and then separated into leaflet, stem (including petiole), root, dead leaflet, dead stem (including petiole) and reproductive organs (flower bud, flower and pod), and weighed after drying at 80°C for 48 hours. For the samples on 14 January, 28 January and 11 February, each dry matter weight was measured on several plants together (10 plants for 14 January and 5 plants for the others). Roots were excavated from about 10 cm in depth and then rinced for weighing. Specific leaf area (SLA) was determined on randomly selected 5 plants on each sampling date except for 14 January, which had 4 plants. Leaf areas were measured by photocopy method from 14 January to 6 May, and by Automatic Area Recording Meter (Hayashi Electronics Co., Ltd., AAM-8 type) after that.

The following growth parameters were calculated based on the data of leaf area and dry matter weight: Relative Growth Rate (RGR), Net Assimilation Rate (NAR), Leaf Area Ratio (LAR), Crop Growth Rate (CGR) and Leaf Area Index (LAI).

For the cut plots, alfalfa plants were cut manually at the height of 5 cm from the ground level monthly after 20 March 1987. All alfalfa plants were cut at the intervals of 10 cm perpendicularly at 5 cm above the ground level. Samples at each layer (0.1 x 0.5 x 0.5 m) were separated into leaflet, stem (including petiole), dead leaflet and reproductive organs, and weighed after drying at 80°C for 48 hours. Leaf areas and weights were also measured monthly except for April for a part of leaflets in each quadrats to estimate SLAs. Leaf areas were measured by photocopy method in March but measured with Automatic Area Recording Meter after that. The stratified clipping was also conducted in the uncut plot on 20 March, 21 May and 20 July.

RESULTS AND DISCUSSION

Morphological characters, dry matter weight and dry matter partitioning ratio under uncut condition:

The morphological characters and the productive perrformances per plant are shown in Fig. 2 to Fig. 5. Plant height increased almost linearly from the first sampling date, 14 January with 5.7 cm, to 29 July with the final height of 55.0 cm. The weight of single stem also increased in a similar manner with plant height, being 0.71 g on the final date. No branching was found till 25 February, and then a little branching was found throughout to 8 April on which alfalfa plant had 4.6 stems on average. No increase in stem number, however, was observed after 8 April (Fig. 2).

Fig. 4 shows the changes in dry matter weight. Total dry weight per plant generally increased during the study period, with a slow rate till 4 January, and then rapidly till 4 June, but stable till 15 July. Root weight changed in a similar manner to total weight. In considering the changing pattern of each part, the change in total weight per plant seemed to be explained well by that in root weight. Culm weight had no changes after 22 April, while it increased till then. This changing pattern was similar to that of stem number per plant. After 15 July, many dead stems were observed, their weight reaching 0.68 g per plant on 29 July. On the other hand, flowers appeared from 6 May, flowers and pods being found till 29 July. The weight of reproductive organs was generally small with the maximum of 0.08 g/plant on 4 June.

Fig. 5 shows the changes in dry matter partitioning ratio based on data at individual plant level. Root ratio increased steadily till 29 July, with 16.7% on the first sampling date and with a rapid increase on second date (40.1%). Stem ratio was likely to have little change but decreased after 1 July. This decrease was explained well by the occurrence of dead steams. In contrast, leaf ratio decreased as time passed, resulting in 4.9% on 29 July.

The productive performances per unit area (1 x 1 m) are shown in Fig. 6 to Fig. 9. Fig. 6 shows both changes in total plant number and total stem number per unit area. Total plant number was high on early dates, 1626.0 plants/m^2 and 2016.7 plants/m^2 on 14 Jaunary and 28 January, respectively, but it decreased rapidly till 8 April, with 300.0

plants/m^2 (14.9% of that on 28 January). After that, it had little change, being 346.7 plants/m^2 on 29 July. The extremely up-and-down like change was observed from 8 April to 29 July, the major cause of this change may be sampling errors. On the other hand, stem number reached the maximum of 2281.3 stems/m^2 on 11 May, followed by the rapid decrease two weeks after that. Then, a slightly increase was found till 20 May, followed by the slight decrease till 29 July, the final number being 874.7 stems/m^2.

Fig. 7 shows the changes in shoot weight per unit area. It generally increased till 29 July, the final weight being 635.04 g/m^2. Fig. 8 shows the changes in total dry weight per unit area. It changed in a similar manner with shoot weight, the final total weight being 1721.55 g/m^2. Its changing pattern was contributed mainly to that in root weight. Stem weight increased to 346.13 g/m^2 on 29 May, which was the maximum, but decreased slightly till 29 July after that, it being 320.43 g/m^2 on 29 July. Leaf weight changed in a similar manner with stem weight, with the maximum of 179.31 g/m^2 on 20 May and with the final weight of 82.24 g/m^2. Reproductive organs weight was generally small during the study period, with 17.28 g/m^2 in maximum on 4 June.

Fig. 9 shows the changes in the dry matter partitioning ratio, Root ratio increased till 29 July, reaching the maximum of 63.1%. Stem ratio had little change from 14 January to 1 July, followed by the decrease due to the occurrence of dead stems. In contrast, leaf ratio decreased to 4.8% on 29 July.

Growth parameters under the uncut condition:

Fig. 10 shows the changes in SLA, leaf area and LAI. While SLA had large fluctuations between 155.52 and 408.80 cm^2/g, a roughly cyclic pattern was found in SLA. It was high, 304.53 – 408.80 cm^2/g, in early-April to mid-May, low, 155.52 – 181.43 cm^2/g in early- to mid-June. It was rather high again, 227.00 – 288.45 cm^2/g, in early- to mid-July, LAI, which had large fluctuations between 1.73 and 5.74, generally increased till mid-May, reaching about 5.5 in maximum, and then decreased to 2.5 in July.

Fig. 11 shows the changes in CGR, RGR and NAR from 15 January to 4 June. The values from 12 February to 25 March were estimated at the pariod of six weeks because of the extremely large fluctuation in data during this period due to the sampling errors. The value from 7 May to 4 June were also estimated at the period of four weeks instead of every two weeks for the same reason. CGR had a cyclic change during the study, being high (12.78 – 14.43 g/m^2/day) till early-February, lowered after that but high again (13.70 g/m^2/day) in mid-April followed by the decrease after that. RGR had the maximum of 0.0986 g/g/day in the early growth stage and had a small peak in late-March, followed by the decrease till 4 June. NAR also had a small peak (3.08 g/m^2/day) in late-April, the maximum value being 9.04 g/m^2/day in the early growth stage.

Dry matter weight and dry matter partitioning ratio under the cut conditions:

The shoot weight per unit area (1 x 1 m) is shown for the cut plots with standard irrigation and with high irrigation in Fig. 12. The dry matter partitioning ratios are also shown in Fig. 13. Shoot dry weight increased from March to June – July, followed by a considerable decrease in August in both plots. The month reached the maximum in shoot weight was different between both plots. Shoot weight reached the maximum of 440.15 g/m^2 in June in the high irrigated plot but reached the maximum of 425.11 g/m^2 in July in the standard irrigated plot. It was also larger in the high plot than the standard plot in April to June. Stem weight and leaf weight also changed in a similar manner with shoot weight, increasing till June – July followed by the considerable decrease in August in both plots. An obvious difference, however, was found between the dry matter partitioning ratios. Leaf ratio decreased slowly till June, followed by a considerable decrease after that, while stem ratio increased slightly till June followed by a considerable increase after that. On the other hand, reproductive organs such as flowers and pods were observed in May, June and July even under the cut condition. No differences in reproductive organs weight were observed between plots.

SLA, leaf weight and LAI are shown in Fig. 14 for both cut plots. SLA for both plots had similar changing patterns, it was low in March, 254.46 cm^2/g and 251.70 cm^2/g for the high irrigation plot and standard irrigation plot, respectively, but high in May, 348.59 cm^2/g and 350.41 cm^2/g, respectively, followed by the decrease again to 232.59 – 279.65 cm^2/g in June to August. No differences in SLA was found between plots. On the other hand, LAI had a similar change with SLA, being low in March, 1.98 and 2.00 in the standard plot and the high plot, respectively, high in May to July (3.32 – 4.73), low again August, 0.89 and 1.41, respectively. For LAI in plots, its increase in May was explained well by the increases of both leaf weight and SLA, while its decrease in June was explained mainly by the decrease of SLA only. In contrast, the considerable decrease of LAI in August was due to the change in leaf weight.

Productive structures under both the cut and the uncut conditions:

The changes in productive structure are shown in Fig. 15 and Fig. 16 for the cut plots with standard irrigation and with high irrigation, respectively. Little differences in productive structure were found between both plots. Leaf weight distributed at the higher layers as plant height increased more from March to June. Dead leaf weight distributed mainly at the layers less than 30 cm in height above the ground level. The distribution of leaf weight was not different in the standard cut plot between June and July but difference was found in the high cutting plot, that in July having more leaf weight at the lower layers than that in June. In August a large part of dead leaf weight distributed at the mid- to high- layers and plant height was considerably low in both plots. In contrast, stem weight distributed more at the lower layers in both plots, this pattern being not different among the sampling months.

Fig. 17 shows the productive structure in the cut plot. It had similar leaf weight at higher layers than the uncut plots, this trend being clear in May. The distribution of dead leaf weight was also remarkable at the lower layers. Stem weight distributed in a similar manner with that in the cut plots. Considerable distribution at the lower layers, however, was found for dead stem weight in July.

The changes in vertical distribution of leaf area are shown in Fig. 18 and Fig. 19 for the cut plots with standard irrigation and with high irrigation, respectively. In both plots, the layers with major leaf areas went up from March to April, resulting in major leaf areas at the layers of 30 – 50 cm in May. Leaf area, however, decreased considerably in August, although it was found mainly at the layers of 30 – 60 cm in June to July. On the other hand, major leaf areas at the layers of 30 – 50 cm were smaller in uncut plot than in both cut plots, although the whole vertical patterns were not different between them (Fig. 20).

Seen production under the uncut conditions:

Table 1 shows the seed yield components of alfalfa under the uncut condition, sampleed on 30 June. The numbers of stems with mature pods and with immature pods or flowers were 54.8 stems/m^2 and 117.2 stems/m^2, respectively. Pod number per stem, seed number per pod and 100 seed weight were 10.2, 5.5 and 0.20 g, respectively. These components data gave an estimate of 3074 seeds/m^2 as seed yield.

Fig. 21 shows the frequency distributions of pod number per stem and seed number per pod over the three quadrats. Many stems had more than 15 pods/stem, 2 – 33 pods as a range. In contrast, seed number per pod distributed evenly over all classes, 1 – 10 seeds as a range.

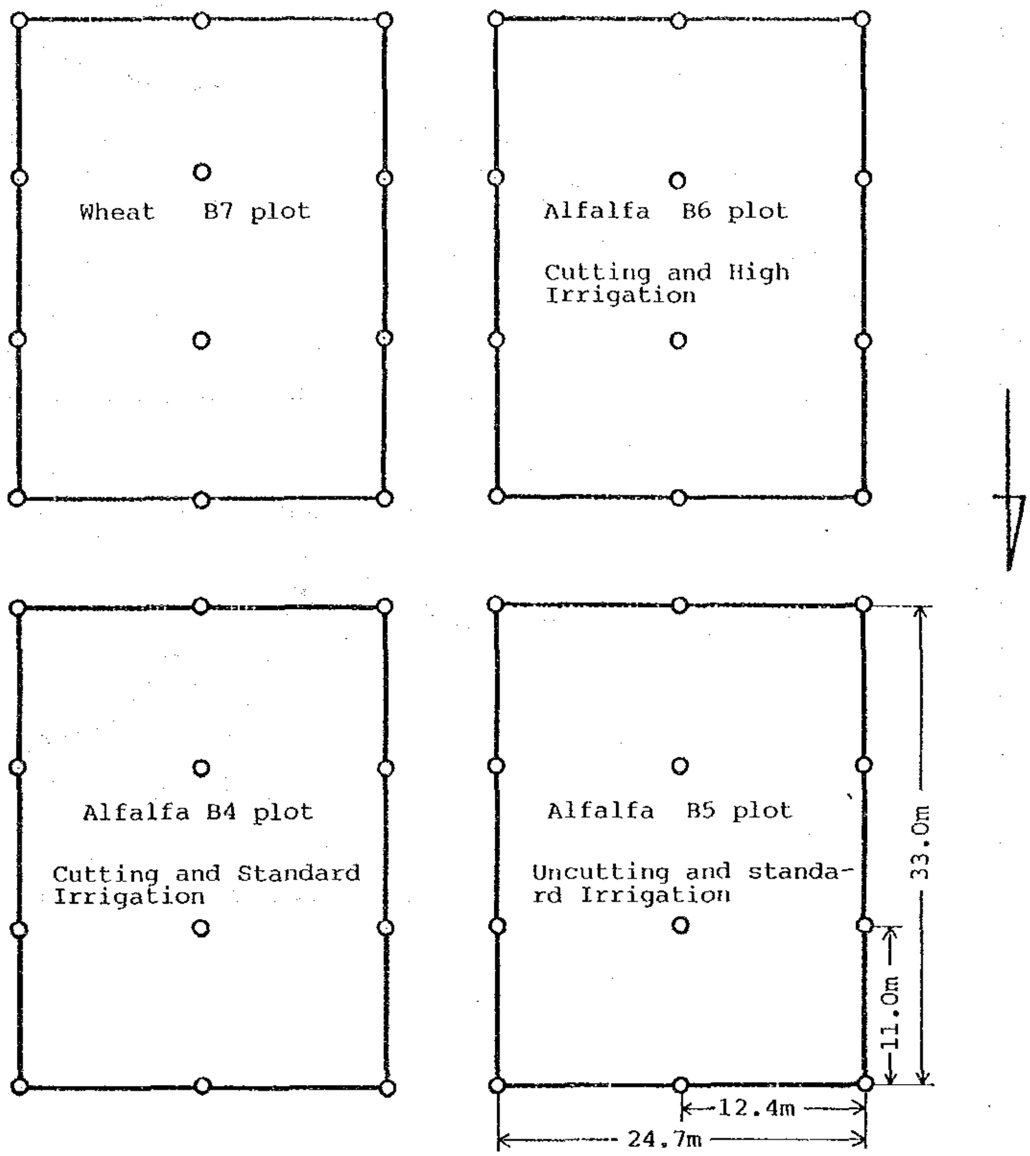


Fig. 1. The location of the plots for wheat and alfalfa, and the arrangement of nozzles (○) for the sprinkler irrigation system

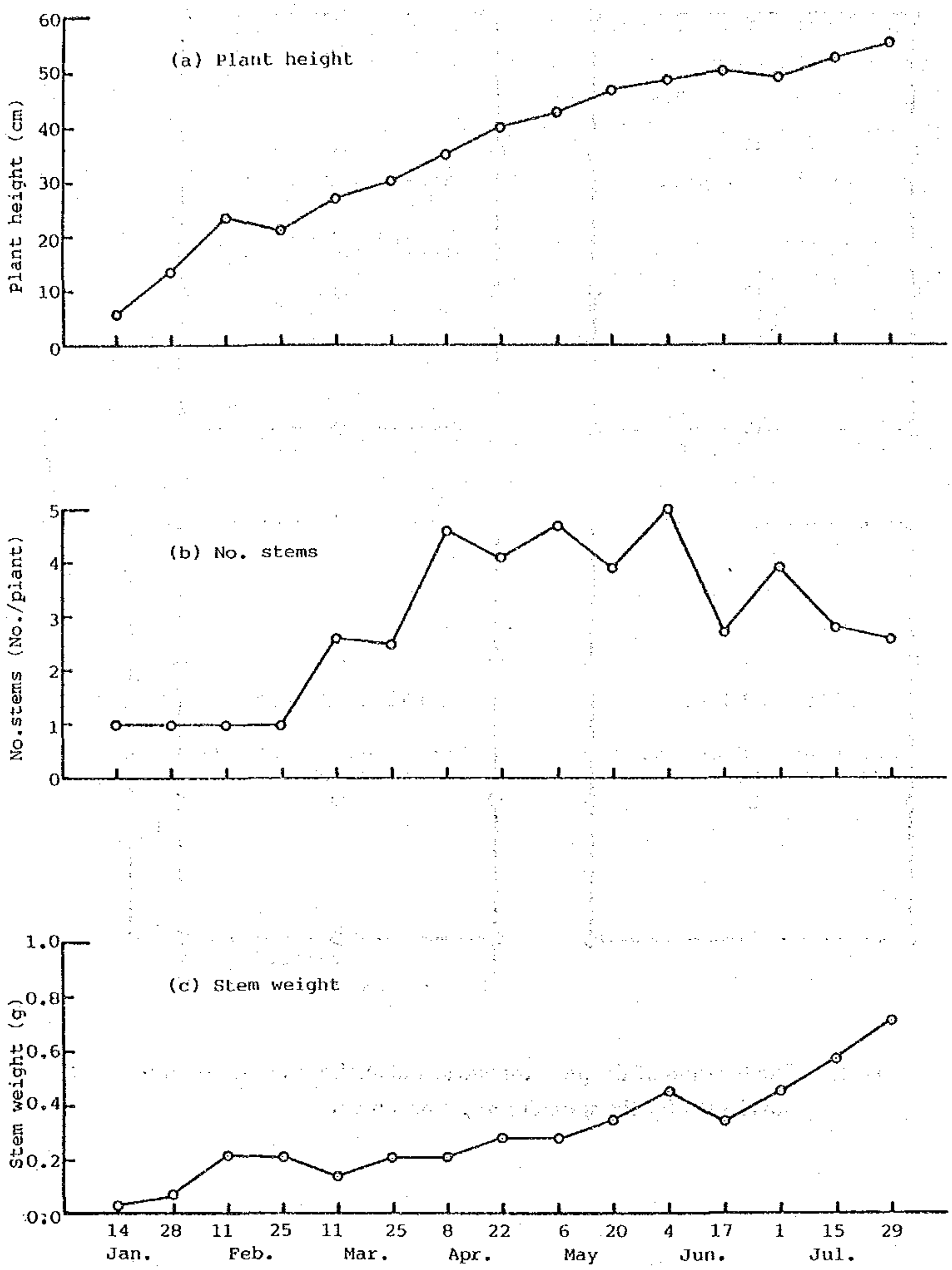


Fig. 2. Changes in plant height (a), number of stems per plant (b) and stem weight (c) of alfalfa under the uncut condition

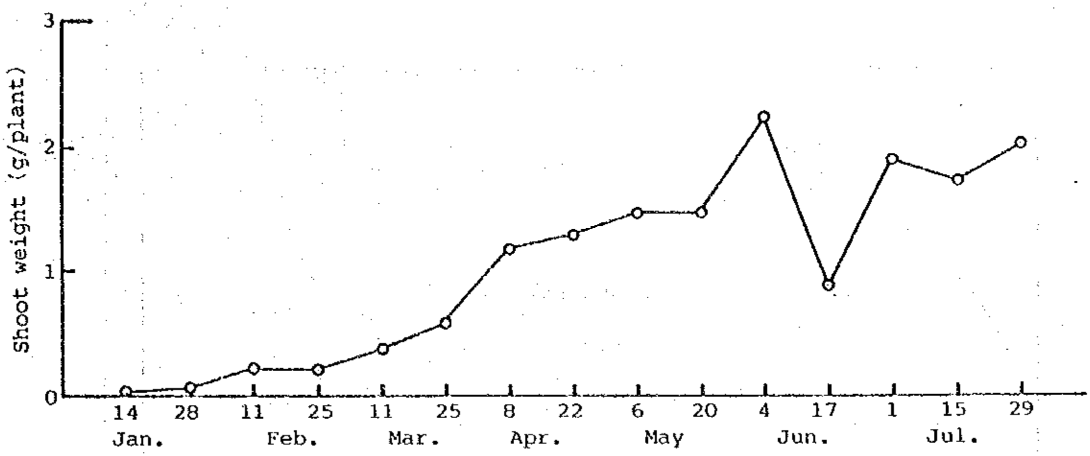


Fig. 3. Changes in shoot weight per plant of alfalfa under the uncut condition

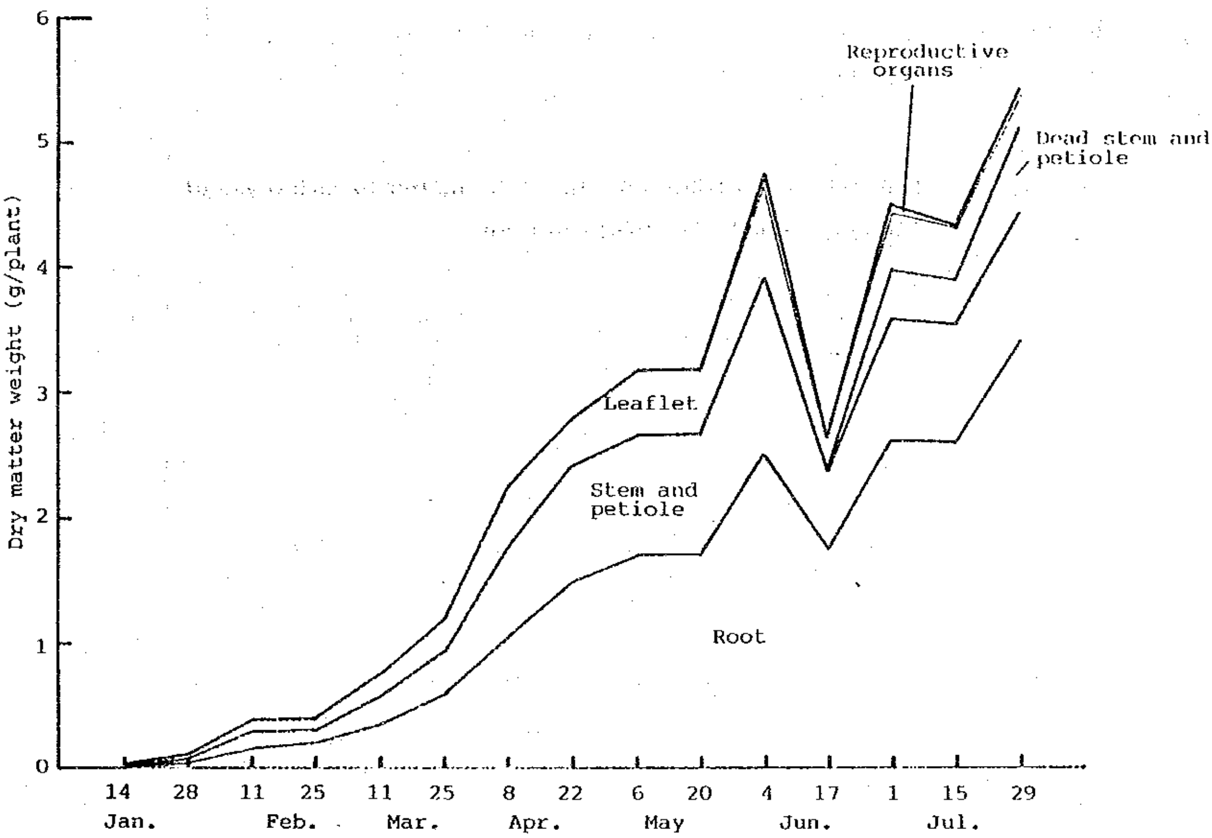


Fig. 4. Changes in total dry weight per plant and the dry weight of each part (root, stem and petiole, dead stem and petiole, leaflet and reproductive organs such as flower bud, flower and pod) of alfalfa under the uncut condition

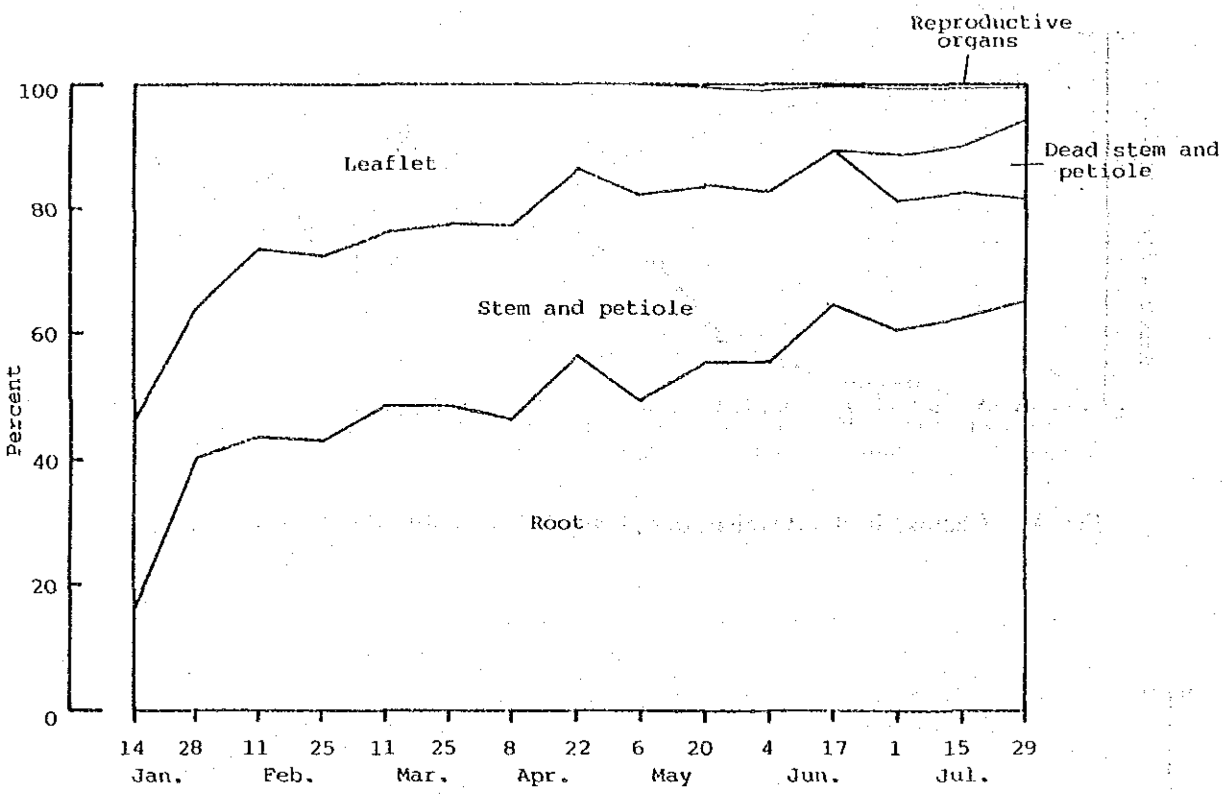


Fig. 5. Changes in the distribution ratio of dry matter to each organ of alfalfa plant under the uncut condition

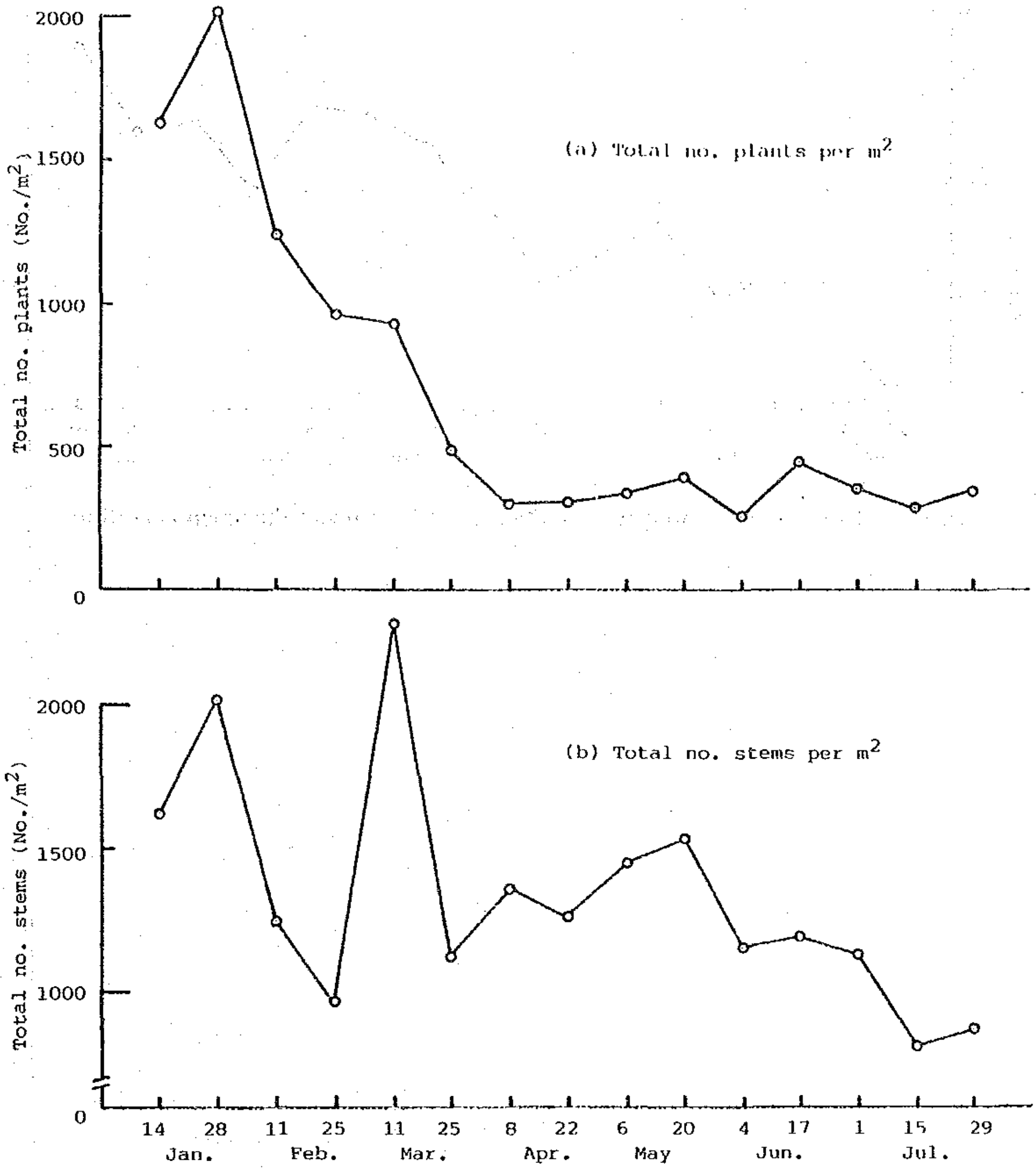


Fig. 6. Changes in total number of plants (a) and stems (b) per 1 × 1 m² of alfalfa under the uncut condition

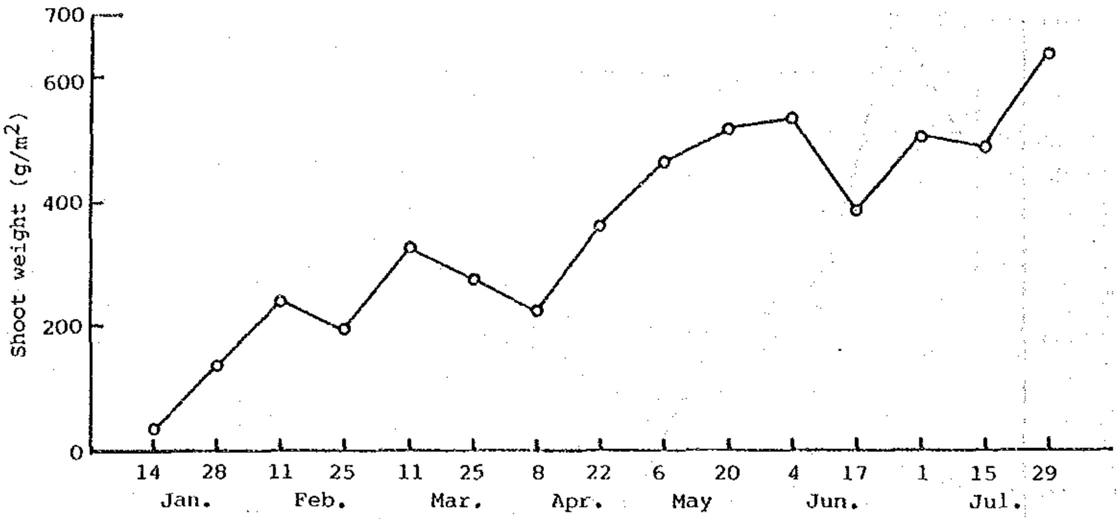


Fig. 7. Changes in shoot weight of alfalfa per 1 x 1 m^2 under the uncut condition

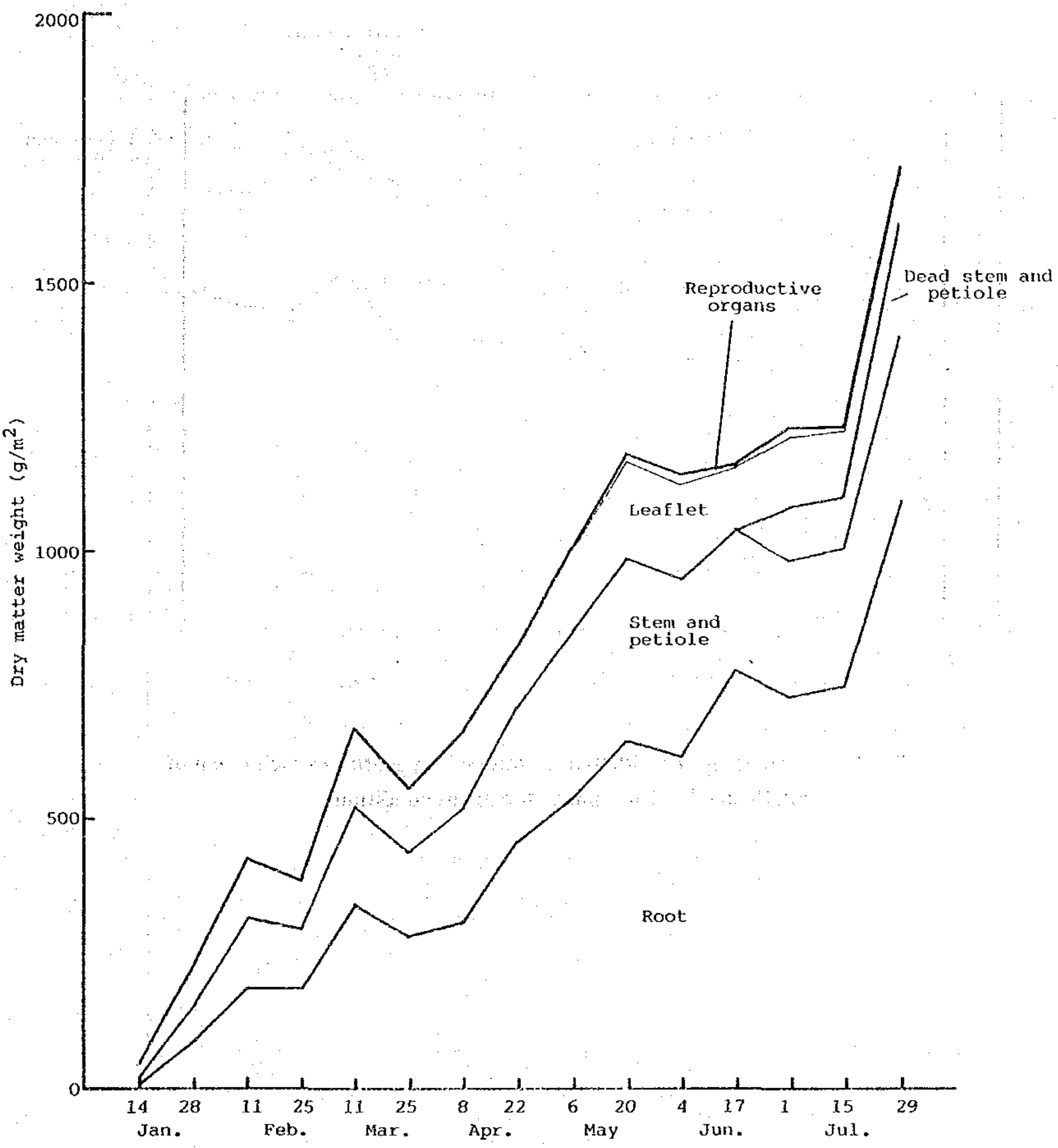


Fig. 8. Changes in total dry weight and the dry weight of each part of alfalfa per 1 x 1 m^2 under the uncut condition

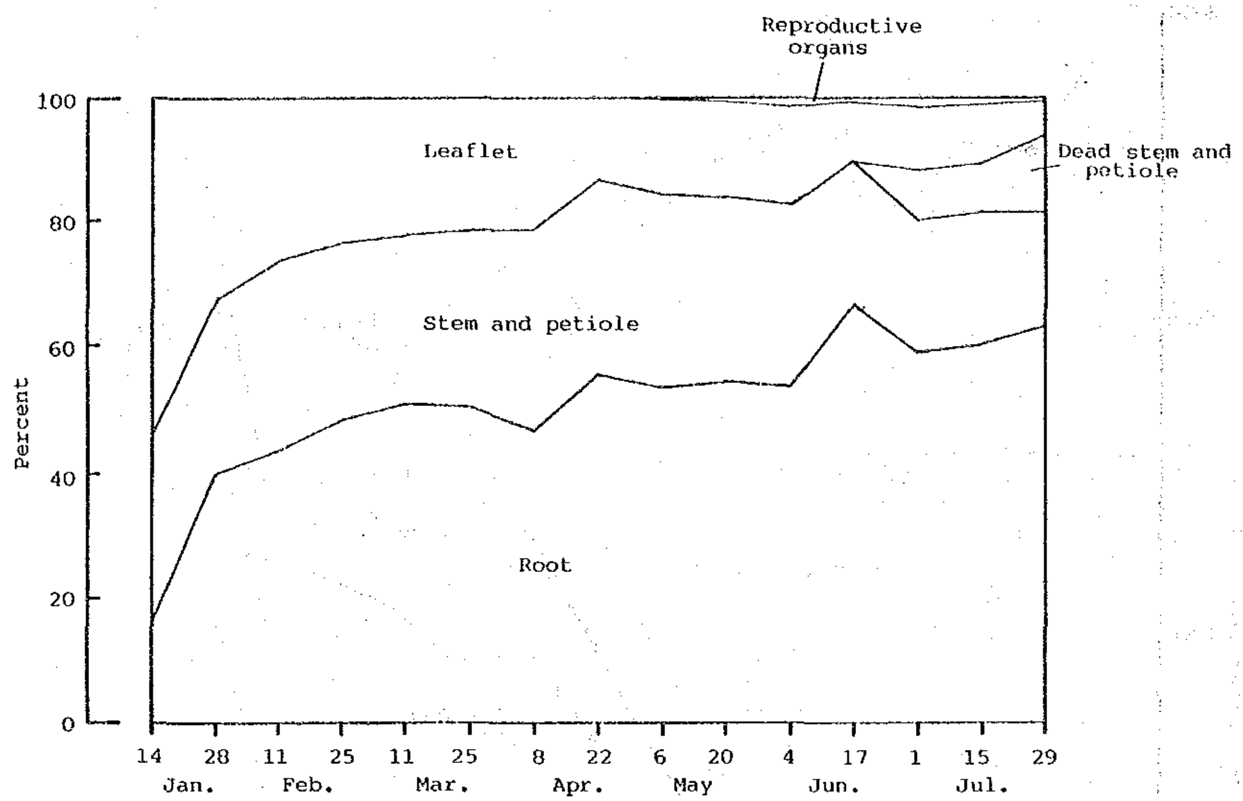


Fig. 9. Changes in the distribution ratio of dry matter to each organ of alfalfa per 1 × 1 m^2 under the uncut condition

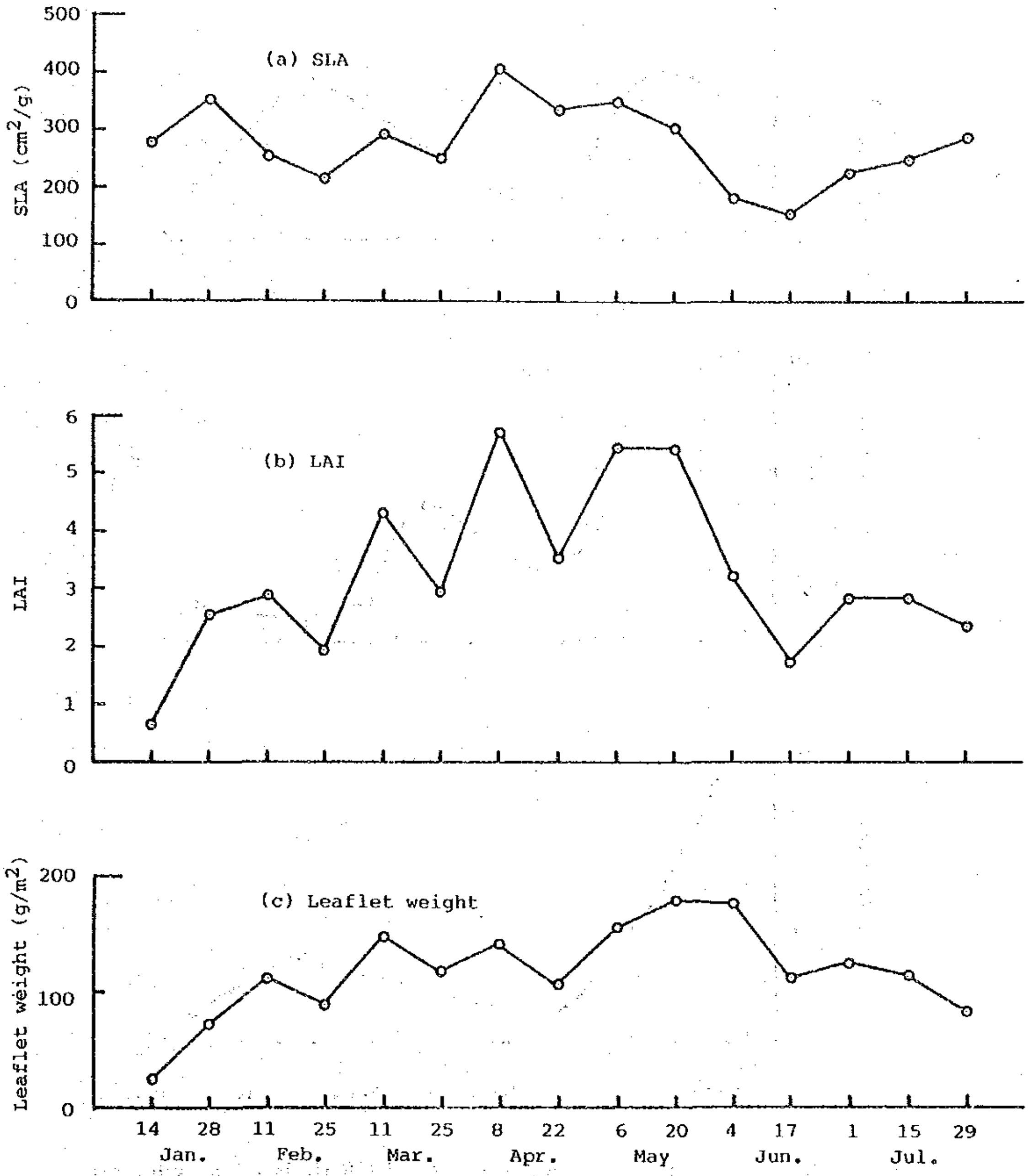


Fig. 10. **Changes in SLA (Specific leaf area), LAI (Leaf area index) and leaflet weight of alfalfa under the uncut condition**

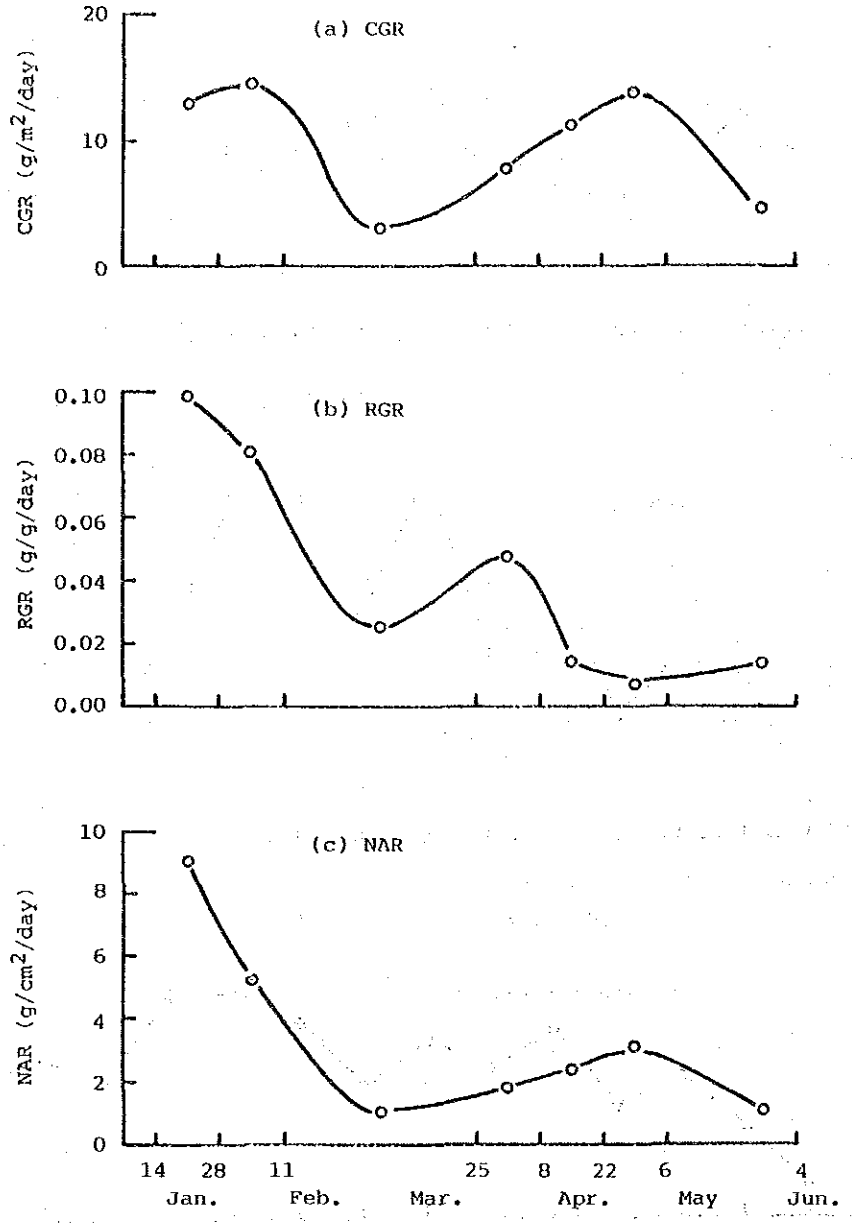


Fig. 11. Changes in CGR (Crop growth rate) (a), RGR (Relative growth rate) (b) and NAR (Net assimilation rate) (c) of alfalfa under the uncut condition

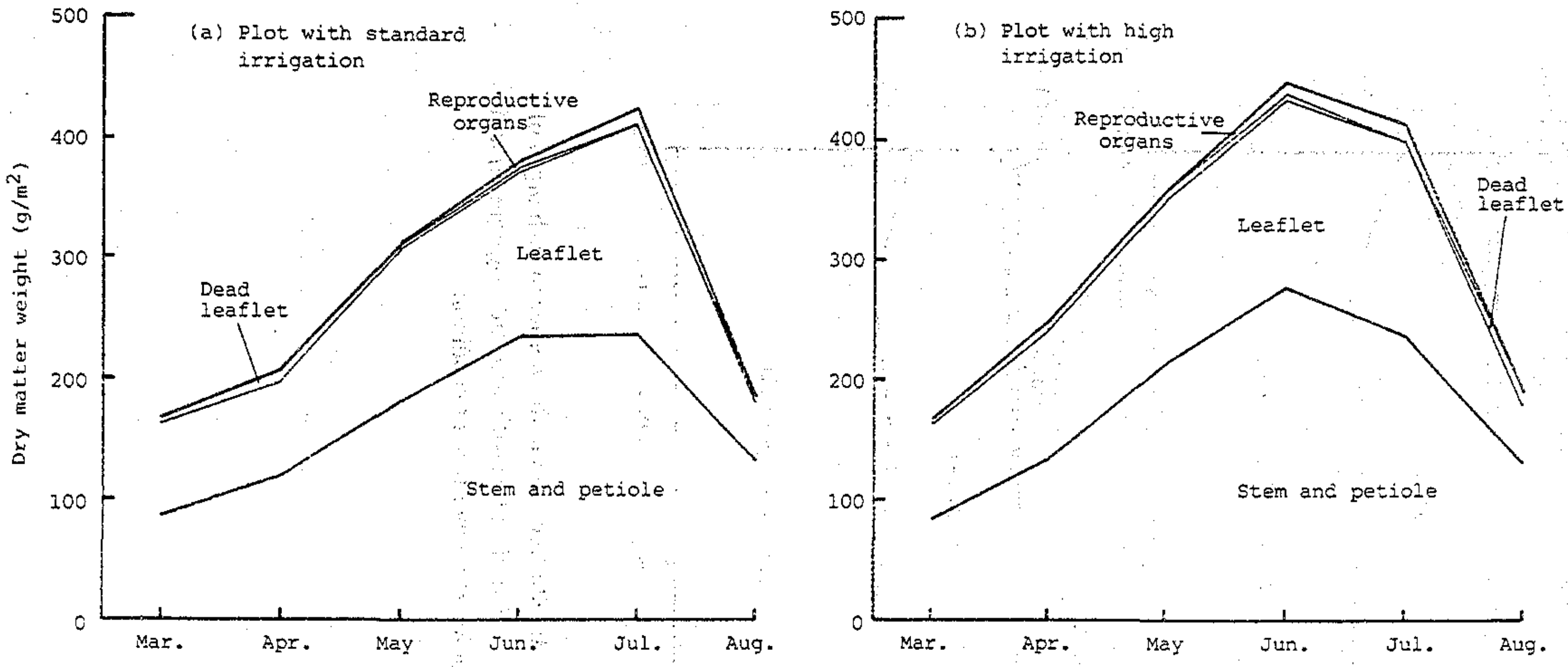


Fig. 12. Changes in total dry weight and the dry weight of each part of alfalfa per 1 × 1 m^2 in the plots with standard irrigation (a) and with high irrigation (b) under the cut condition

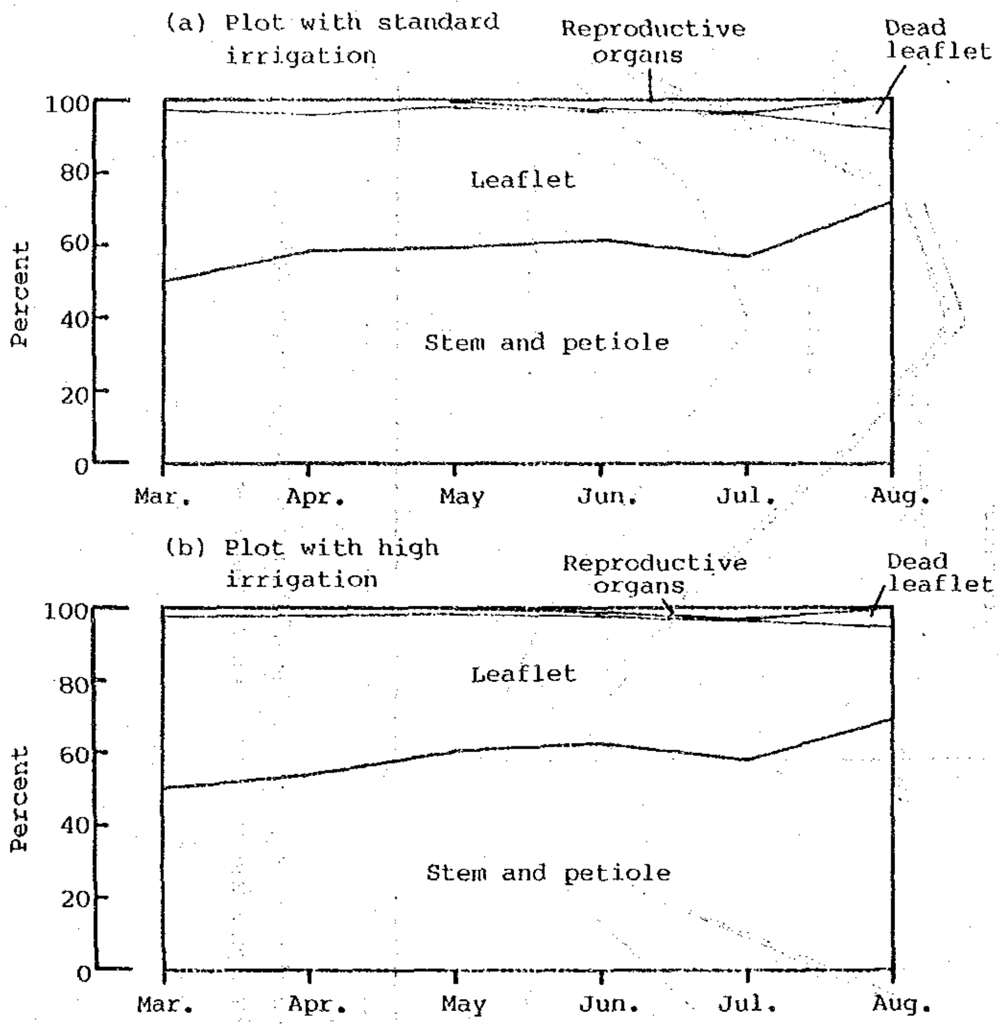


Fig. 13. **Changes in the distribution ratio of dry matter to each organ of alfalfa per 1 x 1 m^2 in the plots with standard irrigation (a) and with high irrigation (b) under the cut condition**

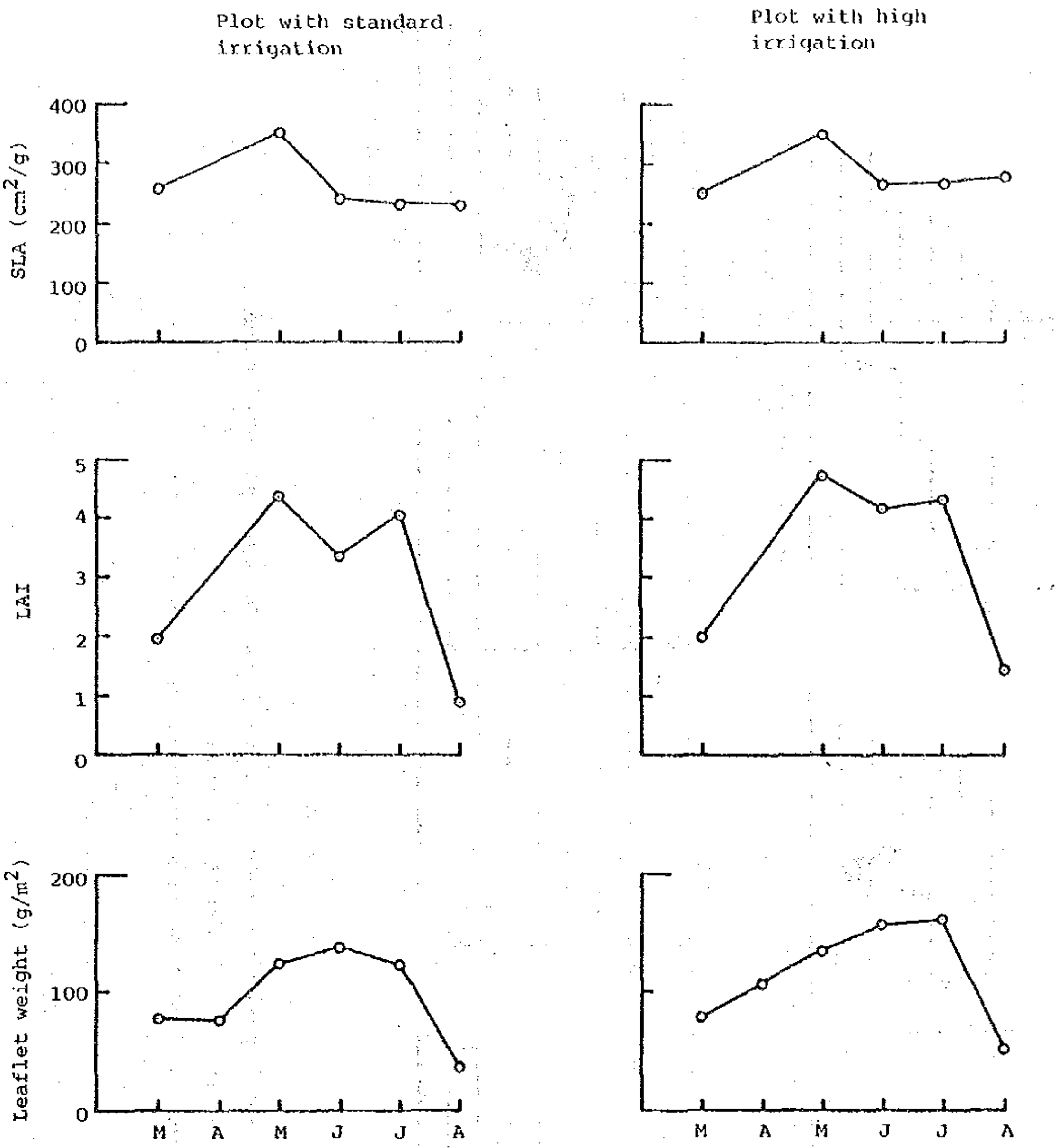


Fig. 14. Changes in SLA, LAI and leaflet weight of alfalfa in the plots with standard irrigation (left fig.) and with high irrigation (right fig.) under cut condition

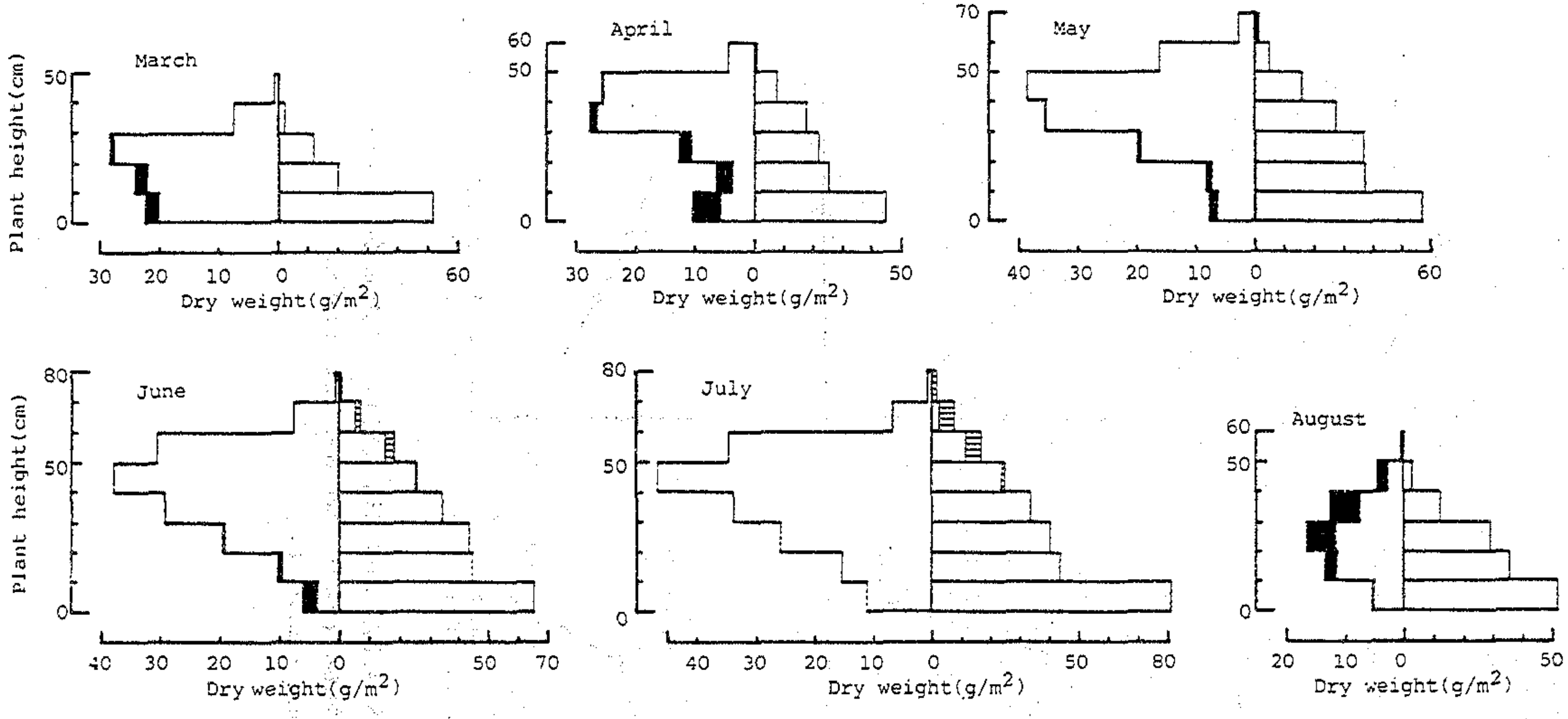


Fig. 15. Changes in productive structure of alfalfa in the plot with high irrigation and cut
In left fig. □ alive leaflet, ■ dead leaflet
In right fig. □ stem and petiole, ▤ flower bud, flower and pod

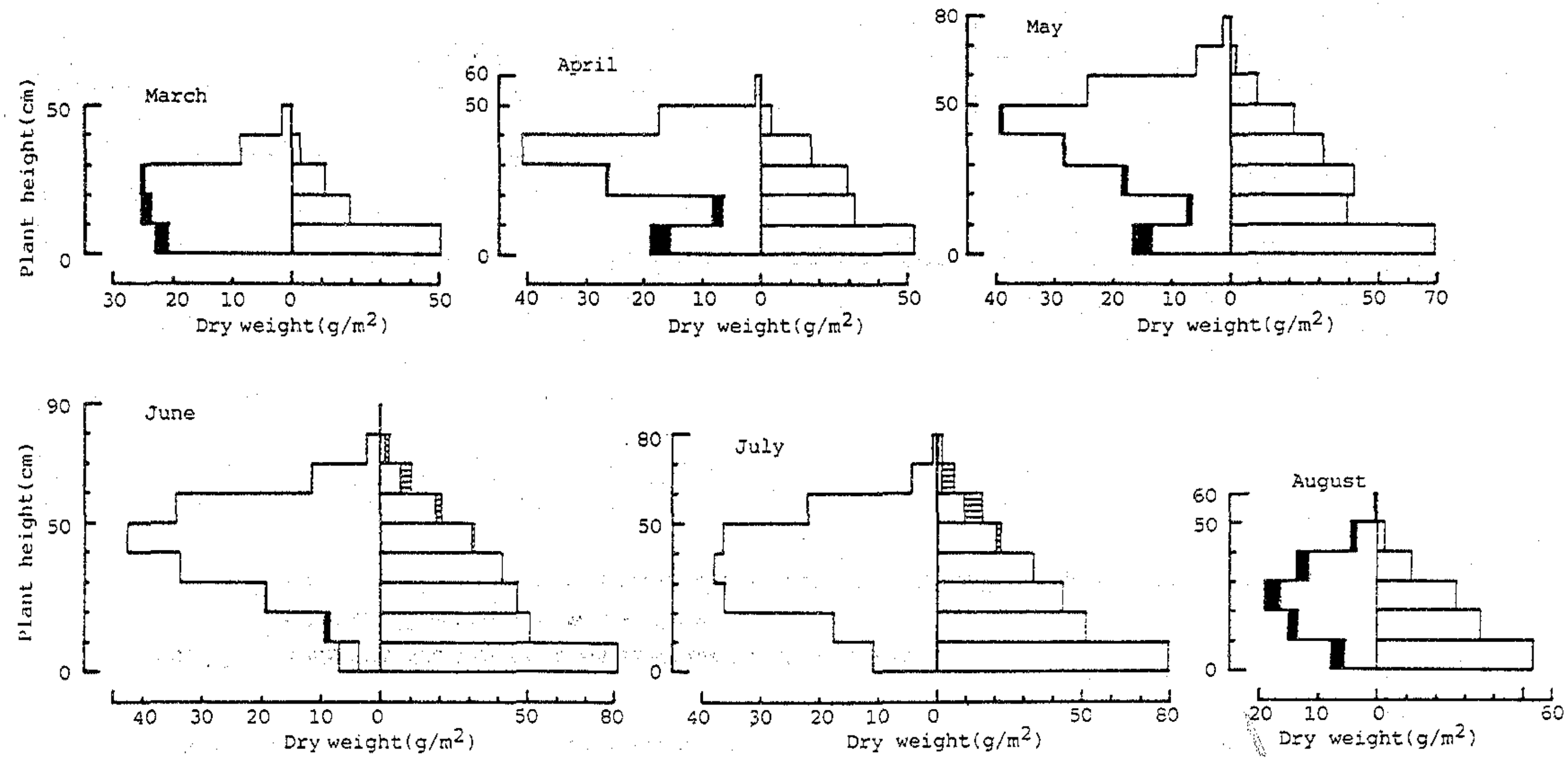


Fig. 16. **Changes in productive structure of alfalfa in the plot with standard irrigation and cut**
In left fig. □ alive,leaflet, ■ dead leaflet
In right fig. □ stem and petiole, ▤ flower bud, flower and pod

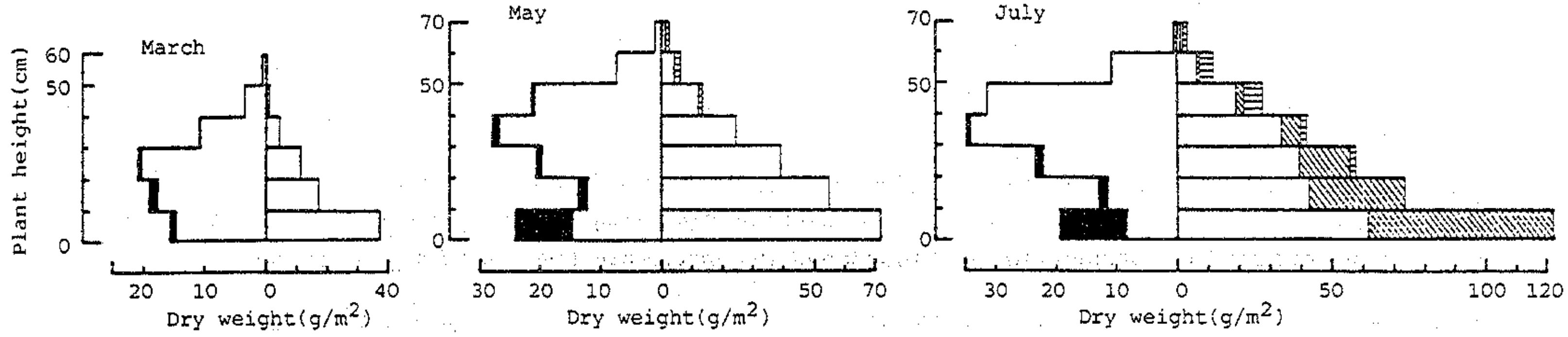


Fig. 17. Productive structure of alfalfa under the uncut condition

In left fig. □ alive leaflet, ■ dead leaflet

In right fig. □ alive stem and petiole, ▨ dead stem and petiole, ▤ flower bud, flower and pod

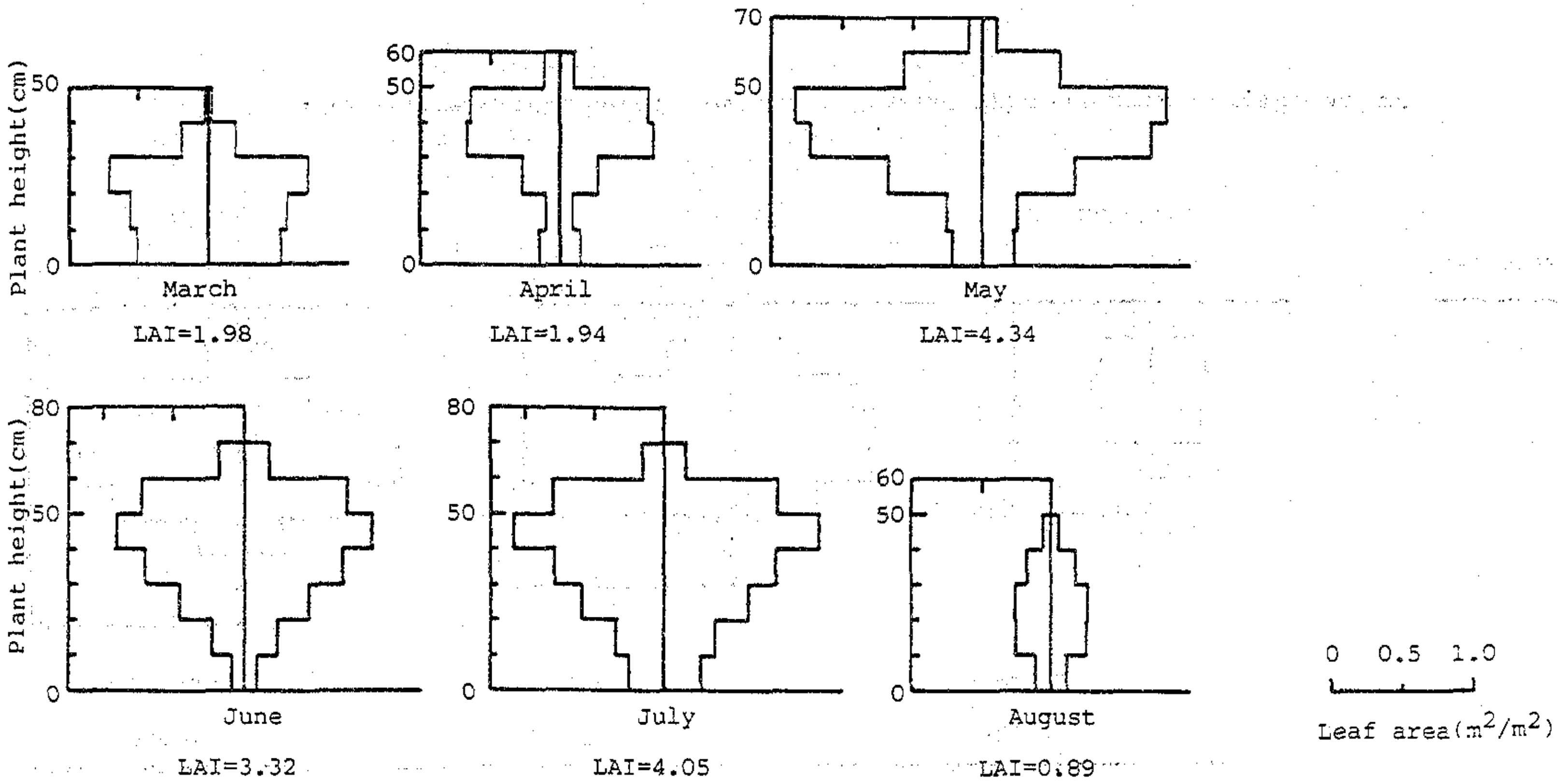


Fig. 18. Changes in vertical distribution of leaf area of alfalfa in the plot with high irrigation and cut

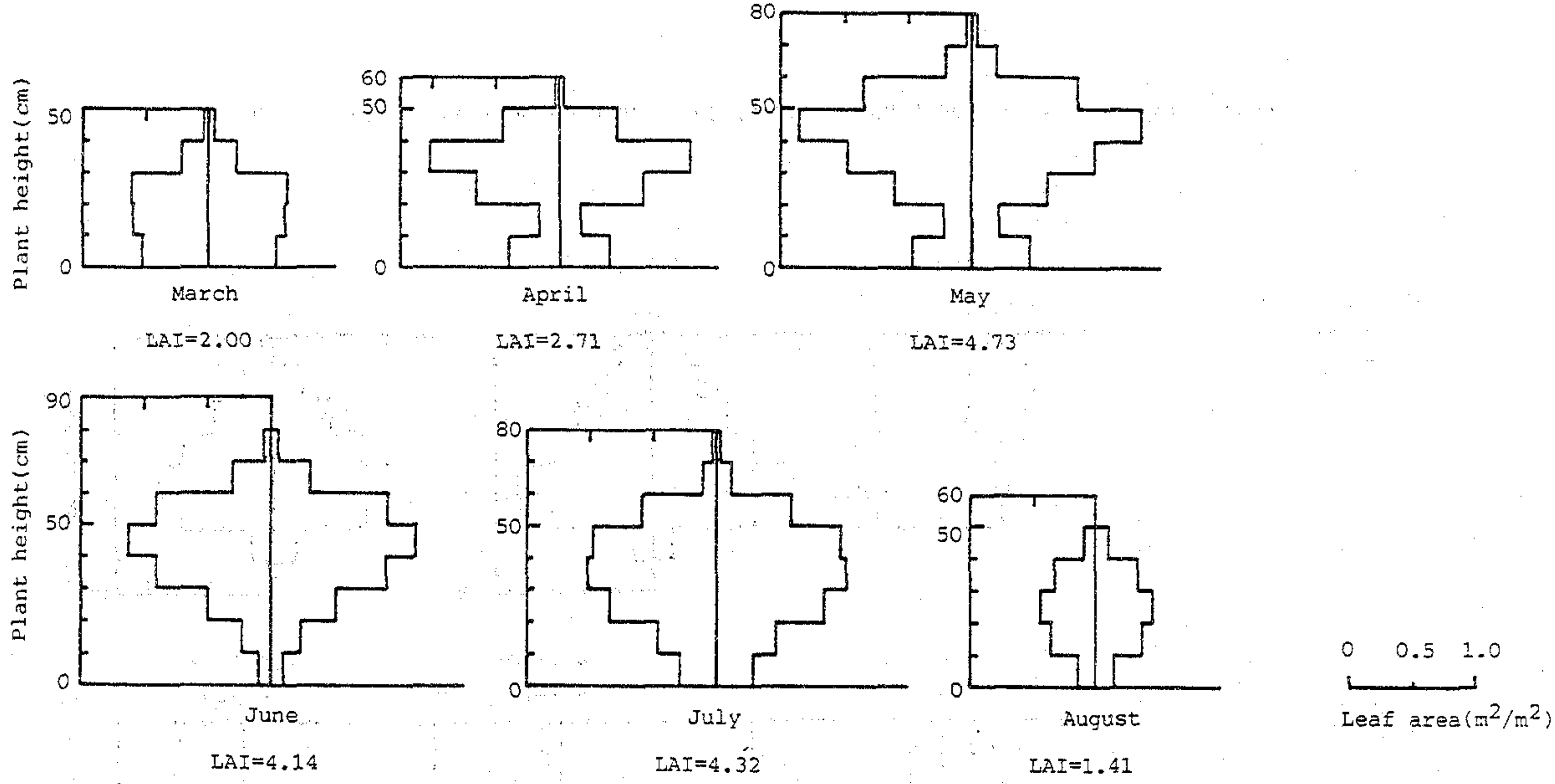


Fig. 19. Changes in vertical distribution of leaf area of alfalfa in the plot with standard irrigation and cut

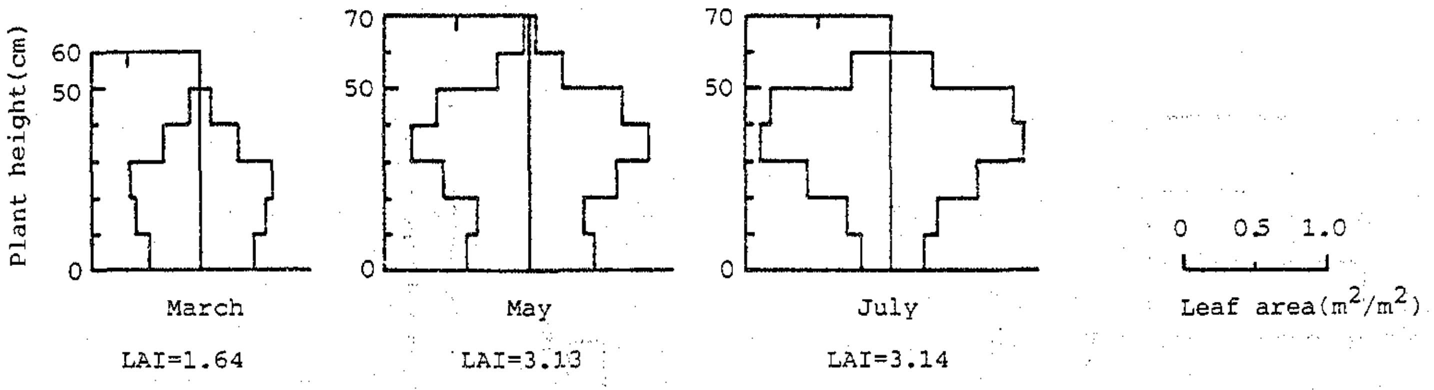


Fig. 20. Vertical distributions of leaf area of alfalfa under the uncut condition

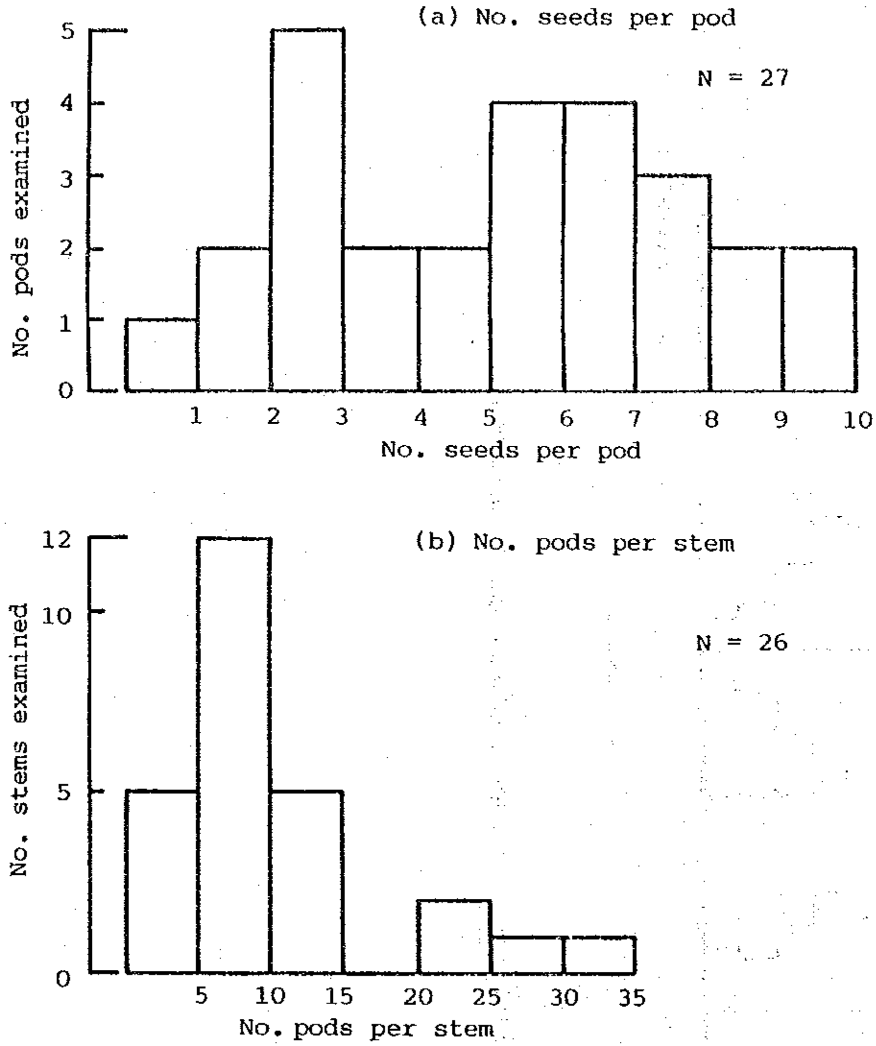


Fig. 21. Frequency distributions of the number of seeds per pod (a) and the number of pods per stem (b) of alfalfa under the uncut condition on 30 June, 1986

Table 1. Means and standard deviations of seed yield components of alfalfa under the uncut condition on 30 June, 1986

No.stems (No./0.25m^2)	(1) No.stems with mature pods	(2) No.stems with flowers or immature pods	(1) + (2)	Stem length (cm)	No.pods per stem	No.seeds per pod	100 seed weight(g)
319.3±125.6	13.7±6.5	15.7±19.4	29.3±13.7	56.1±6.1	10.2±4.2	5.5±1.6	0.250±0.026

Means and standard deviations were calculated on the data of plot means.

(2) Growth Analysis of Wheat

ABSTRACT

Dry matter production and its processes were studied for wheat (cultivar: MEXIPAK). Wheat seeds were sown on 27 November 1986 and sampled regularly from 24 December 1986 to 13 March 1987.

LAI was high, 5.19, in middle of January and then decreased as leaf weight decreased. CGR was high, 27.41 $g/m^2/day$, from late December to middle of January, and then decreased till late January, followed by a peak of 35.50 $g/m^2/day$ in early February. NAR also had a peak of 16.31 $g/m^2/day$ in early February.

In analyzing the productive structure at the full culm elongation stage, a major part of leaf weight distributed at the layers of 20 – 40 cm, and ear weight distributed mainly at the layers of 50 – 70 cm, which were the upper layers of this wheat field. Flag leaf was likely to grow horizontally but second and third leaves grow more erectly in the same stage.

In the yield component analysis, spike number, kernels per spike and 100 grain weight were 277.3 spikes/m^2, 30.6 and 3.26 g in average, respectively, resulting in the grain yield of 276.6 g/m^2.

MATERIALS AND METHODS

Seeds of wheat (cultivar: MEXIPAK) were row-seeded at the rate of 150 kg/ha on 27 November 1986, with the interrow space of 15 cm. The basal fertilizer was applied at the rate of 42 kg N/ha, 110 kg P_2O_5/ha, 96 kg K_2O/ha and 20 tons/ha of Al Ain compost. Top dressing was also applied at each rate of urea; 100 kg/ha on 21 December 1986, 10 January and 9 February 1987.

The plot, which was 24.7 x 33.0 m in size, was set up adjacent to the alfalfa plots. No replication was planned because the objectives was to examine firstly the property of dry matter production and its process of the wheat cultivar used locally under the condition of the local standard cultivation. The plot was irrigated by the sprinkler irrigation system, the positions of nozzles being shown in Fig. 1. It was irrigated at the rate of 10 mm/day from the seeding to 3 December for the good establishment of seedlings. Then irrigation amount was 5.0 mm/day from 4 December to 12 December, 5.0 mm in every two days from 13 December to 14 February and 10.0 mm in every two days from 15 February to 10 March. Irrigation was stopped on 10 March.

Wheat plants were examined on 24 December and about every two weeks from 16 January to 13 March. All plants were sampled from three quardrats placed randomly in the plot, each size was 20 x 20 cm, on each sampling date after the measurement of plant number. They were measured for plant height and tiller number, then separated into leaf blade, culm (including leaf sheath), root, dead leaf blade and ear, and then weighed after drying at 80°C for 48 hours. Roots were excavated from soils about 10 cm in depth and then rinsed for weighing. Leaf areas and weights were measured by photocopy method on all dates. These data were used to calculate the following growth parameters; RGR, NAR, LAR, CGR and LAI.

The stratified clipping was made in three quadrats placed randomly, each size was 50 x 50 cm, on 16 February in order to analyze the productive structure of wheat at the full culm elongation stage. All wheat plants in each quadrat were cut at the intervals of 10 cm perpendicularly from the ground level. Samples of each layer (0.1 x 0.5 x 0.5 m) were separated into leaf blade, culm (including leaf sheath), dead leaf blade and ear, and weighed after drying at 80°C for 48 hours. Leaf areas and weights were also measured for a part of leaves. Leaf areas were measured by photocopy method. In addition 5 average culms with spikes were selected for the measurement of the following morphological characters in each quadrat; culm length, spike length, awn length, the length, breadth, and the inclination of flag leaf, second leaf and third leaf.

Final harvest was made on 17 – 18 March. Three quadrats (each size was 1.00 x 1.05 m) were sampled for the yield component analysis. After the number of culms and spikes were measured, 10 average culms with spikes were selected from each quadrat in order to examine their culm length, spike length and the number of kernels per spike. Kernel weight was also measured 4 times per quadrat after air drying.

RESULTS AND DISCUSSION

Morphological characters, dry matter weight and dry matter partitioning ratio:

The morphological characters and productive performances per plant are shown in Fig. 22 to Fig. 25. Fig. 22 shows the changes in plant height, the number of tillers and the weight of a single tiller. Plant height which was 24.2 cm on the first sampling date, increased linearly to 62.9 cm on 13 February. Single tiller weight also increased almost linearly till 13 February, reaching 1.44 g. Tiller number per plant, however, did not increase during the study period, fluctuating between 1.3 and 2.1.

Fig. 23 and Fig. 24 show the changes in shoot weight and those in total dry weight, respectively. Total dry weight increased rapidly till 13 February, followed by small decrease after that. Culm length also increased rapidly till 13 February, followed by decrease after that, while root weight did not change clearly during the study period. Leaf blade weight decreased almost linearly after 30 January, resulting in little weight on 13 March. In contrast, spike weight increased rapidly from 30 January to 13 March, reached to 1.05 g on the final date.

Fig. 25 shows the changes in dry matter partitioning ratio. Root ratio decreased rapidly from 16 January (36.8%) to 13 February (14.1%), while culm ratio increased from 24 December (27.7%) to 30 January (42.4%), followed by decrease to 28.8% on 13 March. Leaf blade ratio decreased rapidly from 24 December (48.1%) to 13 March (only 0.1%). In contrast, ear ratio increased from 30 January to 13 March, reached to 45.2%.

The productive performances per unit area (1 x 1 m) are shown in Fig. 26 to Fig. 29. Fig. 26 shows the changes in plant number and tiller number. Plant density was high in the early growth stage, 769.3 plants/m^2 and 883.3 plants/m^2 on 24 December and 16 January, respectively, but decreased slowly after that, resulting in the density of 556.7 plants/m^2 on 13 March. Extremely dropping on 30 January may be due to the sampling error. Tiller density, which was 1408.0 tillers/m^2 on 24 December, generally decreased as time passed to 983.3 tillers/m² on 13 March. The reason of the extreme value on 13 February (1375.0 tillers/m²) was not clear.

Fig. 27 shows the change in shoot weight per unit area (1 × 1 m). It increased till 13 February, followed by a small decrease after that. It was 1284.97 g/m² on 13 February and 1072.92 g/m² on 13 March. Fig. 28 shows the changes in total dry weight. It changed in a similar manner with shoot weight. It was 1491.67 g/m² on 13 February and 1211.25 g/m² on 13 March. Root weight increased to 310.50 g/m² on 16 January, followed by a slow decrease to 138.33 g/m². Culm weight also increased to 628.28 g/m² on 13 February, followed by the rapid decrease to 340.25 g/m², which was 54.2% of the maximum. Leaf blade weight increased till 16 January (197.67 g/m²), followed by the rapid decrease to only 1.25 g/m² on 13 March. In contrast, spike weight increased steadily to 571.33 g/m² on 13 March.

Fig. 29 shows the changes in dry matter partitioning ratio. The ratio of each organ had similar change with each weight. Root ratio increased to 39.6% on 16 January, followed by the decrease. Stem ratio increased to 41.1% on 30 January, followed by the decrease from 27 February to 13 March, resulting in the ratio of 28.7%. In contrast, spike ratio increased rapidly as time passed, with the maximum of 45.7% on 13 March.

Growth parameters:

Fig. 30 shows the changes in SLA, leaf weight and LAI. SLA decreased to 209.21 cm²/g on 30 January followed by the decrease to 262.81 cm²/g on 13 March, while it was large, 344.88 cm²/g, on 24 December. LAI was high, 5.19, on 16 January, while it was low, 2.56, on 24 December. After that, LAI decreased as leaf weight decreased.

Fig. 31 shows the changes in CGR, RGR and NAR from 25 December to 13 February. CGR was high, 27.41 g/m²/day, from late-December to mid-January. It decreased after that, but it had a peak, 35.50 g/m²/day, in early-February, RGR, which was 0.00647 g/g/day at the early growth stage, decreased rapidly as time passed. On the other hand, NAR had a high peak, 16.31 g/m²/day, in early-February.

Productive structure:

Fig. 32 shows the productive structure at the full culm elongation stage of wheat. Most leaf blade weight distributed at the layers of 20 – 40 cm but more dead leaf blade weight distributed at the lower layers than those. Culm weight was also larger at the lower lalyers. In contrast, spike weight distributed mainly at the layers of 50 – 70 cm, which were top layers of this wheat field. Leaf area was larger at the layers of 30 – 50 cm but only small at the upper layers (Fig. 33).

Table 2 shows culm length, spike length, awn length and the length, breadth and the inclination of flag leaf, second leaf and third leaf at the full culm elongation stage. Spike length and awn length were 8.4 cm and 5.90 cm in average, respectively. The breadth of leaf was larger in flag leaf but the length was longer in third leaf, resulting in large leaf area in flag leaf and second leaf. Fig. 34 shows leaf inclinations of the upper three leaves. Flag leaf was likely to grow horizontally but second and third leaves grow more erectly.

Yield components:

Table 3 shows the yield components of wheat. The numbers of culms and spikes were 356.0 culms/m^2 and 277.3 spikes/m^2 in average, respectively. Kernels per spike and 100 kernel weight were 30.6 and 3.26 in average, respectively. These components gave the estimate of grain yield of 276.6 g/m^2 in this plot.

Fig. 35 shows the frequency distribution of kernel number per spike. Many spikes had 25 – 35 kernels, ranging from 23 to 57.

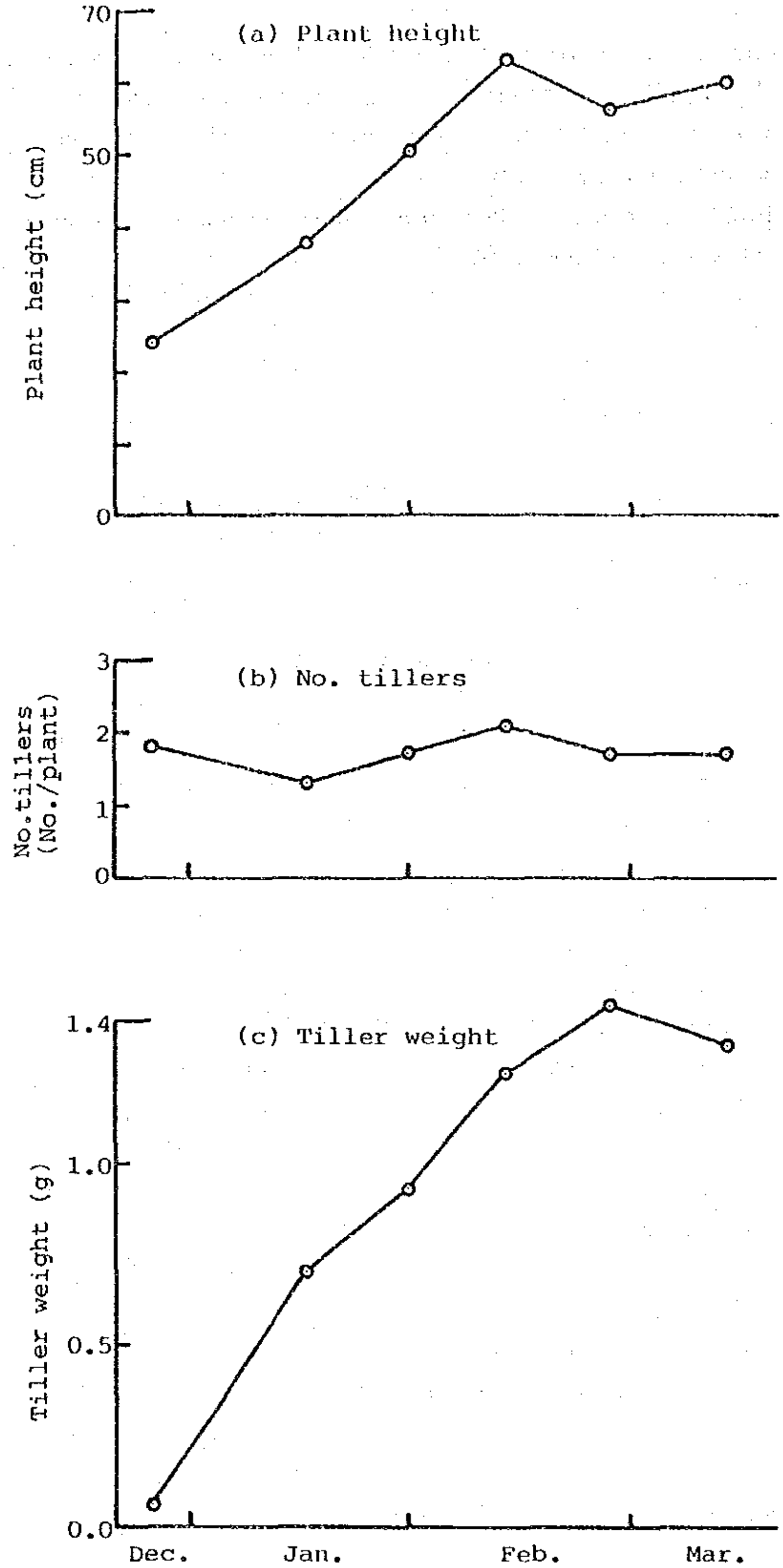


Fig. 22. Changes in plant height (a), number of tillers per plant (b) and tiller weight (c) of wheat

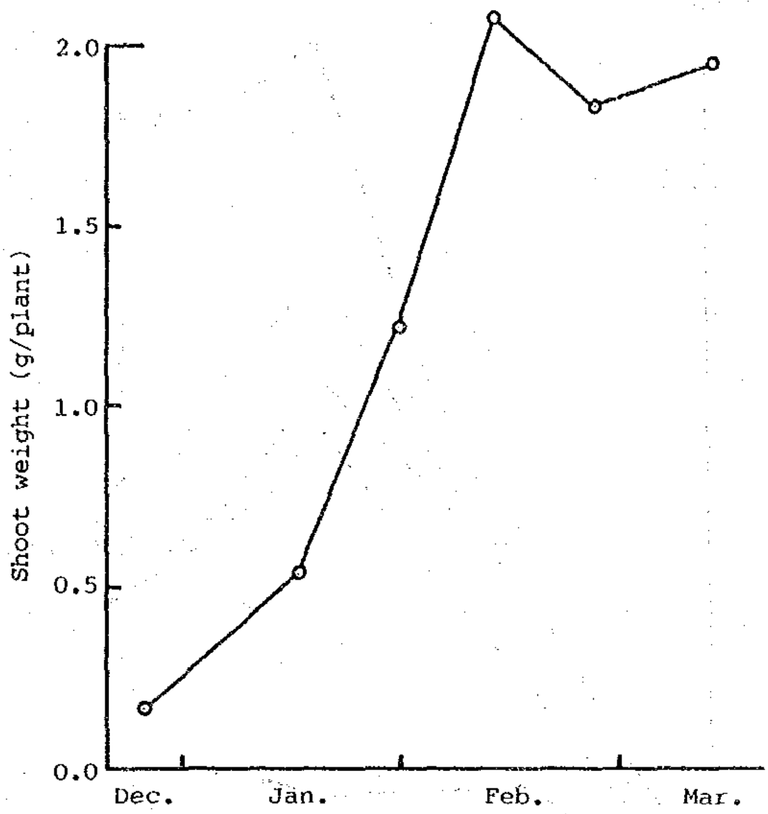


Fig. 23. Changes in shoot weight per plant of wheat

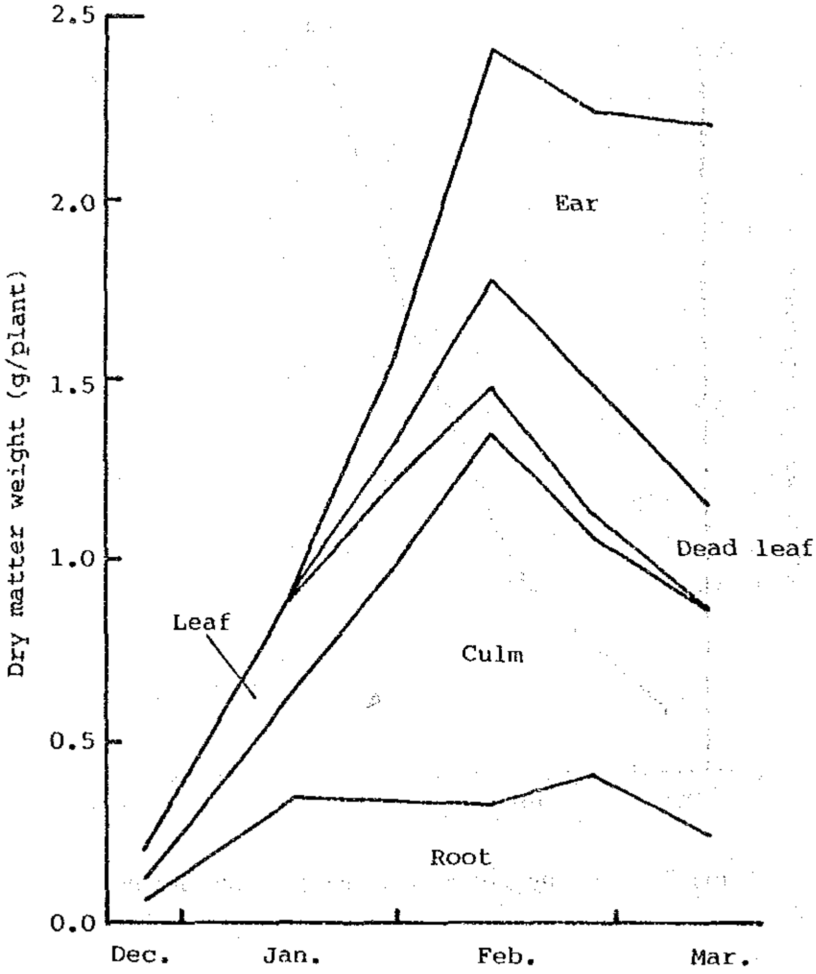


Fig. 24. Changes in total dry weight per plant and the dry weight of each part (root, culm, leaf, dead leaf and ear) of wheat

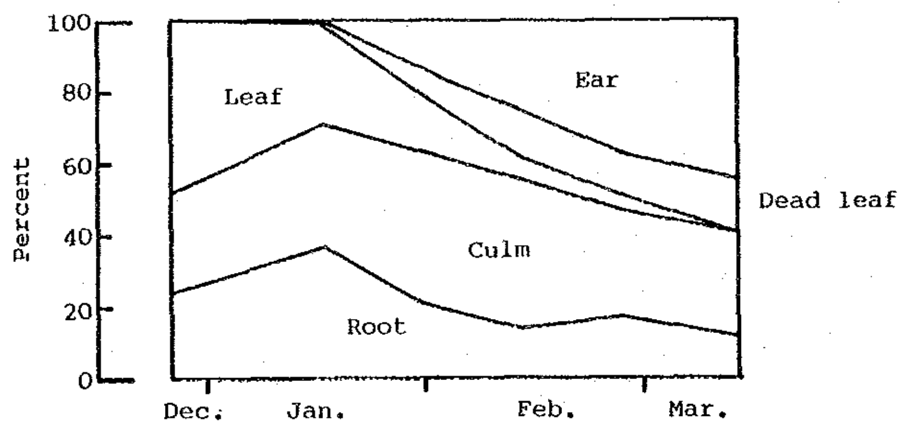


Fig. 25. Changes in the distribution ratio of dry matter to each part of wheat

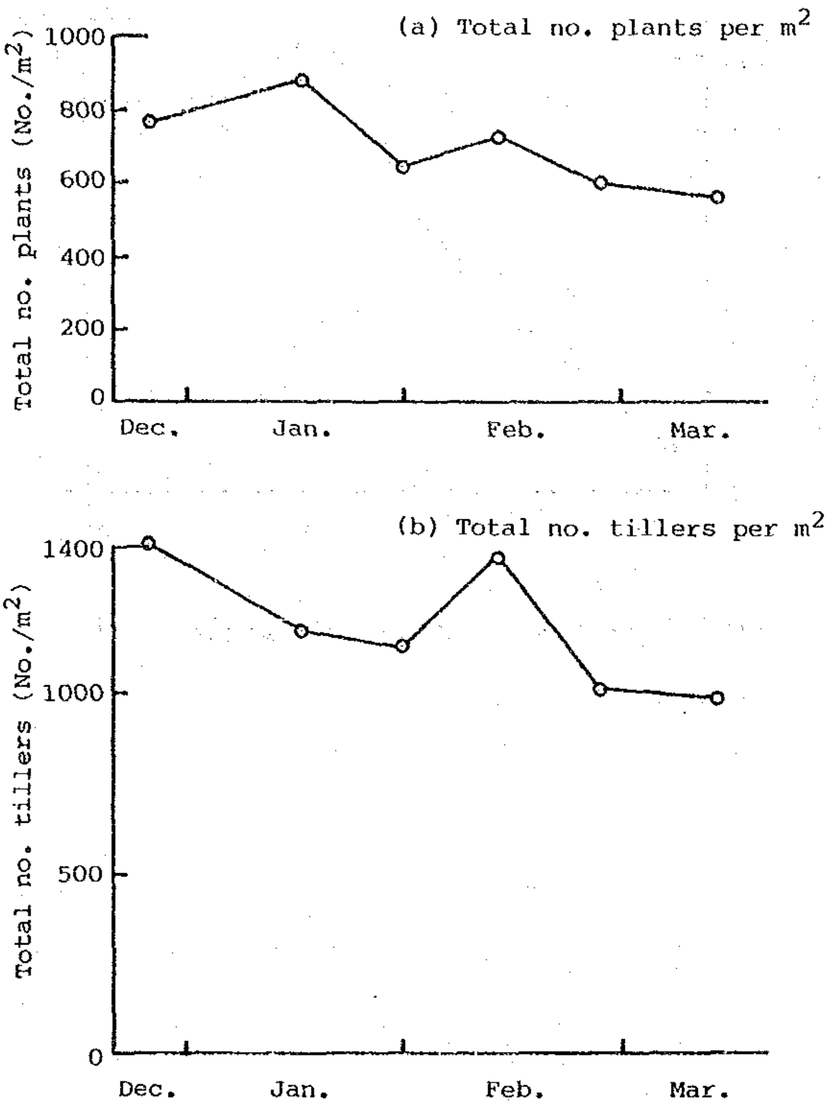


Fig. 26. **Changes in total number of plants (a) and tillers (b) per 1 x 1 m^2 of wheat**

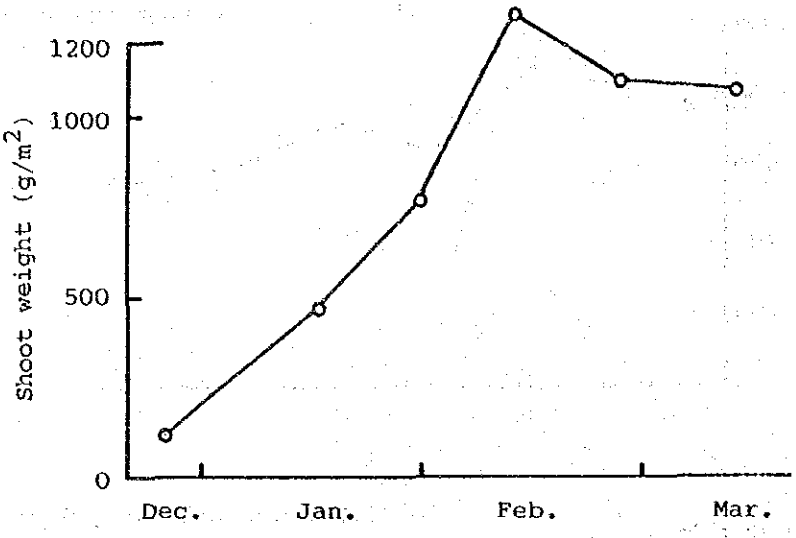


Fig. 27. Changes in shoot weight of wheat per 1 × 1 m²

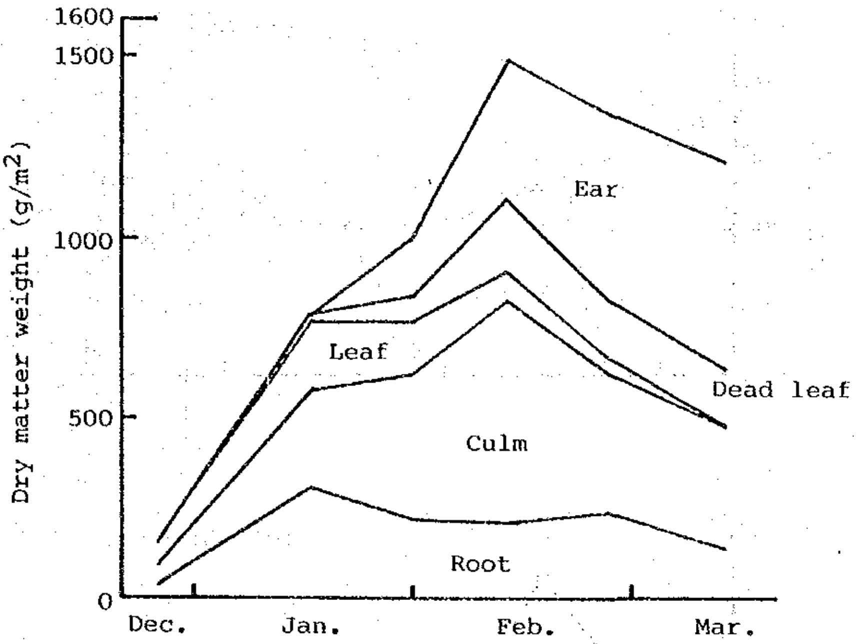


Fig. 28. Changes in total dry weight and the dry weight of each part of wheat per $1 \times 1\ m^2$

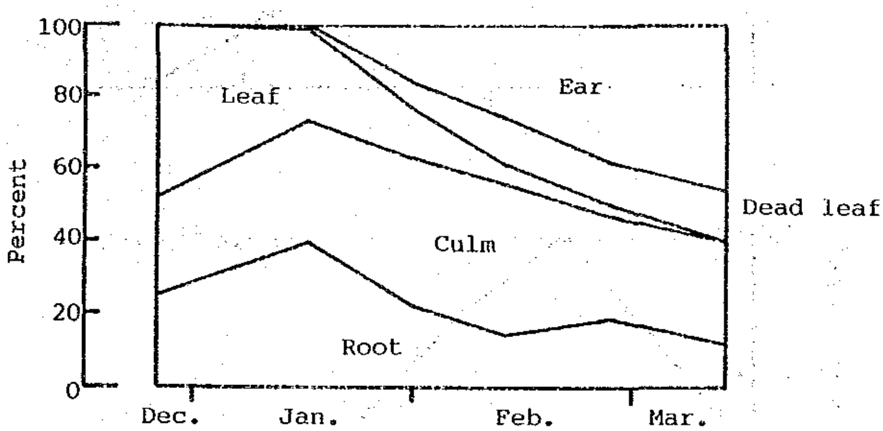


Fig. 29. Changes in the distribution ratio of dry matter to each part of wheat per $1 \times 1\ m^2$

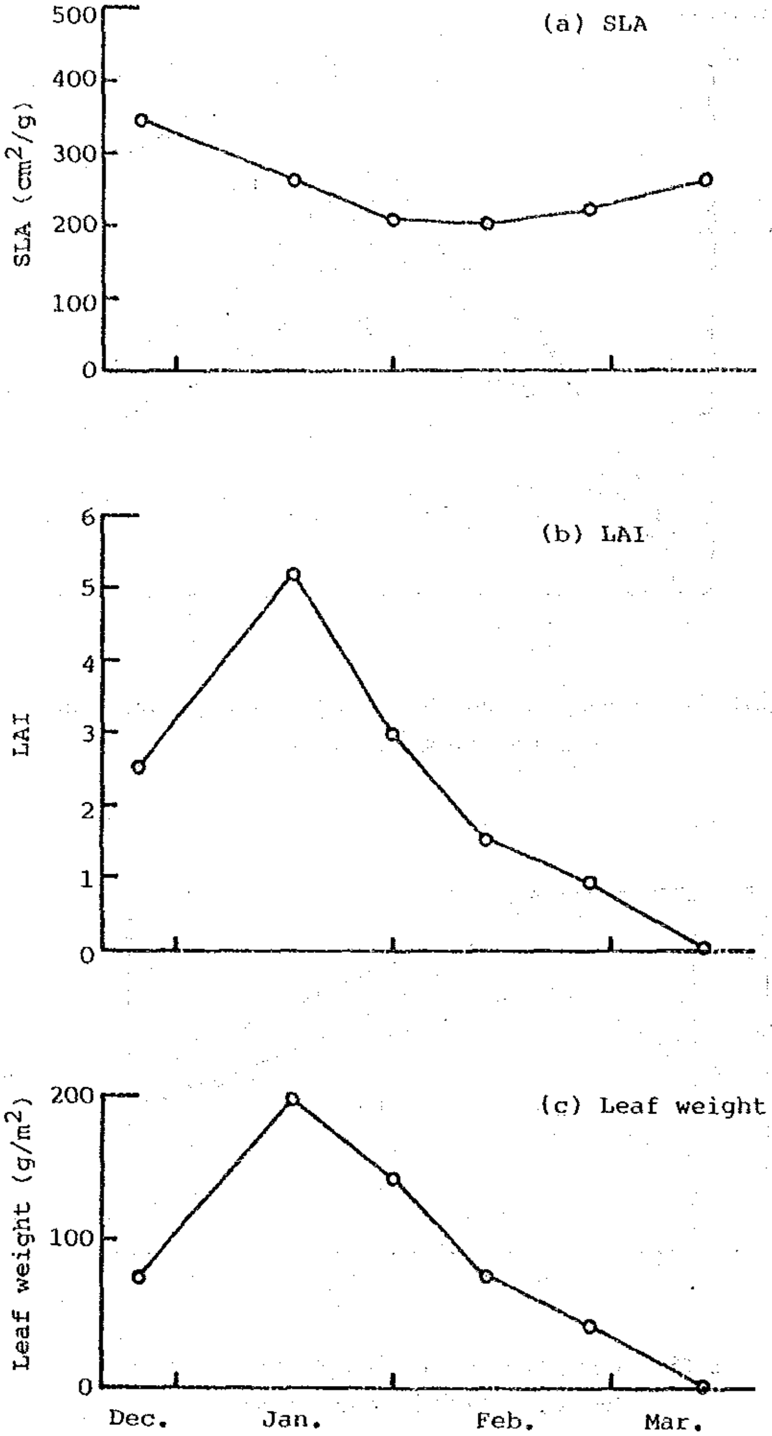


Fig. 30. Changes in SLA (a), LAI (b) and leaf weight (c) of wheat

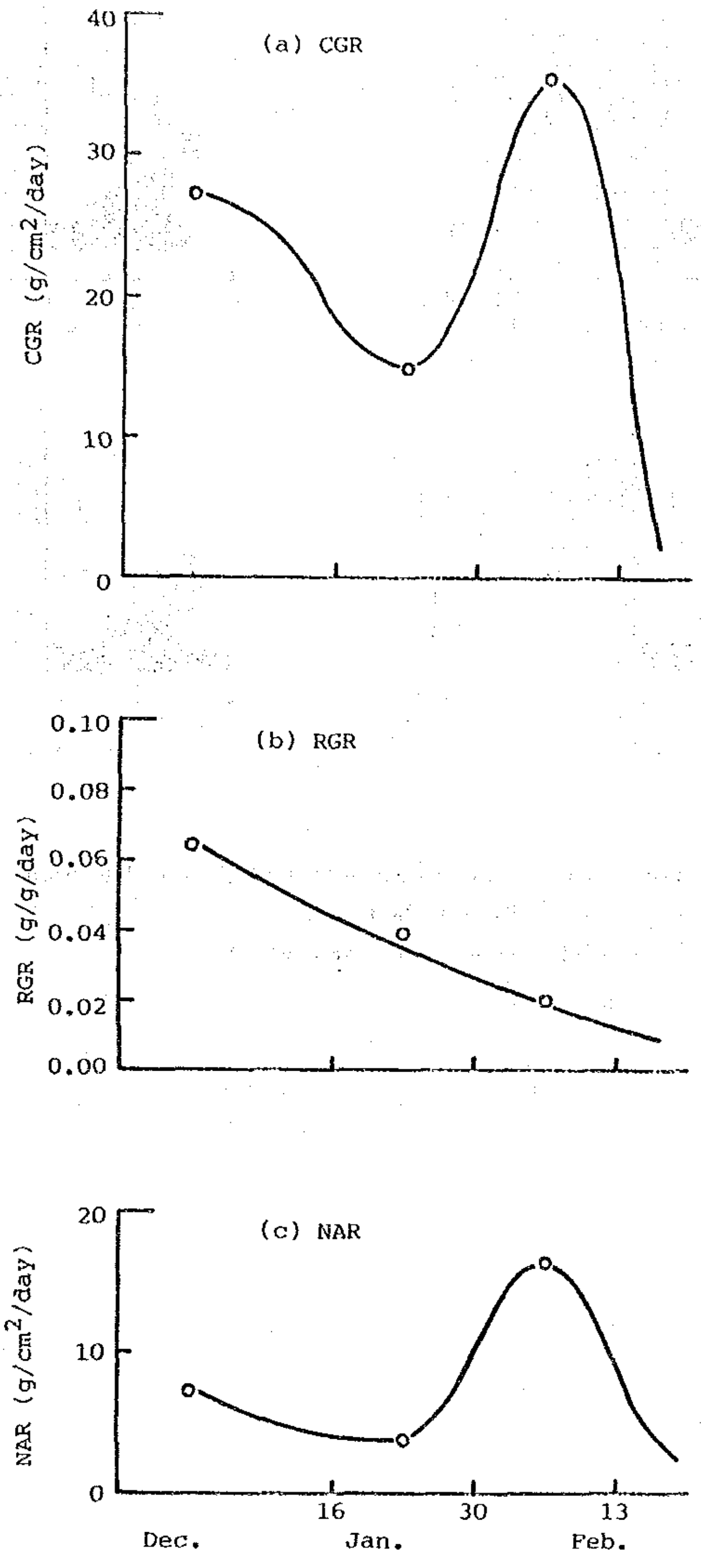


Fig. 31. Changes in CGR (a), RGR (b) and NAR (c) of wheat

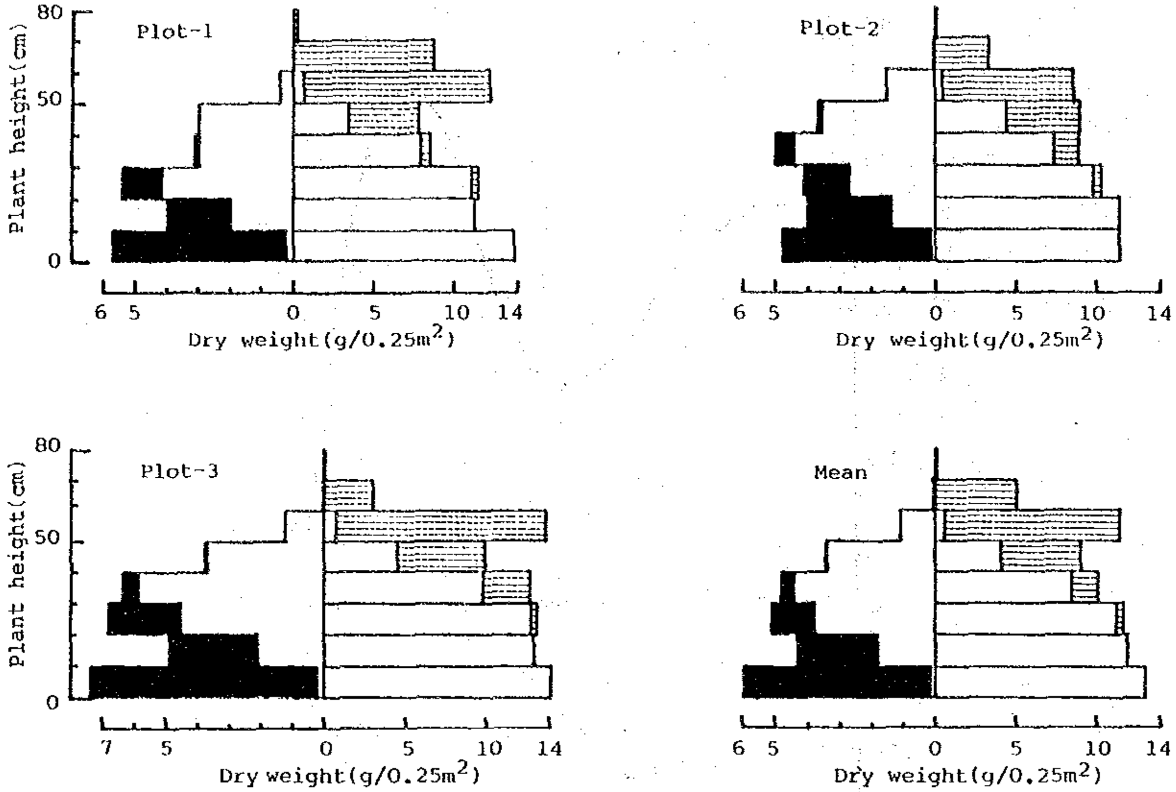


Fig. 32. Productive structure of wheat at the full-culm elongation stage
In left fig. □ alive leaf, ■ dead leaf
In right fig. □ culm + leaf sheath, ▤ ear

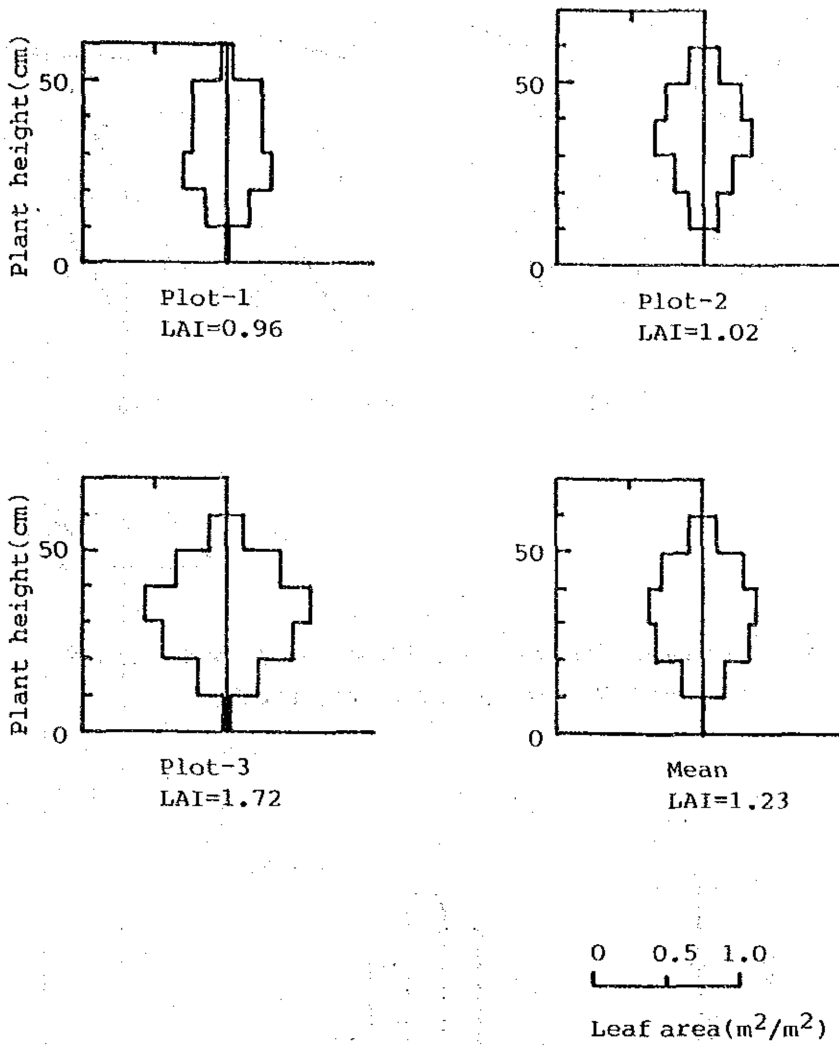


Fig. 33. Vertical distribution of leaf area at the full-culm elongation stage

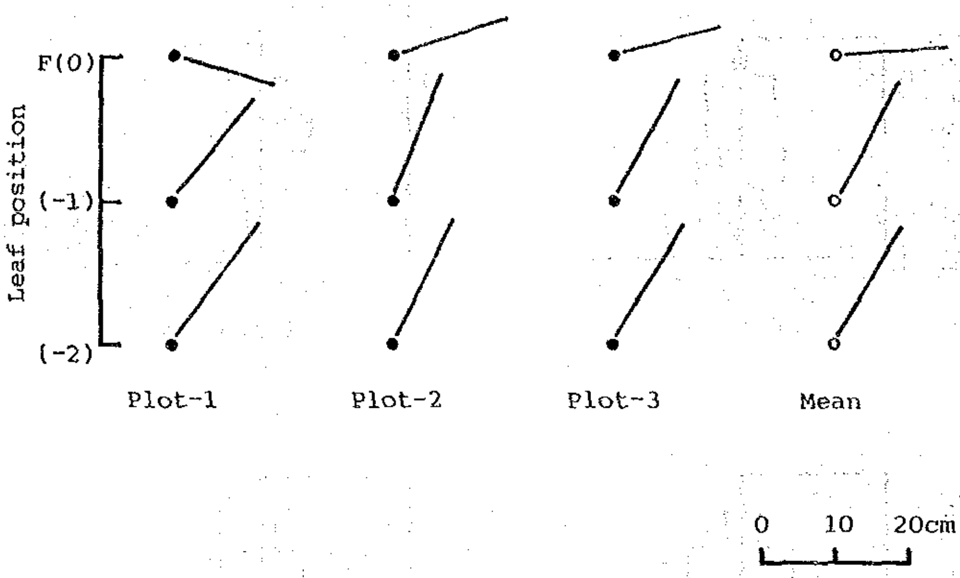


Fig. 34. Leaf inclination of flag leaf (F), penultimate leaf (−1) and third leaf (−2) at the full-culm elongation stage

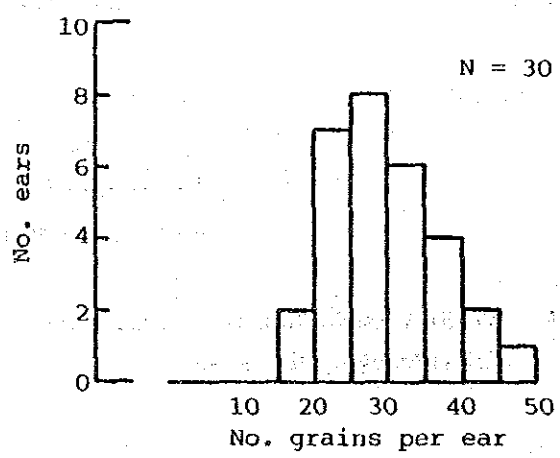


Fig. 35. Frequency distribution of the number of grains per ear of wheat

Table 2. **Means and standard deviations of several morphological characters of wheat at the full-culm elongation stage**

Characters	Plot-1	Plot-2	Plot-3	Means of plots
	(5)*	(5)	(5)	
Ear length(cm)	8.4±0.4	8.8±0.9	8.1±0.8	8.4
Culm length(cm)	52.0±4.2	46.4±2.8	53.2±3.4	50.5
Awn length(cm)	5.8±0.7	6.0±0.5	5.9±0.3	5.9
Flag leaf				
length(cm)	13.9±1.6	16.6±2.8	15.0±1.8	15.2
breadth(cm)	1.2±0.2	1.5±0.2	1.3±0.1	1.3
area(cm^2)	17.2±4.7	25.4±7.1	20.2±4.2	20.9
Second leaf				
length(cm)	17.2±1.9	19.0±1.6	18.5±1.1	18.2
breadth(cm)	0.9±0.2	1.2±0.1	1.1±0.1	1.1
area(cm^2)	16.0±4.0	22.5±3.7	21.2±2.5	19.9
Third leaf				
length(cm)	19.9±2.0	18.9±1.9	18.7±0.8	19.2
breadth(cm)	0.8±0.1	1.0±0.0	0.9±0.1	0.9
area(cm^2)	15.2±2.9	18.5±1.8	16.1±1.4	16.6

* The number of samples examined was indicated in parenthesis.

Leaf area was calculated as the product of leaf length and leaf breadth.

Table 3. Means and standard deviations of grain yield components of wheat

No.culms (No./m^2)	No.ears (No./m^2)	Culm length (cm)	Ear length (cm)	No.grains per ear	No.grains (No./m^2) ($x10^3$)	100 grain weight (g)
356.0±26.2	277.3±49.5	50.4±2.6	8.6±0.2	30.6±2.1	8.43±1.12	3.26±0.49

Means and standard deviations were calculated on the data of plot means.

(3) The Pattern of Dry Matter Production in a 6 Year-old Sward of Alfalfa located in Al Ain City, UAE in September 1986

ABSTRACT

The pattern of dry matter production was studied in a 6 year-old sward of alfalfa located in Kuwaitat Agricultural Station, Al Ain city in September 1986.

Alfalfa plant density and shoot dry weight were 23.8 plants/m^2 and 99.54 g/m^2 on average, respectively. Individual shoot weight was 4.87 g on average. The proportions of dry matter allocated into the organs (leaf, stem and reproductive organs) were measured, 44.5% of dry matter being allocated into leaf, 54.3% into stem, and only 1.2% into reproductive organs on average. Specific leaf area (SLA) and Leaf area index (LAI) were 205.1 cm^2/g and 0.91, respectively.

The distribution of dry matter into the different organs including root, only 5.6% and 8.6% of dry matter were allocated into leaf and stem, respectively, but 82.8% into root, on average.

The study of the productive structure using the stratified clip method showed that most of leaves distributed at the layers of 25 – 35 cm above the ground level but stem dry weight was larger at the lower layers.

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is well adapted to a wide range of environment and also well adapted to the dry climate on the irrigated soil. It has been one of the most valuable forage crops for camel and sheep in the United Arab Emirates (UAE). The annual production of alfalfa is estimated to be 109,000 tons in UAE. Its importance seemed to increase for forage use in future. It is, therefore, necessary to increase the yield per unit area.

The knowledge of the pattern of dry matter production is necessary to attain the high yields of crops. Few studies, however, had been carried out on the above subject in the considerably severe drought areas such as UAE, which has the annual precipitation of approximately 50 mm and the maximum temperature of 50°C.

The objectives of this study is to clarify the property and the processes of dry matter production of alfalfa in the area of Al Ain city.

MATERIALS AND METHODS

The following observations were made in the 6 year-old sward of alfalfa in Kuwaitat Experimental Station in Al Ain city, UAE: (1) Dry matter allocation and leaf area, (2) Dry matter allocation including root, (3) Productive structure using the stratified clipping method.

The cultivated method and the managements of alfalfa in this station were reported elsewhere (JICA, 1987). The variety cultivated was "OMANI". Alfalfa plants were cut manually 12 times per year, the intervals of cutting being 25 days in summer but 30 – 35 days in winter. The level of cutting was at ground level. The swards were irrigated by the sprinkler system, the amount of irrigation being 2 hours per day in summer and 1 hour per day in winter.

All observations were made during 10 – 14 September 1986 when the swards were about to be cut. Five 1 x 1 m quadrats (Quadrats 1, 2, 3, 4 and 5) were set up and all alfalfa plants were sampled from each quadrat. Sampling of alfalfa was made by scissors at 5 cm above the ground level, then used for the measurements. Of Quadrat 1, the spatial distribution of alfalfa plants was recorded into a map. Forty-seven plants in Quadrat 1 and 3 were recorded for their growth stage, plant height and the number of stems, and then separated into leaf, stem and reproductive organs such as flower and flower bud, and weighed after drying at 80°C for 48 hours. Of Quadrat 5, four plants were measured for only shoot dry weight. Of Quadrat 4, the number of plants were counted at the sampling, and the weight of whole plants were measured.

Five alfalfa plants were excavated from 15 cm under the soil in order to understand roughly the property of dry matter allocation into the organs including root. They were measured for their growth stage, plant height and number of stems, and then separated into leaf, alive stem, dead stem, reproductive organs, crown and root, and weighed after overn drying.

Five 0.5 x 0.5 m quadrats were set up randomly in the sward and cut by the stratified clip method. All alfalfa plants were cut by scissors at the intervals of 10 cm perpendicularly at 5 cm above the ground. Samples at each layer (0.1 x 0.5 x 0.5 m) were separated into leaf, stem and reproductive organs, and weighed after drying.

Specific leaf area (SLA) was determined by two kinds of method. First, leaf punch method; Fifty circle-shaped samples with 10 mm in diameter were taken from leaves (their total area was 39.25 cm^2) and then weighed. Second, photocopy method; Fifty-six leaflets sampled from a single plant selected randomly were photocopied and then weighed. Their total area was dtermined as the following equation: ((the weight of the photocopied leaflet)/(the weight of whole paper)) x (the area of whole paper).

RESULTS AND DISCUSSION

Table 1 shows the number of alfalfa plants, whole dry weight and total number of stems per 1 × 1 m, and mean individual dry weight and stem number. Number of plants and whole dry weight were different considerably among the quadrats, 23.8 plants/m^2 and 99.54 g/m^2 in average and 11 – 39 plants and 70.16 – 144.08 g/m^2 in range, respectively. Although all stem number was measured in only two quadrats, it was less different, 253 and 267 per 1 x 1 m.

Table 2 shows several plant characteristics. Plant height was 41.7 cm on average and 4.5 – 64.0 cm in range, it was considerably different among plants. Number of stems was 10.6 on average but the plant with 59 stems was observed. Of dry weight and the proportion of dry weight into each organ, leaf had 1.80 g (44.5%) on average, stem 2.17 g (54.3%) and reproductive organs 0.09 g (1.2%).

The spatial distribution of alfalfa plants in Quadrat 1 is shown in Fig. 1. Each circle size is proportionate to shoot weight. A rough aspect of spatial distribution may be taken from this figure, although the spatial distribution was not analysed using any technique because of its small sample size. On the other hand, the root excavation demonstrated the development of lateral roots almost near the surface level under the ground (Sawada, personal observation). The developmental aspects of root system not only perpendicularly but also lateraly, and the relationship between spatial distribution at shoot level and at root level may be necessary to understand the spatial structure of alfalfa sward under desert conditions.

Frequency distribution of shoot weight is shown in Fig. 2. It was a typical L-shaped distribution with enormous small plants and few large plants. This fact suggest that a hi-erarchical structure was developed within the sward due to the inter-plant competition during 6 years after the seeding.

Specific leaf area was estimated as 178.4 cm^2/g by leaf punch method and as 231.7 cm^2/g by photocopy method, the average being 205.1 cm^2/g. The reason of this difference in SLA was not clear. Leaf area index (LAI) was estimated as 0.91 by the estimated SLA.

The pattern of dry matter allocation into each organ including root is shown in Fig. 3 and Table 3. Of 5 plants observed, 4 plants were in flowering. Dry weight per plant was 59.19 g on average. Proportions allocated into root was considerably large, 82.8% but those into leaf and stem were small, 5.6% and 8.6%, respectively. The allocation pattern was different among the plants, R5 plant allocating more into root (96.4%) but R3 less into root (72.4%).

Productive structures are presented in Fig. 4. Five quadrats had a similar structure, most leaves distributed at the layer of 25 – 35 cm above the ground level but stem increased at the lower layers. Most reproductive parts distributed above 35 cm above the ground level.

The productivity was low and the spatial distribution of plants was sparse in this sward. The reason of low productivity were not clear, but might be partially due to the drought and hot season observed and old ages after seeding. It is necessary for the improve-ment of production to understand the property of dry matter production at present.

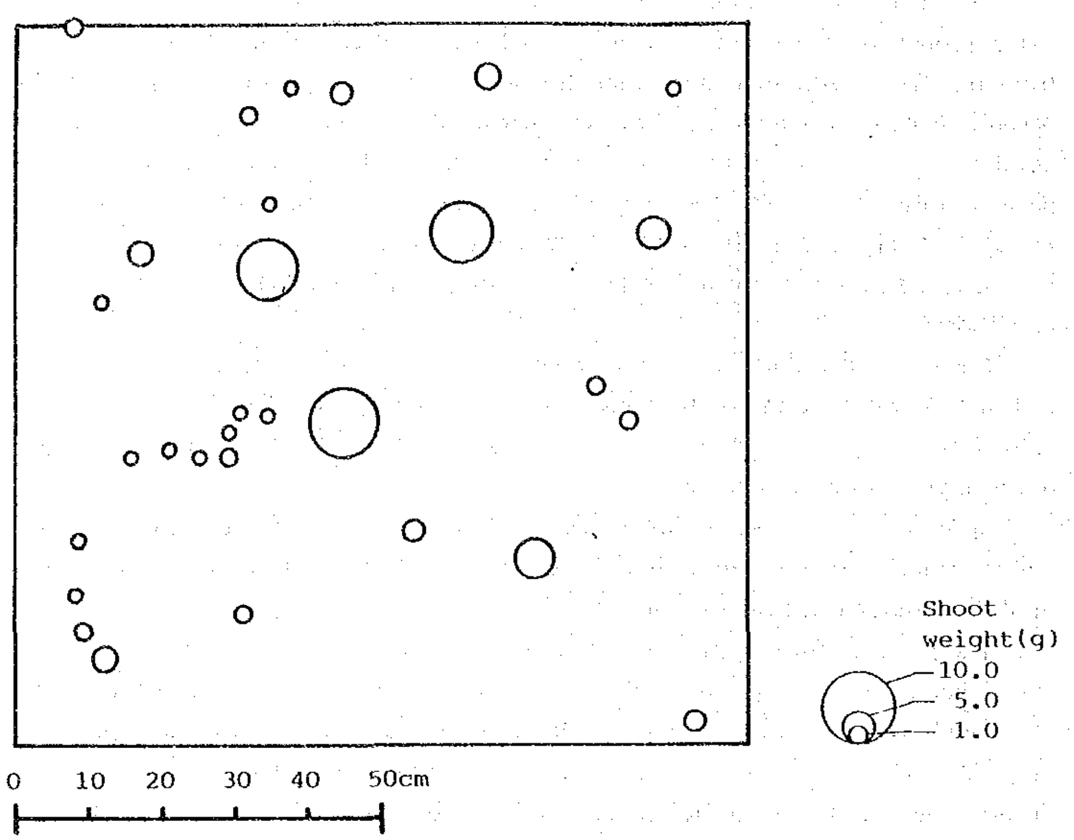


Fig. 1. Spatial distribution of alfalfa plants in Quadrat-1.

Each circle indicates the postion of alfalfa plant, and its size is proportionate to shoot dry weight.

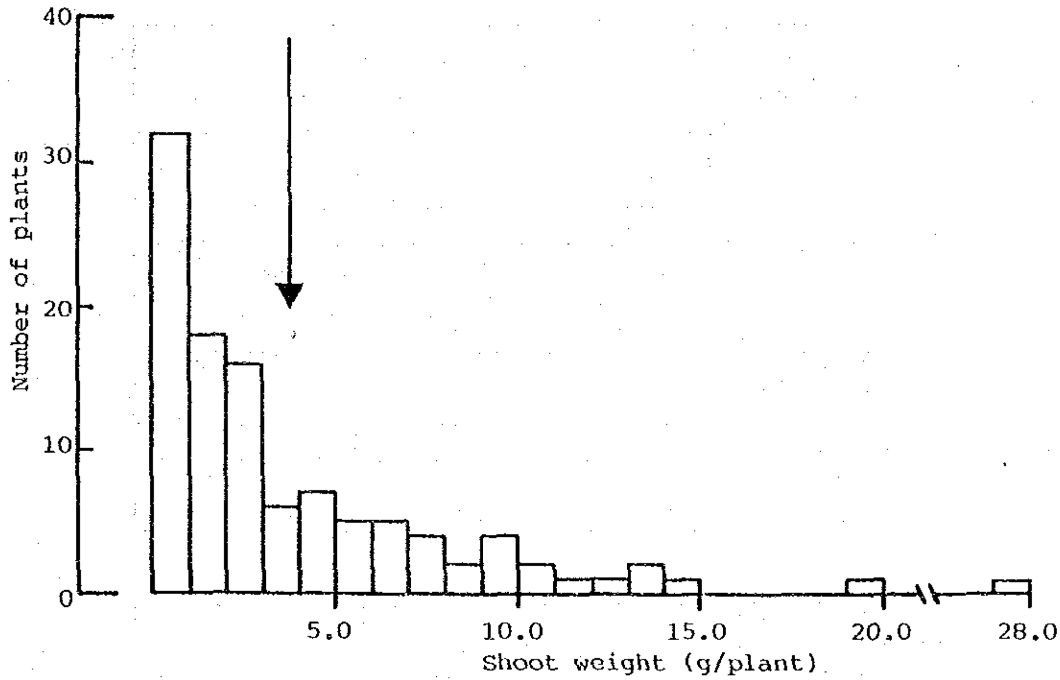


Fig. 2. Size distribution of alfalfa plants

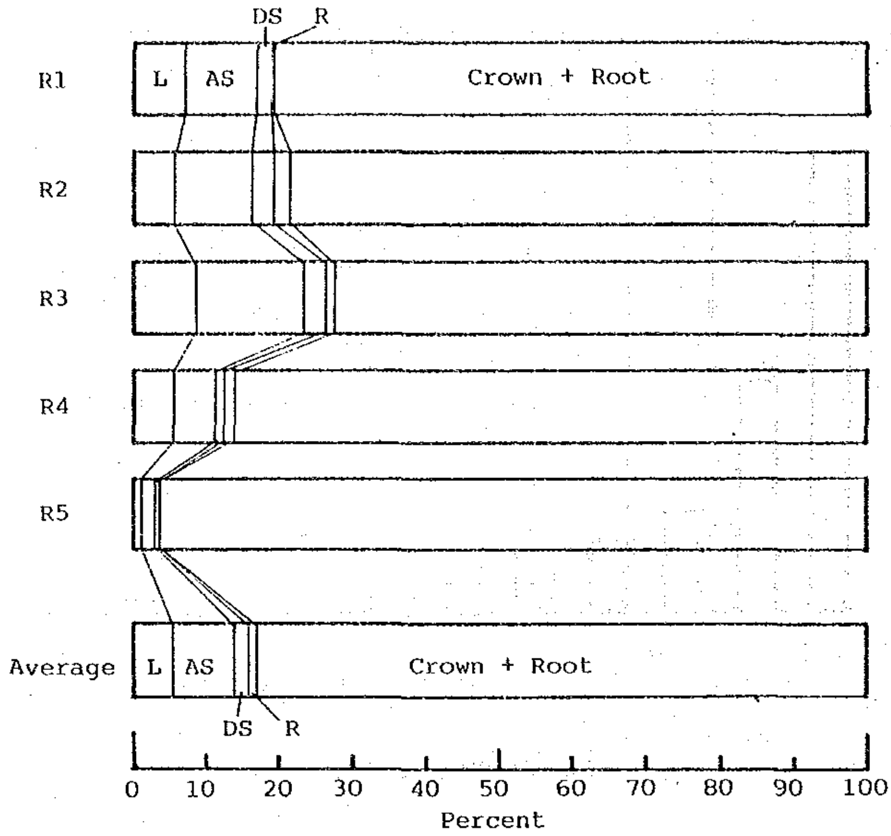


Fig. 3. Dry matter allocation of alfalfa plants

L : Leaf ; AS : Alive stem ; DS : Dead stem
R : Reproductive organs

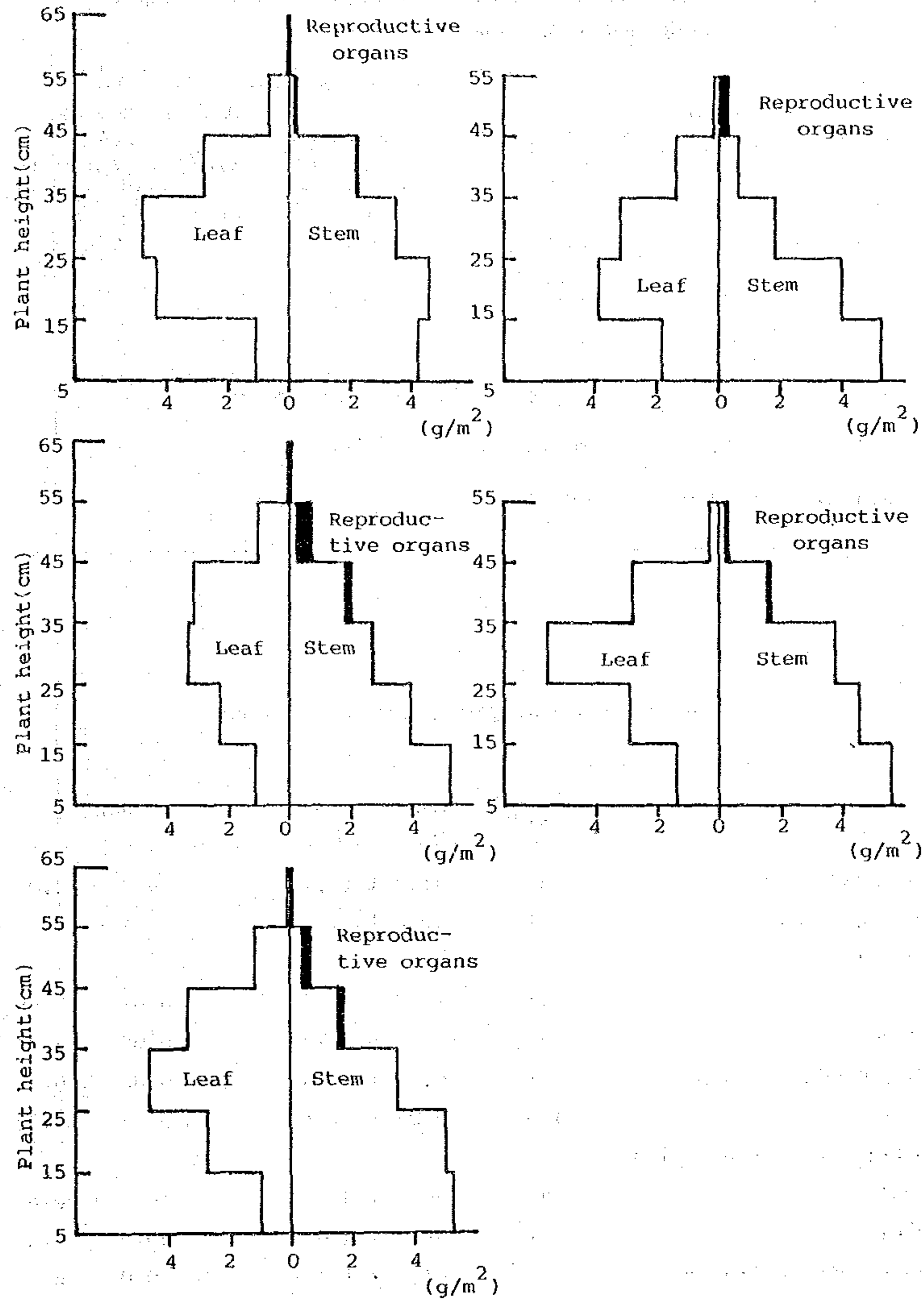


Fig. 4. Productive structure of alfalfa in September

Table 1. Some agronomic characters of alfalfa in the quadrats sampled for dry-matter allocation

Quadrats	No. of plants (/m²)	Total weight (g/m²)	Plant weight (g/plant)	No. of stems (/m²)	No. of stems (/plant)
1	30	76.57	2.55	253	8.4
2	39	144.08	3.69	-	-
3	17	121.33	7.14	267	15.7
4	11	85.54	7.78	-	-
5	22	70.16	3.19	-	-
Average	23.8	99.54	-	-	-

Table 2. Productive performance of alfalfa plant

	Sample size	Mean ± S.D.	Range
Plant height(cm)	51	41.7 ± 12.2	4.5 - 64.0
Number of stems	51	10.6 ± 11.8	1 - 59
Dry weight(g)			
Leaf	51	1.80 ± 2.36	0.01 - 12.66
Stem	51	2.17 ± 2.78	0.05 - 14.24
Reproductive organs	51	0.09 ± 0.16	0.00 - 0.63
Total	119	4.87 ± 2.41	0.02 - 27.53
Proportion of dry weight(%)			
Leaf	51	44.5 ± 8.1	16.7 - 80.0
Stem	51	54.3 ± 8.0	20.0 - 83.3
Reproductive organs	51	1.2 ± 1.7	0.0 - 8.4

Table 3. Some agronomic characters, dry weight of each part and distribution ratio of dry matter to each part

Plant number	Growth stage	Plant height (cm)	No. of stems	Dry weight (g) Leaf	Alive stem	Dead stem	Reproductive organs	Crown + Root	Total	Proportion of dry weight (%) Leaf	Alive stem	Dead stem	Reproductive organs	Crown + Root
R1	Bud	56.0	27	4.94	6.74	1.53	0.08	55.40	68.69	7.2	9.8	2.2	0.1	80.7
R2	Flower	48.5	7	1.33	2.69	0.73	0.55	19.35	24.65	5.4	10.9	3.0	2.2	78.5
R3	Flower	75.5	28	6.78	11.33	2.38	1.01	56.44	77.94	8.7	14.5	3.1	1.3	72.4
R4	Flower	43.0	7	1.92	2.12	0.29	0.59	30.07	34.99	5.5	6.1	0.8	1.7	85.9
R5	Flower	45.0	8	1.05	1.57	0.44	0.16	86.48	89.70	1.2	1.8	0.5	0.2	96.4
Mean		53.6	15.4	3.20	4.89	1.07	0.48	49.55	59.19	5.6	8.6	1.9	1.1	82.3
± s.d.		13.2	11.1	2.53	4.14	0.87	0.37	26.16	28.07	2.8	4.8	1.2	0.9	9.0

(4) The Pattern of Dry Matter Production in a 4 Year-old Sward of Alfalfa near Al Ain City, UAE in December 1986

ABSTRACT

Dry matter production was studied in a 4 year-old sward of alfalfa, located in Um Gafa Experimental Farm near Al Ain city, UAE in December 1986.

Plant density and shoot weights per unit area and per plant were 17.7 plants/m^2, 147.60 g/m^2 and 9.02 g on average, respectively. Dry matter partitioning ratios of leaf and stem were 46.5% and 53.5% on average, respectively, but no flowering was observed. Specific leaf area (SLA) was 171.96 cm^2/g, which gave the value of 1.18 LAI.

In the case of dry matter partitioning ratio including root, only 15.1% and 20.4% of total dry matter were allocated into leaf and stem, respectively, but 64.6% into root on average.

For productive structure, most of leaves distributed at the layers of 25 – 45 cm above the ground level but stem weight was larger at the lower layers.

INTRODUCTION

This study is one of a series of studies, which have been conducted to clarify the pattern of dry matter production of various alfalfa swards in UAE in different seasons. We previously reported on the dry matter production of the 6 year-old alfalfa sward in September in Kuwaitat Agricultural Experimental Station, Al Ain city. Unfortunately, it was renovated later so it made impossible to study continuously in the same field. Instead we had another chance to observe the 4 year-old sward in Um Gafa Experimental Farm near Al Ain too.

MATERIALS AND METHODS

Three observations were made in the 4 year-old sward of alfalfa in Um Gafa Experimental Farm near Al Ain city, UAE with an area of 20 ha of alfalfa. The observations were: (1) Dry matter allocation and leaf area, (2) Dry matter allocation including root, (3) Productive structure using the stratified clip method.

The cultivated methods and the managements of alfalfa in this farm were similar to those in Kuwaitat Experimental Station, which were described previously. The cultivar used was OMANI. Alfalfa plants were cut manually 12 times per year since 70 days after seeding, the intervals of cutting being 20 – 35 days. The swards were irrigated by the sprinkler irrigation system.

All measurements were carried out on 28 December 1986 when the swards were just about to be cut. Three 1 x 1 m quadrats (Quadrat 1, 2 and 3) were set up and all alfalfa plants were sampled from each quadrat. Sampling of alfalfa plant were made by scissors at 5 cm above the ground level, then used for the later measurements. Fifteen plants (five plants from each quadrat) were measured for growth stage, plant height and the number of stems, and then separated into leaf and stem, and weighed after the drying at 80°C for 24 hours. The other plants were measured for growth stage, plant height, the number of stms and total shoot weight only. No flowering were observed in this study.

Five alfalfa plants were randomly dug from 10 cm depth in order to examine roughly the property of dry matter allocation into each organ including root. They were measured for growth stage, plant height and the number of stems, and then separated into leaf, stem and root, and weighed after drying at 80°C for 24 hours.

Two 0.5 x 0.5 m quadrats were set up randomly in the sward and cut by the stratified clip method. All alfalfa plants in each quadrat were cut at the intervals of 10 cm perpendicularly from 5 cm in height above the ground level. Samples at each layer (0.1 x 0.5 x 0.5 m) were separated into leaf and stem, and weighed after drying at 80°C for 24 hours.

Specific leaf area (SLA) was determined by photocopy method. This method was described previously in detail. Parts of leaflets from three plants selected randomly were photocopied.

RESULTS AND DISCUSSION

Table 1 shows the number of alfalfa plants, total dry weight, mean individual dry weight, total number of stems and mean number of stems. Plant density and total dry weight were 17.7 plants/m^2 and 147.60 g/m^2 on average, and with a range of 13 – 25 plants/m^2 and 140.34 – 156.01 g/m^2, respectively. In comparison with the results on Kuwaitat in September, Um Gafa had about 1.5 times as large as yield and about 1.3 times as large as stem density, while plant density was lower.

Table 2 shows the productive performances per plant. Plant height was 52.2 cm on average, and with a range of 39.0 – 63.5 cm. The number of stems was 18.8 on average, with the maximum of 65. The dry matter weight of each part and the proportion of dry matter into each part were 3.29 g and 46.5% for leaf, 3.65 g and 53.5% for stem on average, respectively. Um Gafa had higher plant height and larger stem number per plant than Kuwaitat but similar dry matter partitioning patterns into leaf and into stem with Kuwaitat.

Fig. 1 shows the frequency distribution of shoot weight based on 53 plants. L-shaped distribution, with few larger plants and numerous smaller plants, was not found, although it was observed in Kuwaitat in September.

Fig. 2 and Table 3 show the dry matter partitioning ratio including root. Root had larger ratio, 64.6%, but leaf and stem had smaller ratio, 15.1% and 20.4%, respectively. Clear difference in dry matter partitioning pattern was found among the plants examined, R3 plant had larger allocation into root (76.5%) but R2 and R4 plants had rather small allocation into root (58.1% and 59.0%, respectively). The proportion into root was smaller in Um Gafa than Kuwaitat. This reason is because roots were excavated from 15 cm depth in Kuwaitat but from 10 cm depth in Um Gafa.

The productive structures in two quadrats are shown in Fig. 3. No differences in the structure were found, though large differences were found in leaf dry matter weight. A major part of leaves distributed at the layers of 25 – 45 cm, while stem weight was larger at the lower layers.

Specific leaf area (SLA) was estimated as 171.96 cm^2/g, which gave the estimate on LAI of 1.18.

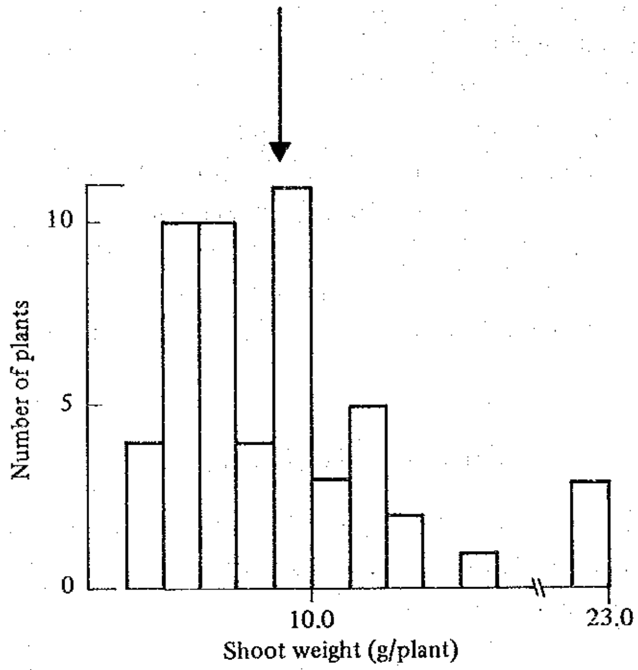


Fig. 1. Size distribution of alfalfa plants

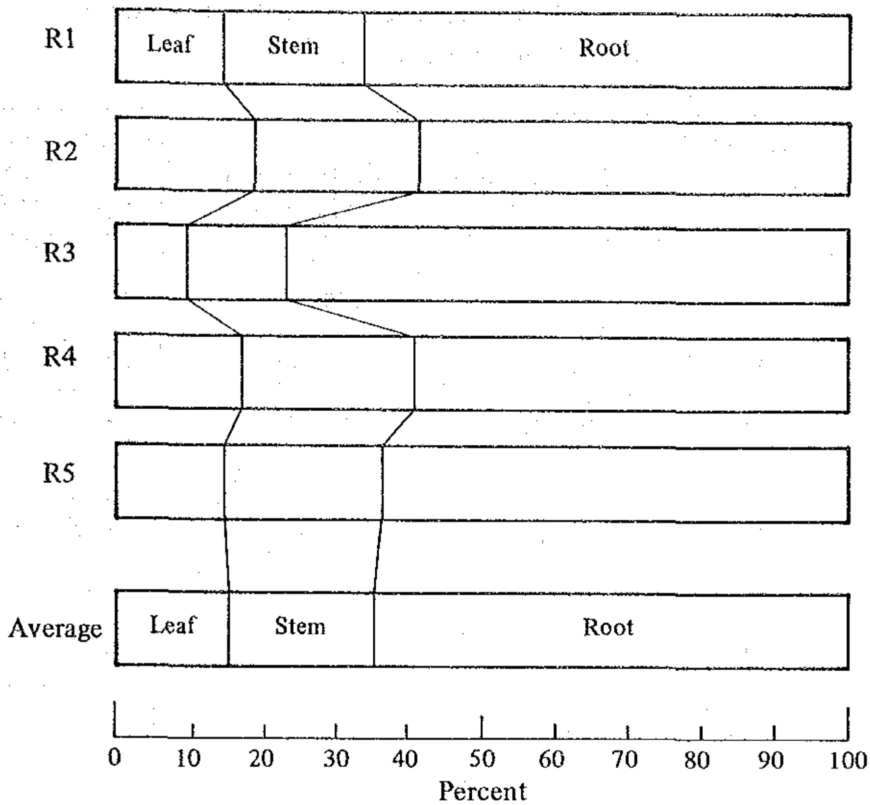


Fig. 2. Dry matter allocation of alfalfa plants

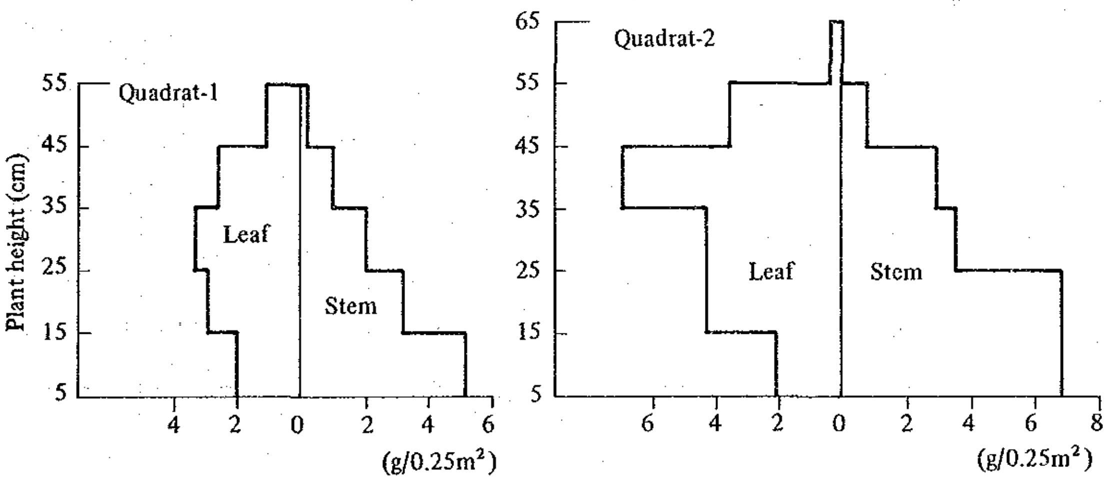


Fig. 3. Productive structure of alfalfa in December

Table 1. Some agronomic characters of alfalfa in the quadrats sampled for dry-matter allocation

Quadrats	No. of plants (/m^2)	Total weight (g/m^2)	Plant weight (g/plant)	No. of stems (/m^2)	No. of stems (/plant)
1	25	146.44	5.86	370	14.8
2	13	140.34	10.80	278	21.4
3	15	156.01	10.40	347	23.1
Average	17.7	147.60	9.02	331.7	19.8

Table 2. Productive performance of alfalfa plants

	Sample size	Mean ± S.D.	Range
Plant height(cm)	53	52.2 ± 5.6	39.0 - 63.5
Number of stems	53	18.8 ± 11.3	2 - 65
Dry weight(g)			
Leaf	15	3.29 ± 1.67	0.91 - 7.77
Stem	15	3.65 ± 1.38	1.55 - 6.33
Total	53	8.35 ± 6.20	1.44 - 29.69
Proportion of dry weight(%)			
Leaf	15	46.5 ± 5.3	34.9 - 55.1
Stem	15	53.5 ± 5.3	44.9 - 65.1

Table 3. Some agronomic characters, dry weight of each part and distribution ratio of dry matter to each part

Plant number	Growth stage	Plant height (cm)	No. of stems	Dry weight(g)				Proportion of dry weight(%)		
				Leaf	Stem	Root	Total	Leaf	Stem	Root
R1	Vegetative	53.5	17	3.59	4.76	16.09	24.44	14.7	19.5	65.8
R2	Vegetative	56.5	10	2.62	3.14	7.98	13.74	19.1	22.9	58.1
R3	Vegetative	55.5	13	1.42	2.04	11.24	14.70	9.7	13.9	76.5
R4	Vegetative	59.0	10	2.86	3.95	9.78	16.59	17.2	23.8	59.0
R5	Vegetative	54.0	13	3.66	5.44	15.92	25.02	14.6	21.7	63.6
Mean		55.7	12.6	2.83	3.87	12.20	18.90	15.1	20.4	64.6
± s.d.		2.2	2.9	0.91	1.34	3.66	5.43	3.5	4.0	7.4

(5) The Diurnal Changes in Soil Temperature and Some Micrometeorological Variables in the Desert near Al Ain City, UAE

ABSTRACT

The diurnal changes in soil temperature and some micrometeorological variables were studied in the desert near Al Ain city, UAE in September and December 1986. Their changes were followed in serveral plots, which differed in soil surface conditions, the amount of irrigation water and the irrigation frequency.

September, an extremely hot and dry month, had high daily maximum temperature of 41.9°C, and large diurnal changes in air temperature. Total amount of evaporation was high, 10.59 mm/12 hours, the diurnal changing patterns of evaporation being well corresponded to those of air temperature. The bare soil plot with no irrigation had the maximum temperature of 49.7°C at 5 cm depth. The irrigation frequency had some effects on soil temperature. On the other hand, the plots with plant cover were lower in the maximum soil temperature than the bare soil plots at 5, 15 and 30 cm depth.

December had low daily maximum temperature of 23.0°C, and small amount of evaporation during the day, 2.34 mm/11 hours. Large diurnal changes in soil temperature were found at 5 cm depth, which well correspondes to those in air temperature, though little changes were found at 30 cm depth. The amount of irrigation water and the irrigation frequency had no effects on soil temperature. On the other hand, the plot with plant cover was likely to be lower in the maximum soil temperature than bare soil plot at 5 cm depth.

The diurnal changes in air temperature was examined inside and outside the canopy of *Haloxylon salicornicum*, the inside temperature being lower than the outside in September but these difference were not observed in December.

INTRODUCTION

Crops are grown under irrigation in the dry lands of the Middle East. Even if large amount of water is used in the fields, soils dry rapidly and soil temperature rise rapidly. These phenomena cause water loss and crop injury. Thus, the knowledge of the micrometeorological variables such as soil temperature and soil water are essential for improvement of crop production under dry land conditions. Few studies, however, have been conducted to clarify these effects.

This study investigates the diurnal changes in soil temperature and some micrometeorological variables in plots differing in the amount of irrigation water, the irrigation frequency and the state of soil surfaces (bare soil or plant cover).

STUDY SITE AND METHODS

The study was conducted in the desert land near the Experimental Farm, Faculty of Agriculture, UAE University near Al Ain city, UAE on 14 – 16 September and on 22 – 23 December 1986. The study sites were about 15 × 5 m in size in both periods. Several plots (each size was 1 × 1 m), which differed in the conditions of soil surface (bare soil or plant cover), the amount of irrigation water and the irrigation frequency, were set up within the sites in both periods. The treatments were described in Table 1 in details, they differed slightly between both periods. All "BA" plots were placed in bare soil, all "HA" plots were placed inside a small patch of *Haloxylon salicornicum*, and all "PR" plots were placed near the roots of *Prosopis spicigera*. L-tube thermometers were installed into soil at 5, 15 and 30 cm depth from soil surface in BA20-1, BA20-2, BA20-4, BA10-1, BA-10-2 and HA10-1 plots, and at 5, 10, 20, 30 and 50 cm depth from soil surface in the BA-0, PR10-1 and PR5-1 plots. They were installed into soil in the center of each plot a few days before taking measurements.

The following micrometeorological variables were measured during the day: (1) air temperature, relative humidity and evaporation inside the instrument shelter, (2) air temperature inside and outside the canopy of *Haloxylon salicornicum* at about 20 cm in height from soil surface, in which HA10-1 plot was placed, (3) temperature of irrigation water in each irrigation time and the temperature of the first irrigation water placed in the shade (first watering was at 6 a.m. in Sptember but 7 a.m. in December).

RESULTS AND DISCUSSION

A. 14 – 16 September 1986

(1) Air temperature, evaporation and relative humidity

Fig. 1 shows the diurnal changes of air temperature, evaporation and relative humidity on 14 – 16 September. Air temperature rised rapidly after sunrise, with the maximum of 41.2°C, 41.9°C and 39.0°C for 14, 15 and 16 September, respectively, at 13:00 – 14:00 hour. Slight changes in temperature were found after that. Evaporation also increased after sunrise, the following patterns being different among the dates. It increased till sunset on 14 September but not increased on the other dates. The maximum and the minimum evaporation were 1.16 mm/hr and 0.00 mm/hr on 14, 1.19 mm/hr and 0.30 mm/hr on 15 and 0.75 mm/hr and 0.29 mm/hr on 16 September, respectively. Total amount of evaporation per 12 hours was higher on 14 and 15 than on 16, being 9.03 mm on 14, 10.59 mm on 15 and 7.16 mm on 16. Evaporation dropped considerably between 10:00 and 11:00 on both 15 and 16 September, without a clear explanation. Relative humidity decreased till 12:00 after sunrise but the changing patterns after that were different among the dates, decreased to sunset on 16 but not changed on the other dates. The maximum and the minimum relative humidity were 58% and 17% on 14, 37% and 14% on 15, and 56% and 20% on 16, respectively.

(2) Air temperature inside and outside the canopy of *Haloxylon salicornicum*

Fig. 2 shows the diurnal changes of air temperature inside and outside the canopy of *Haloxylon salicornicum*. Temperature rised rapidly after sunrise, reaching the maximum at 13:00 – 14:00, and then fell. Inside temperature was lower than outside temperature, the difference between them being large in the periods exept for 13:00 and 14:00. It had lower maximum, which was 41.8°C, than outside, 45.3°C on 16 September.

(3) Irrigation water temperature

Fig. 3 shows the diurnal changes of water temperature. The temperature of irrigation water, which measured at 6:00, 9:00, 12:00, 15:00 and 18:00 hour, changed in a similar diurnal pattern with air temperature inside the instrument shelter. They rised rapidly after sunrise, reaching the maximum at 15:00, and then fell. The maximum water temperature were 55.0°C, 63.6°C and 52.3°C on 14, 15 and 16, respectively, which being 13.8°C, 23.2°C and 14.1°C higher, respectively, than those inside the instrument shelter. In contrast, little changes were found throughout the day for the temperature of the first irrigation water set under the shade.

(4) Soil temperature

The diurnal changes of soil temperature are shown for each plot in Fig. 4 for 14 September, in Fig. 5 for 15 September and in Fig. 6 for 16 September, respectively. The diurnal changes were generally similar among the plots at each depth. Those at the shallower depth were larger than those at the deeper depth. The times reached the maximum were also faster at the lower depth. Heat in deeper soil is conducted from that in shallower soil, so that deeper soil have later maximum.

The diurnal changes of soil temperature of BA9 plot on 14 September, which was not irrigated, had generally higher temperature during the day than the other seven plots. It also had large diurnal change at 5 cm depth, the maximum being 49.7°C. This value was 8.7°C higher than that inside the instrument shelter (41.0°C). Little differences were found among the dates examined.

Two kinds of the amount of irrigation water were set up, 20 l/m^2 (for BA20-1 and BA20-2 plots) and 10 l/m^2 (for BA10-1 and BA10-2 plots), for bare soil, and they were compared in order to examine the effects of the irrigation amount on soil temperature. No differences were found at each depth between the plots with the irrigation of 20 l/m^2 and 10 l/m^2. The irrigation frequency, however, had small effect on soil temperature, the maximum at 5 cm depth under the twice watering per day being lower a little than those under the once watering in both plots with the irrigation of 20 l/m^2 and 10 l/m^2.

The effects of plant covers on soil temperature were examined in HA 10-1 and PR 10-1 plots. The former was placed in the small patch of *Haloxylon salicornicum*, the latter was placed near the roots of *Prosopis spicigera*. In comparison with BA10-1 plot, which placed in bare soil and irrigated by the same amount of water, they had lower maximum at 5 cm depth on 14 September. BA10-1 plot had the maximum of 37.7°C but HA10-1 and PR10-1 plots had the maximum of 31.8°C and 35.0°C, respectively. The other two dates had almost similar trends to 14 September.

The vertical distribution of soil temperature in each plot are shown in Fig. 7 for 14 that the soil at shallower depth had larger diurnal changes in temperature than those at that the soil at shallower depth had larger diurnal changes in temperature than those at deeper depth.

B. 22 – 23 December 1986

(1) Air temperature, evaporation and relative humidity

Fig. 10 shows the diurnal changes of air temperature, evaporation and relative humidity on 22 and 23 December. Both air temperatures on 22 and 23 rised rapidly after sunrise, reaching the maximum at 14:00 to 15:00 of 22.0°C and 23.0°C for 22 and 23, respectively. Evaporation also increased from sunrise to 15:00, then decreased till sunset. The maximum and the minimum evaporation during the day were 0.37 mm/hr and 0.03 mm/hr on 22 December, respectively, and 0.57 mm/hr and 0.01 mm/hr on 23 December, respectively. Total evaporation from 7:00 to 18:00 was 2.84 mm on 22 and 2.38 mm on 23. Both dates had a similar diurnal changes in relativel humidity, which decreased rapidly from sunfise to 13:00 followed by the increase from 15:00 to sunset. The maximum and the minimum relative humidity during the day were 100% and 44% on 22, and 100% and 36% on 23, respectively.

(2) Air temperature inside and outside the canopy of *Haloxylon salicornicum:*

Fig. 11 shows the diurnal changes of air temperature inside and outside the canopy of *Haloxylon salicornicum.* Both temperatures rised rapidly after sunrise, the maximum being reached at 15:00 for 22 December and at 13:00 for 23 December, and then fell till sunset. Inside temperature were rather low from 7:00 to 10:00 but rather high after that.

(3) Water temperature

Fig. 12 shows the irrigation water temperature. They were measured at 7:00, 9:00, 12:00 and 15:00, rised steadily till 15:00. The maximum were 36.9°C and 32.0°C on 22 and 23 December, respectively. They were 14.6°C higher than the maximum reached inside the instrument shelter on 22 December and 9.0°C higher than that on 23 December. In contrast, the extremely slow increase was found for the temperature of the first irrigated water set in the shade on both dates.

(4) Soil temperature

The diurnal change of soil temperature are shown for each plot in Fig. 13 for 22 December and in Fig. 14 for 23 December. They were similar among the plots, larger diurnal changes being found in the shallower depth but smaller in the deep depth. The time reached the maximum were also faster at the shallower depth.

In comparing the diurnal changes of the plots in soil temperatures on 22 December, BA0 plot, which was not irrigated, had generally higher soil temperature during the day and also 5°C higher than other seven plots at even 30 cm depth, which had relatively small diurnal changes. BA0 plot had large diurnal change at 5 cm depth, its maximum soil temperature being 25.2°C. It was 3.2°C higher than the temperature reached inside the instrument shelter (22.0°C). Little differences were found between 22 and 23 December.

Two kinds of the amount of irrigation water, 20 l/m^2 (for BA20-1, BA230-2 and BA20-4 plots) and 10 l/m^2 (for BA10-1 and BA10-2 plots) for bare soil were set up, and compared in order to examine the effects of the irrigation amount on the soil temperature.

Little differences were observed at each depth between the plots with the irrigtaion of 20 l/m^2 and 10 l/m^2.

The irrigation frequency also had no effects on soil temperature. No differences were found among BA20-1, BA20-2 and BA20-4 plots, which had the same amount of irrigation. Also, no differences were found between BA10-1 and BA10-2 plots, which had the same amount of irrigation.

The effects of plant covers on soil temperature were examined in HA10-1 plot, which placed in a small patch of *Haloxylon salicornicum.* In comparison with BA10-1 plot, which placed in bare soil and irrigated the same amount of water, HA10-1 plot had lower maximum temperature at 5 cm depth on 22 December. It had the maximum of 18.2°C but BA10-1 plot had 21.6°C. Similar trend was observed on 23 December.

The vertical distribution of soil temperature in each plot are shown in Fig. 15 for 22 December and in Fig. 16 for 23 December. The soil at lower depth had larger diurnal changes than those at higher depth.

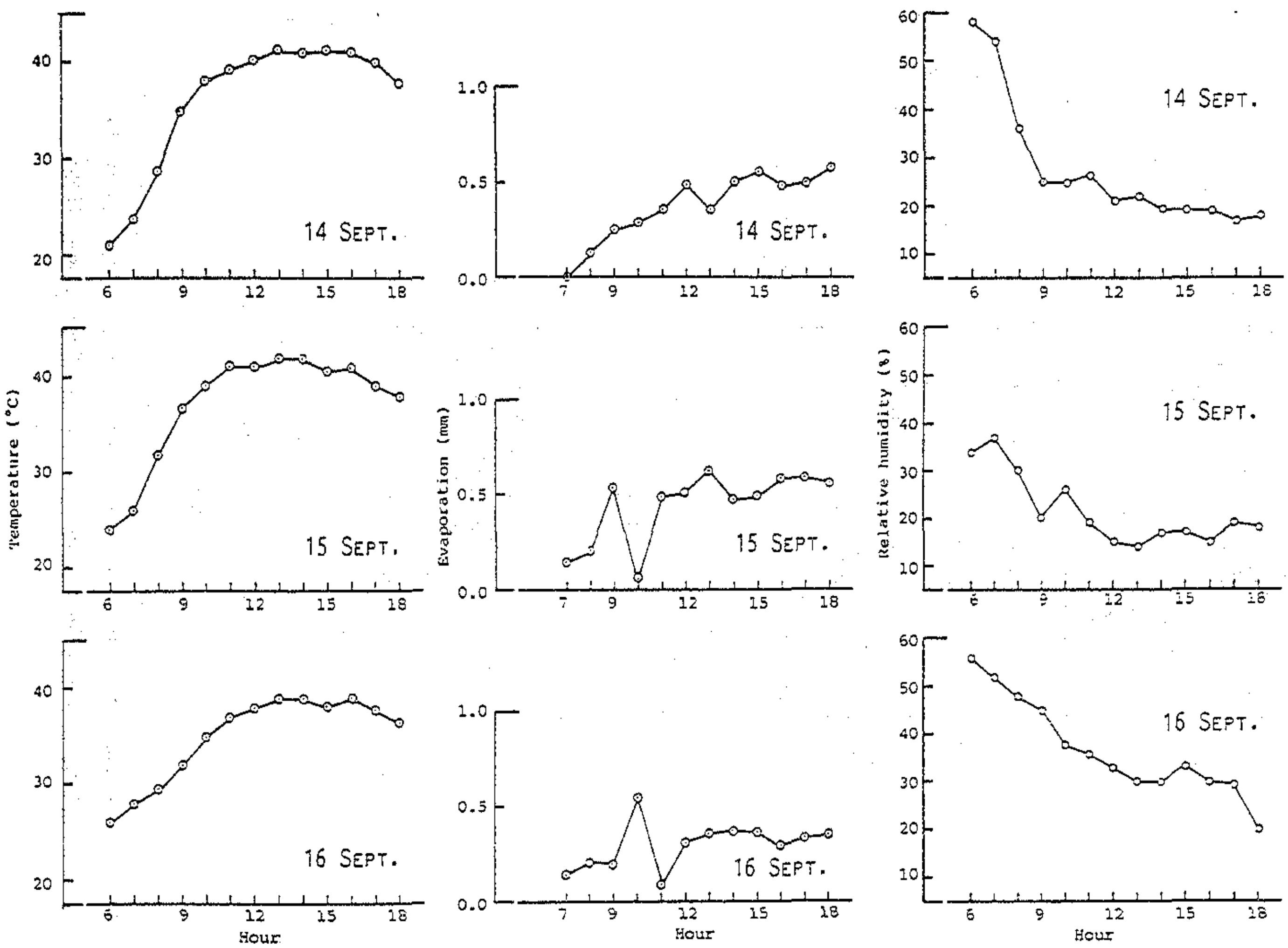


Fig. 1. Diurnal changes in temperature, evaporation and relative humidity on 14, 15 and 16 September, 1986

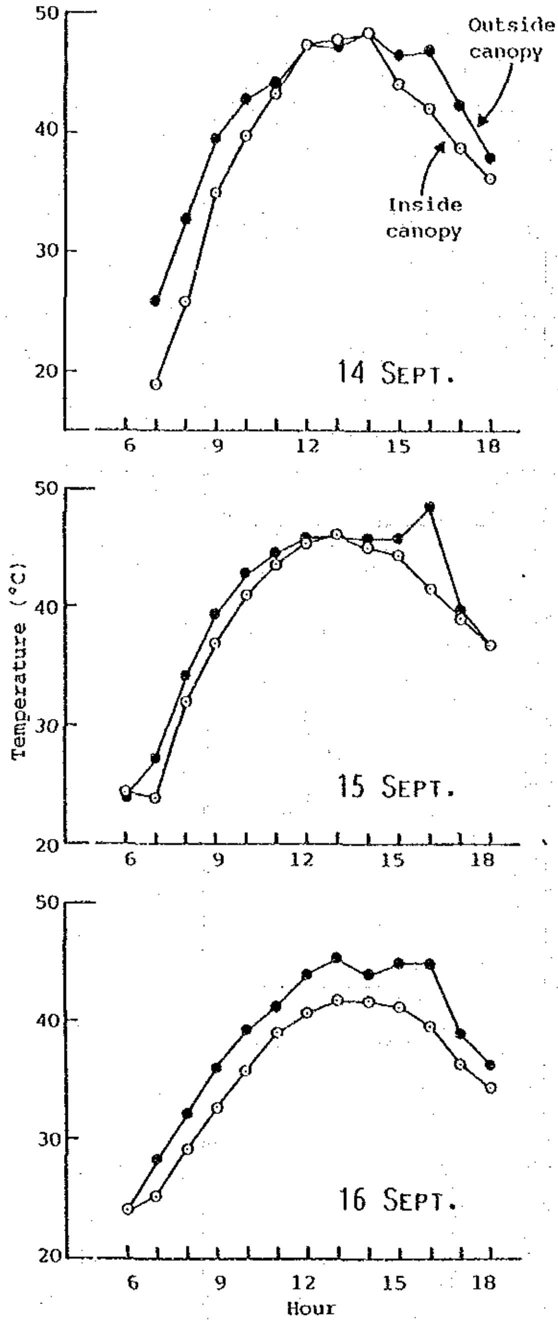


Fig. 2. Diurnal changes in the temperatures inside (○) and outside (●) the canopy of *Haloxylon* sp. on 14, 15 and 16 Septempber, 1986.

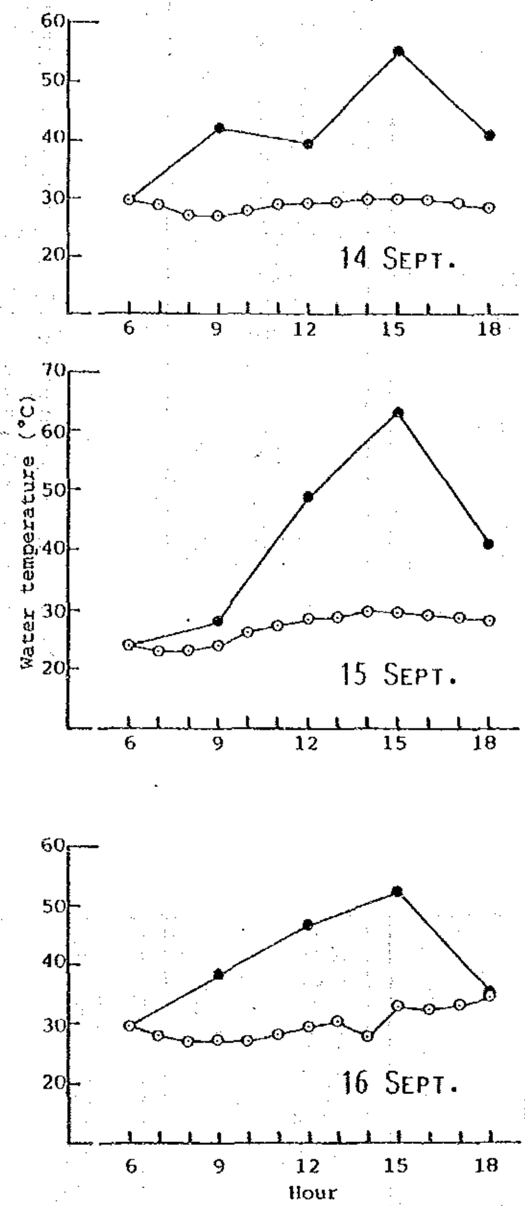
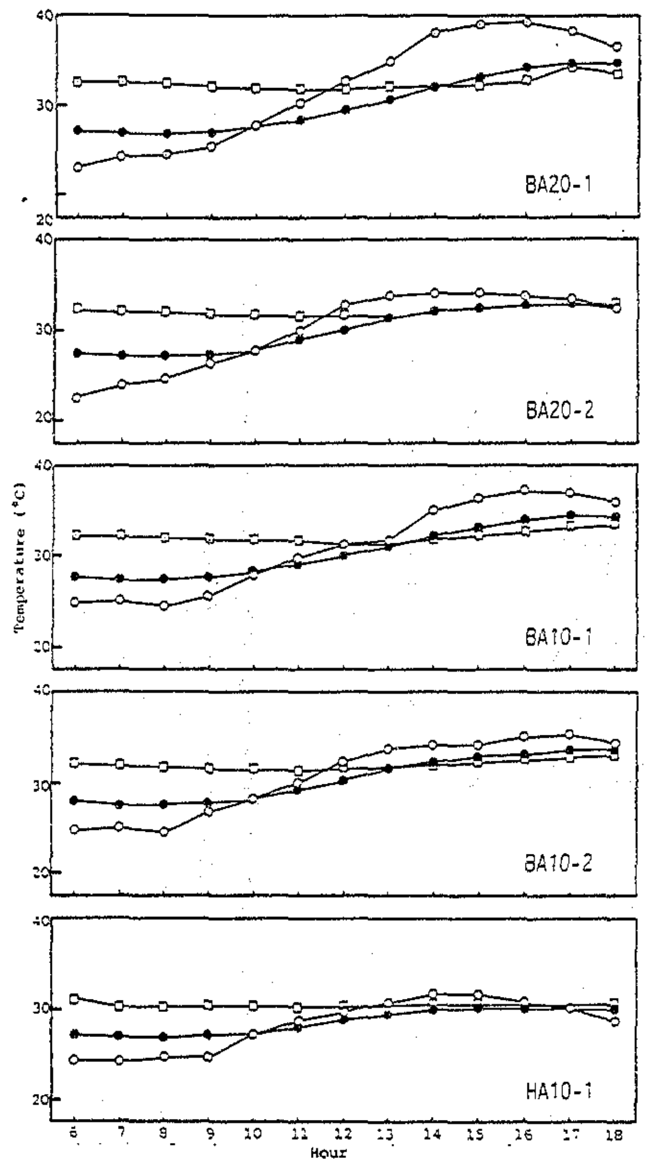


Fig. 3. Diurnal changes in the temperatures of water irrigated (●) and set in the shade (○) on 14, 15 and 16 September, 1986



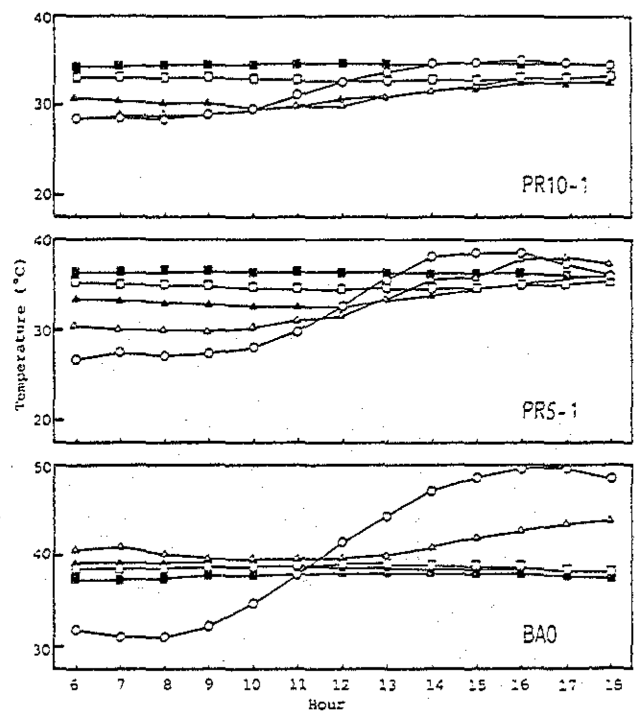
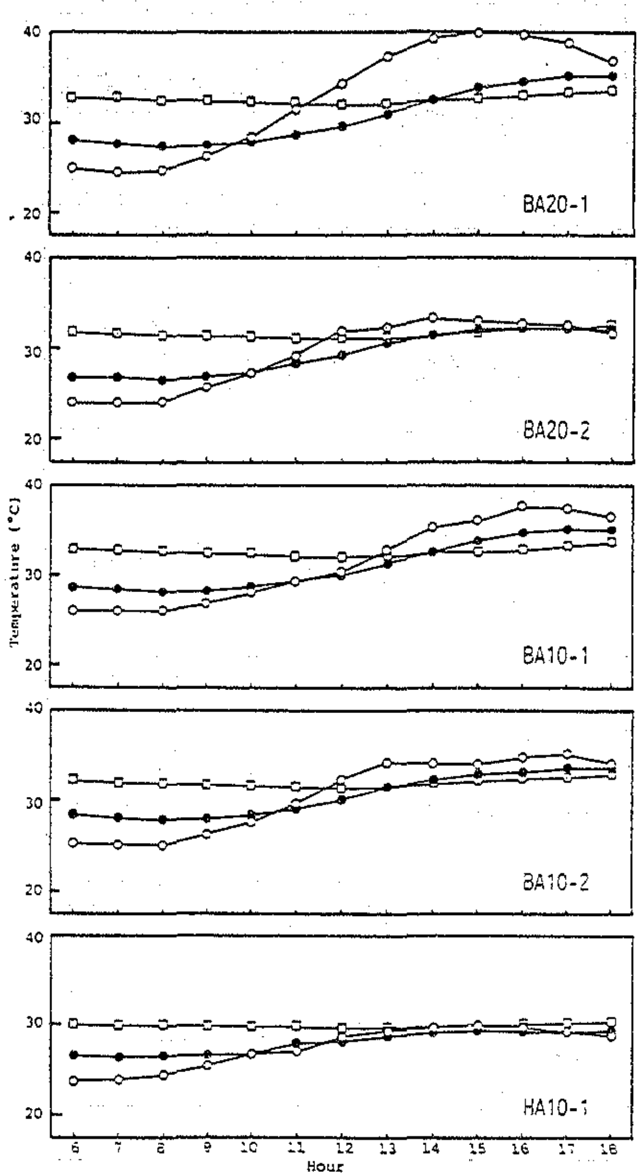


Fig. 4. **Diurnal changes in soil temperatures in various plots on 14 September, 1986**

○ = 5 cm depth, ● = 15 cm depth, □ = 30 cm depth,
△ = 10 cm depth, ▲ = 20 cm depth, ■ = 50 cm depth



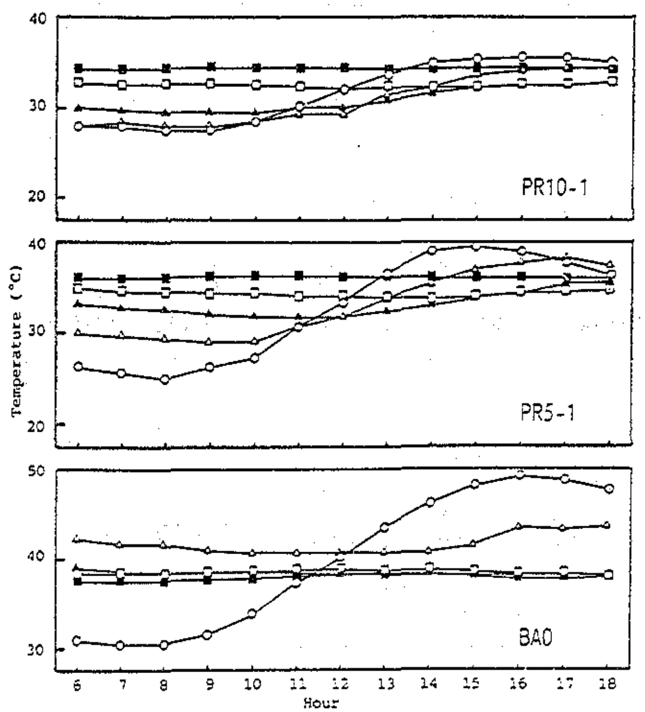


Fig. 5. **Diurnal changes in soil temperatures in various plots on 15 September, 1986**

The symbols are the same as Fig. 4.

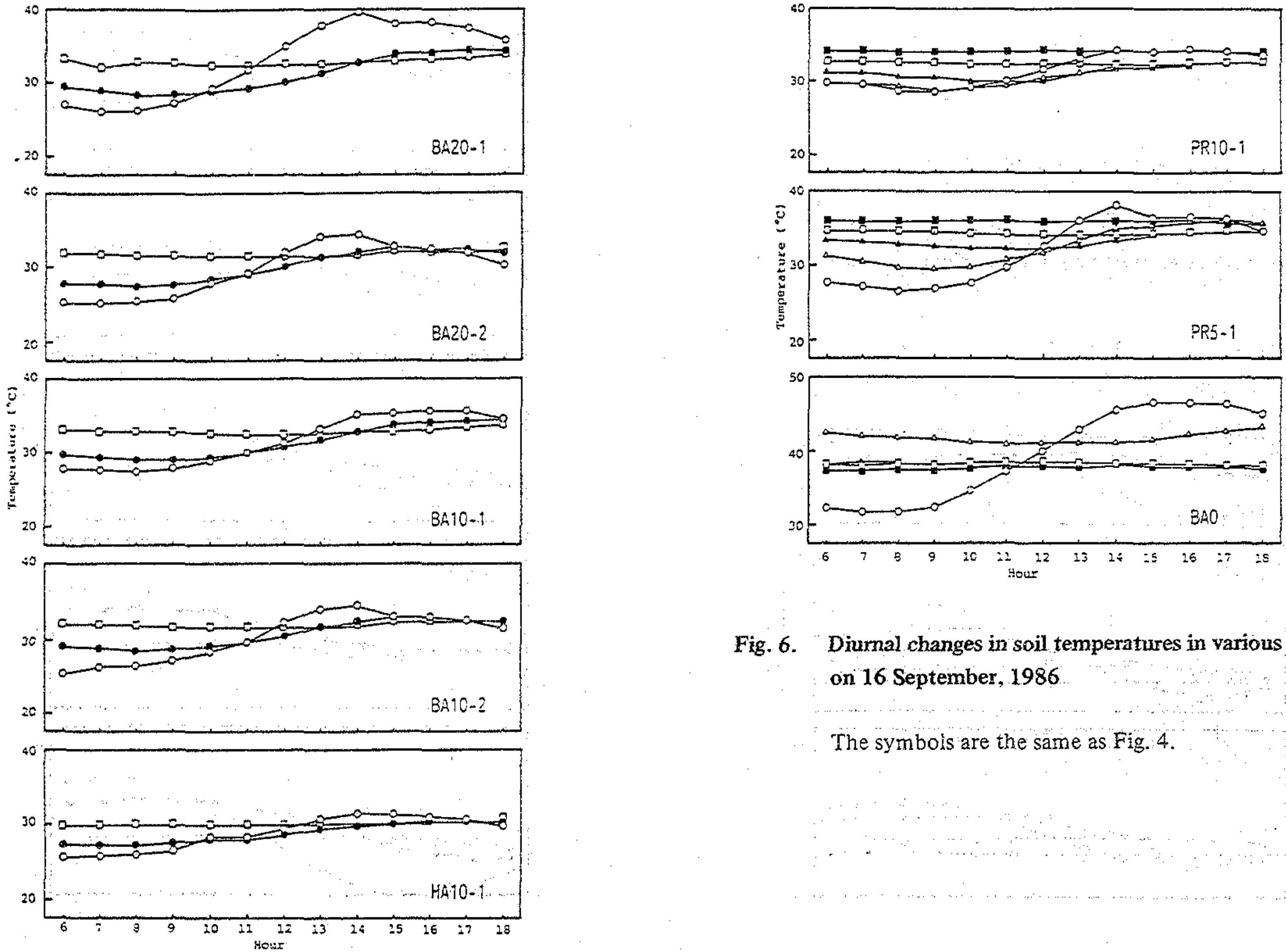


Fig. 6. **Diurnal changes in soil temperatures in various plots on 16 September, 1986**

The symbols are the same as Fig. 4.

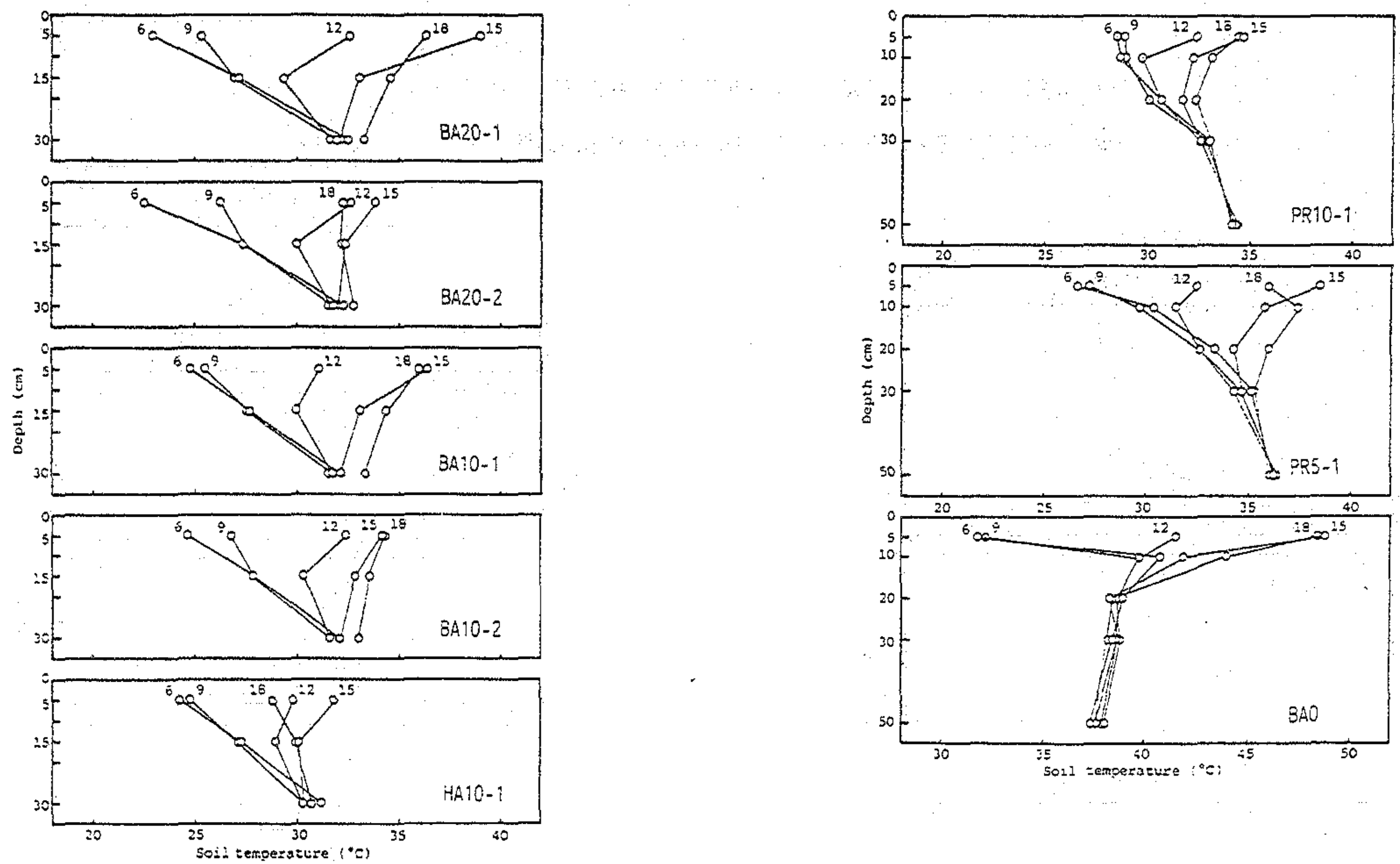


Fig. 7. Vertical distributions of soil temperatues in various plots on 14 September, 1986

The temperature data are presented at 6.00, 9.00, 12.00, 15.00 and 18.00 hours.

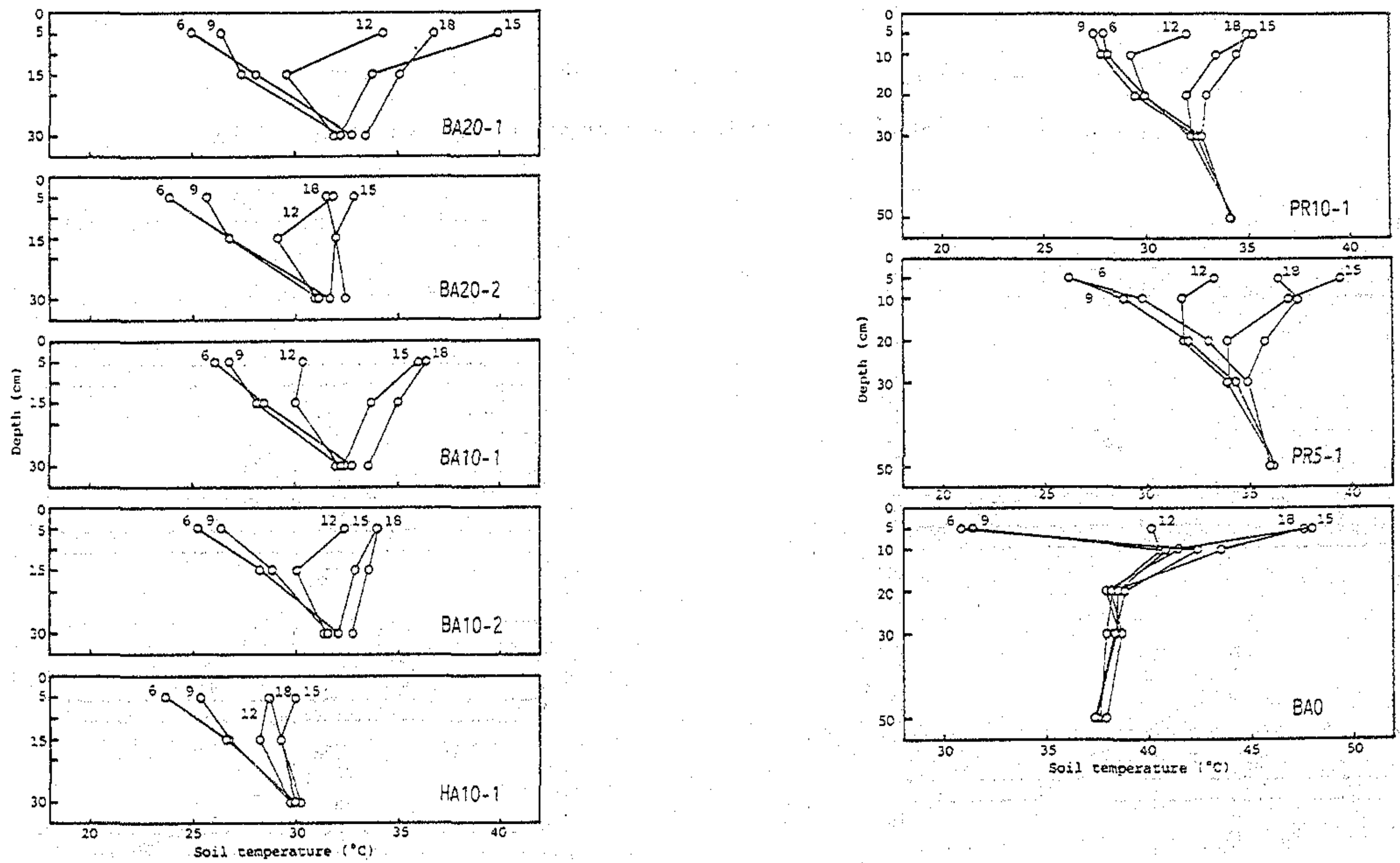


Fig. 8. **Vertical distribtuions of soil temperatures on 15 September, 1986**

The temperature data are presented at 6.00, 9.00, 12.00, 15.00 and 18.00 hours.

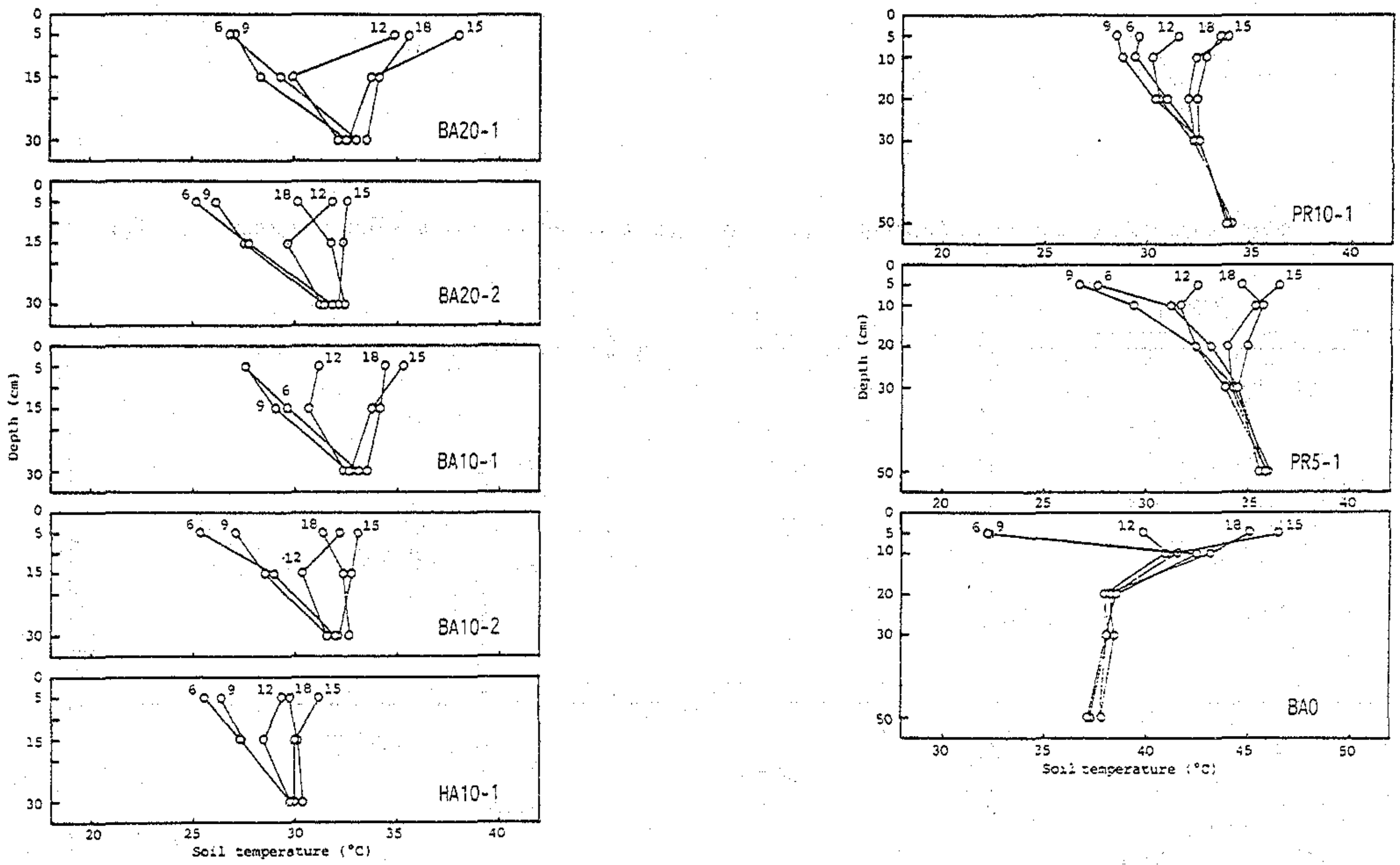


Fig. 9. Vertical distribtuions of soil temperatures on 16 September, 1986

The temperature data are presented at 6.00, 9.00, 12.00, 15.00 and 18.00 hours.

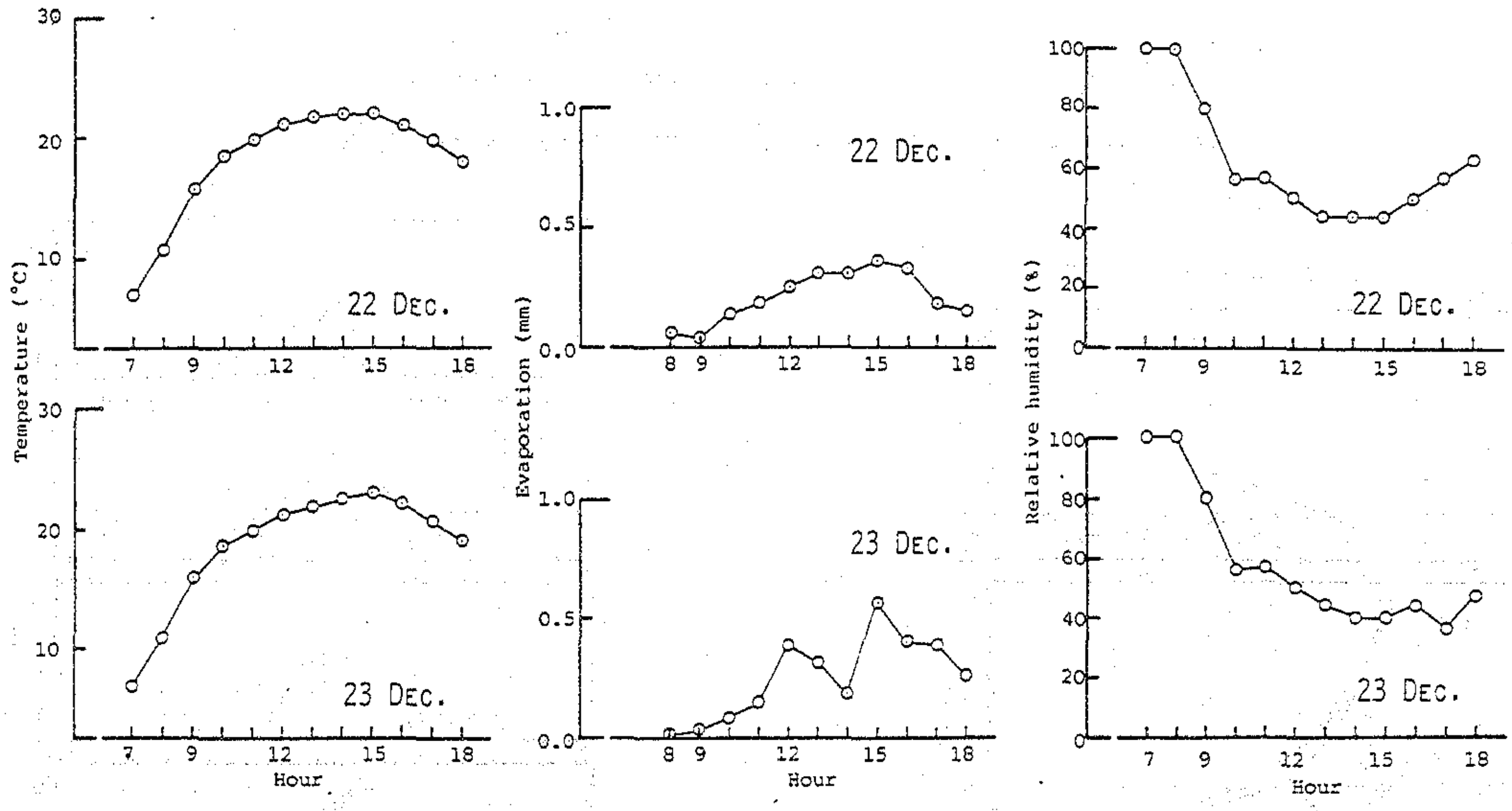


Fig. 10. Diurnal changes in temperature, evaporation and relative humidity on 22 and 23 December, 1986

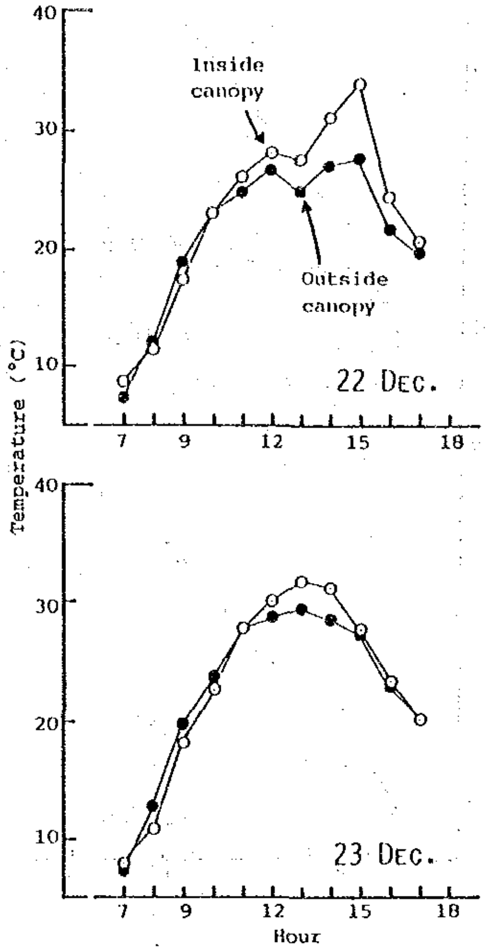


Fig. 11. Diurnal changes in the temperatures inside (○) and outside (●) the canopy of *Haloxylon* sp. on 22 and 23 December, 1986

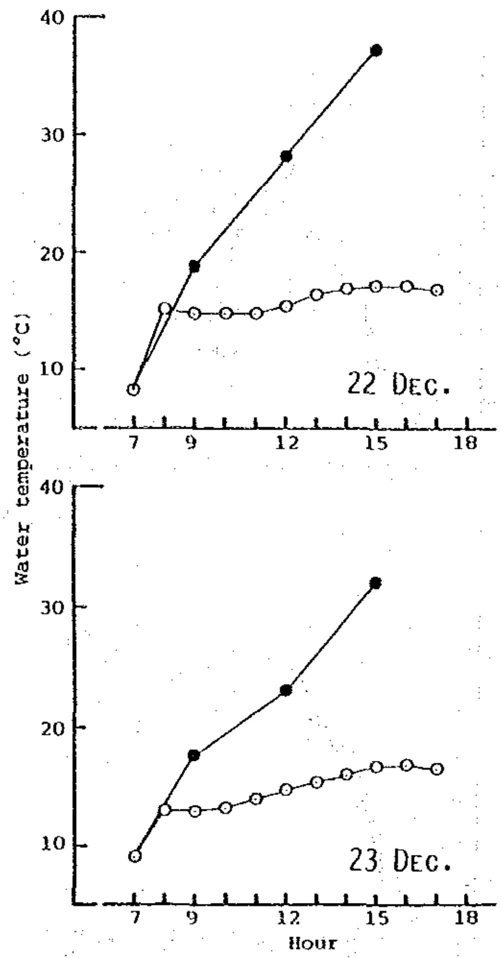


Fig. 12. Diurnal changes in the temperatures of water irrigated (●) and set in the shade (○) on 22 and 23 December, 1986

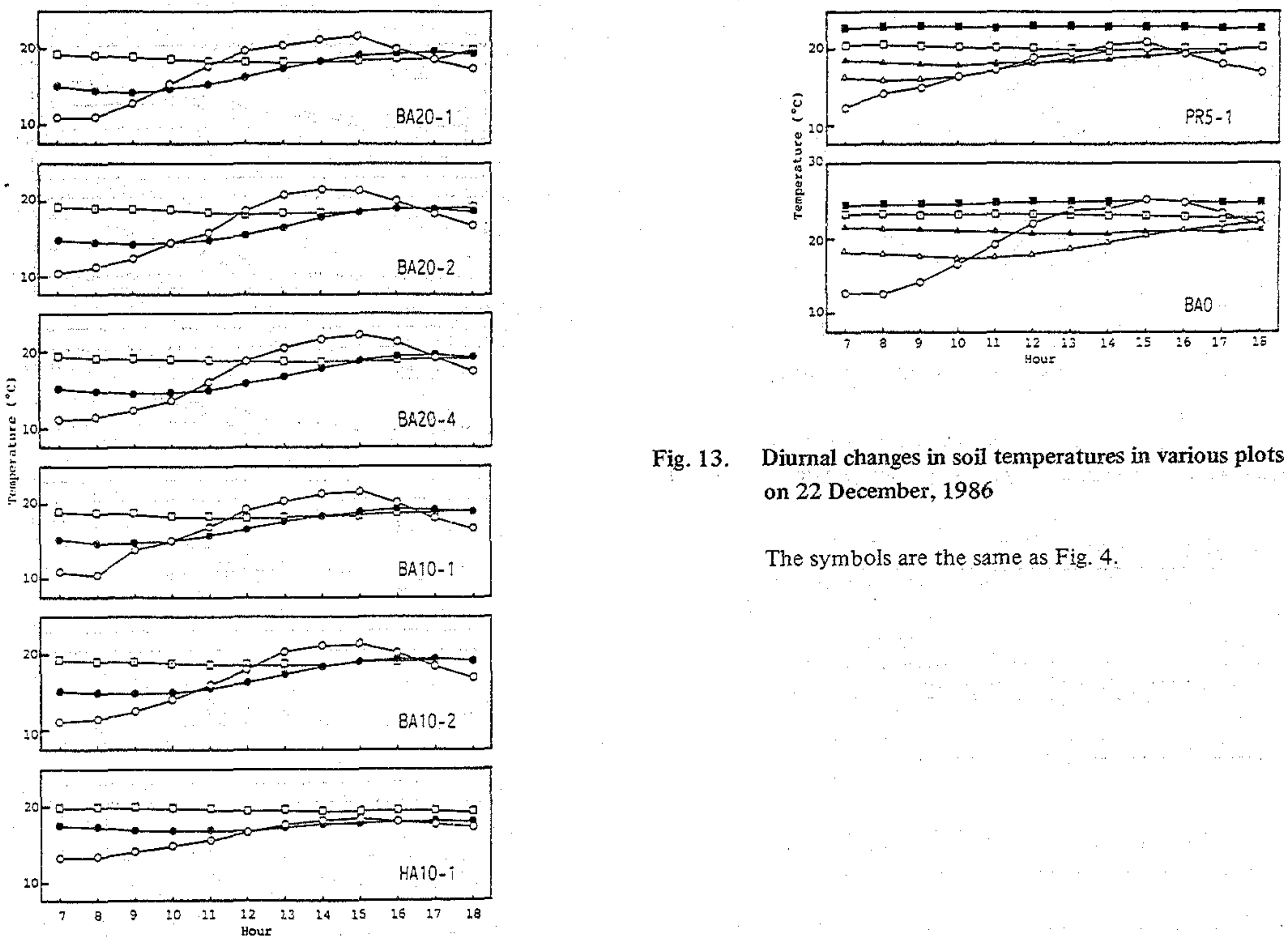
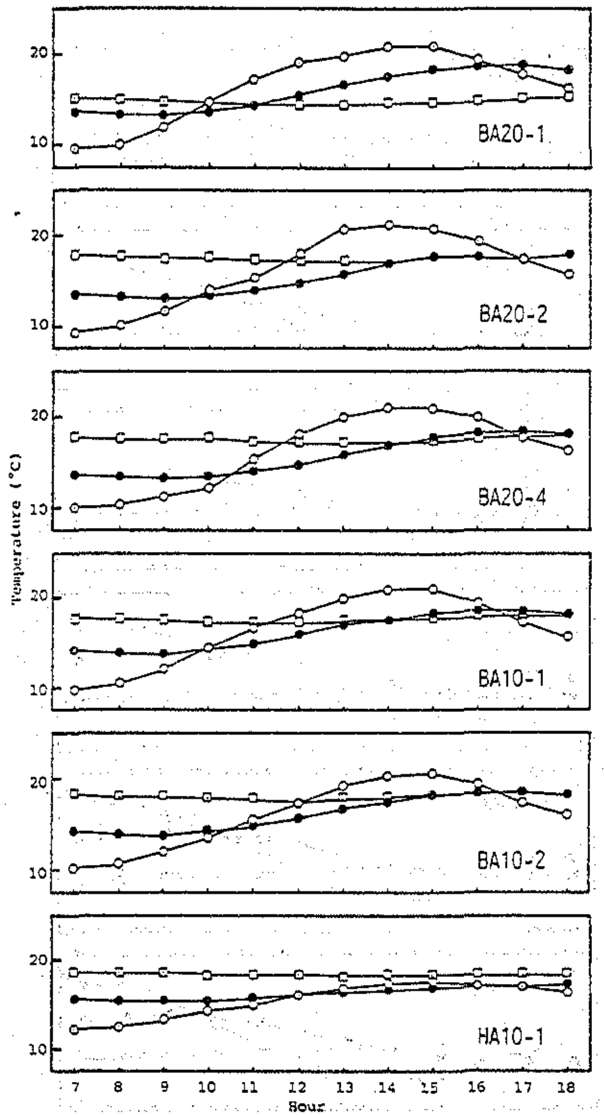


Fig. 13. **Diurnal changes in soil temperatures in various plots on 22 December, 1986**

The symbols are the same as Fig. 4.



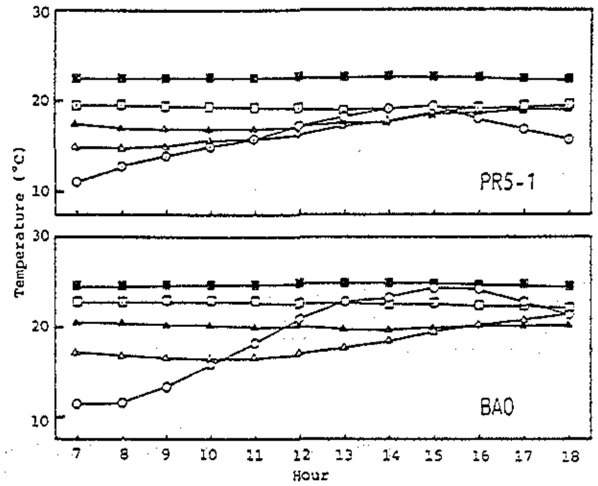
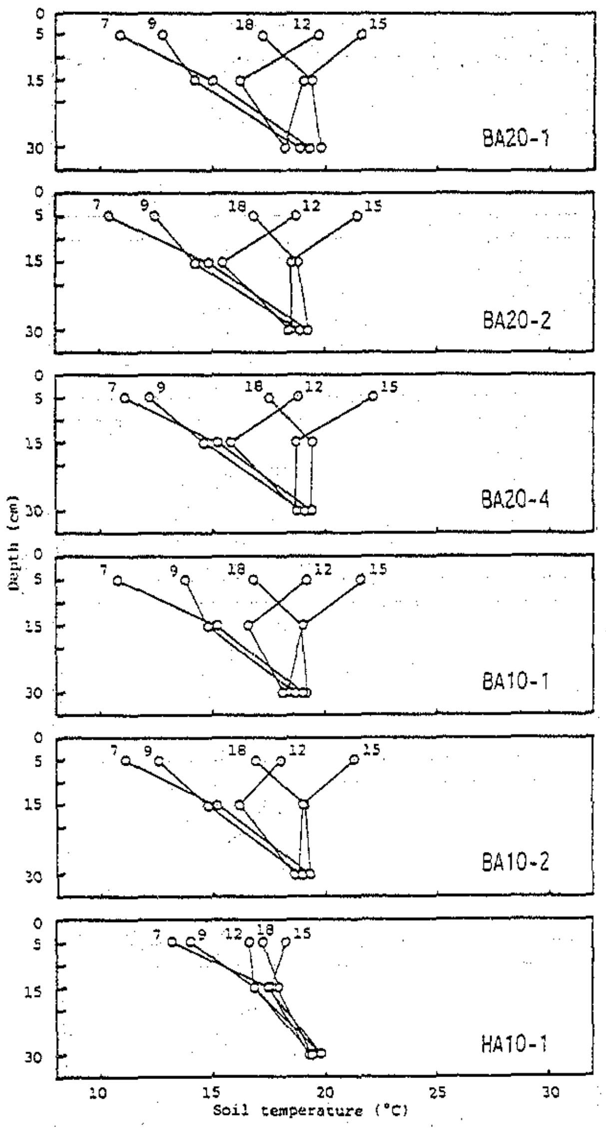


Fig. 14. **Diurnal changes in soil temperatures in various plots on 23 December, 1986**

The symbols are the same as Fig. 4.



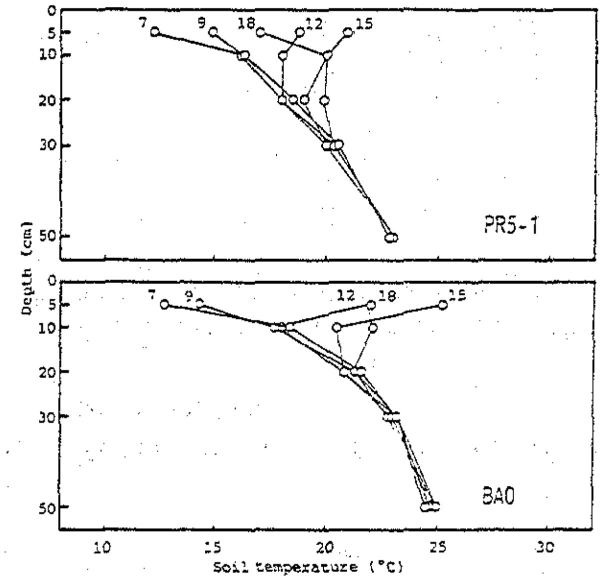
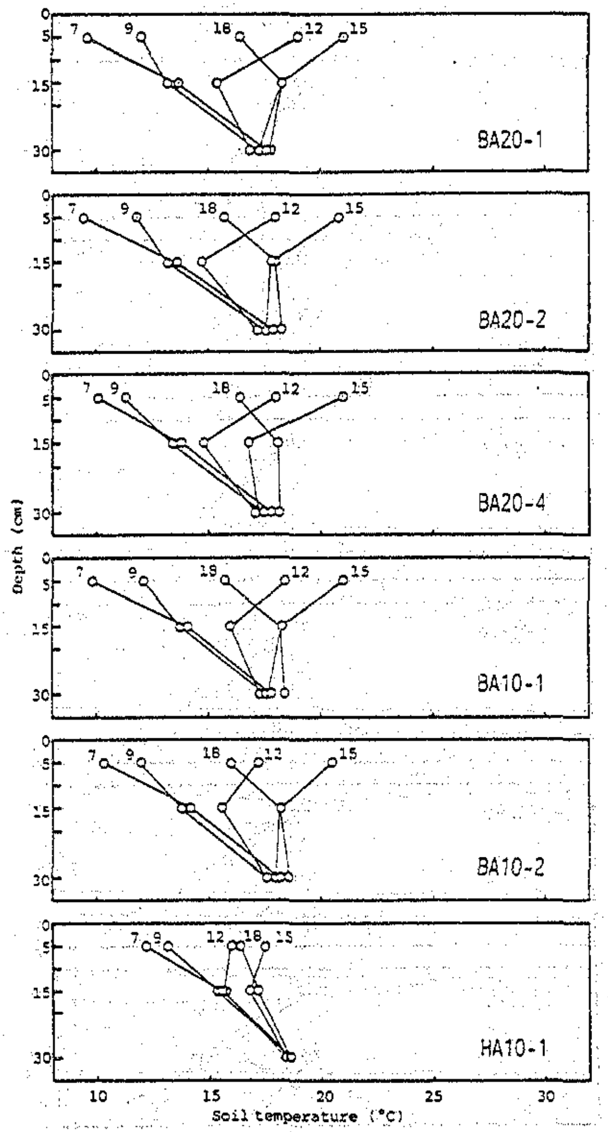


Fig. 15. **Vertical distributions of soil temperatures on 22 December, 1986**

The temperature data are presented at 6.00, 9.00, 12.00, 15.00 and 18.00 hours.



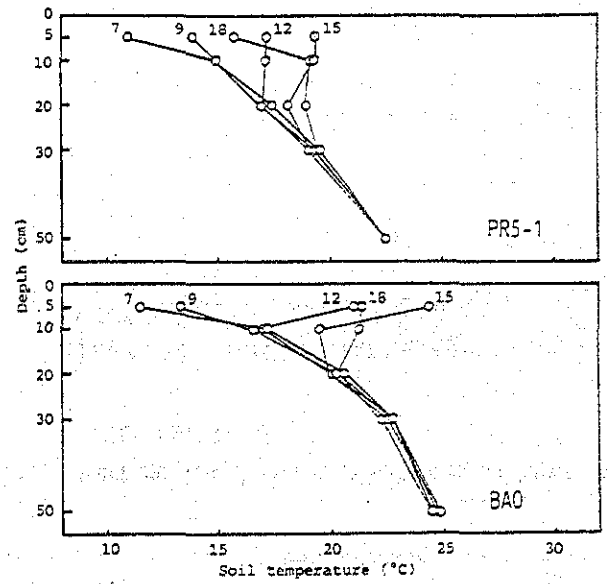


Fig. 16. Vertical distributions of soil temperatures on 23 December, 1986

The temperature data are presented at 6.00, 9.00, 12.00, 15.00 and 18.00 hours.

Table 1. The outline of treatments

Plot	Plant cover	Watering method
September 1986		
BA20-1	Bare soil	Total amount of water is 20 l/m^2 per day, which watered once per day (each amount is 20 l/m^2)
BA20-2	Bare soil	Total amount of water is 20 l/m^2 per day, which watered twice per day (each amount is 10 l/m^2)
BA10-1	Bare soil	Total amount of water is 10 l/m^2 per day, which watered once per day
BA10-2	Bare soil	Total amount of water is 10 l/m^2 per day, which watered twice per day (each amount is 5 l/m^2)
HA10-1	*Haloxylon* sp.	Total amount of water is 10 l/m^2 per day, which watered once per day
BA0	Bare soil	No watering
PR10-1	*Prosopis spicigera*	Total amount of water is 10 l/m^2 per day, which watered once per day
PR5-1	*Prosopis spicigera*	Total amount of water is 5 l/m^2 per day, which watered once per day
December 1986		
BA20-1	the same as BA20-1 in September	
BA20-2	the same as BA20-2 in September	
BA20-4	Bare soil	Total amount of water is 20 l/m^2 per day, which watered four times per day (each amount is 5 l/m^2)
BA10-1	the same as BA10-1 in September	
BA10-2	the same as BA10-2 in September	
HA10-1	the same as HA10-1 in September	
BA0	the same as BA0 in September	
PR5-1	the same as PR5-1 in September	

3. Theme C : Studies on Introduction and Breeding of Well-known Drought-tolerant and Salt-tolerant Crops in UAE

(1) Growth Comparisons among Varieties of Certain Crops

Growth was compared between varieties of cucumber, okra and alfalfa from UAE and other countries.

Varieties used and growth period of each crop were as follows:

Crop	Variety	Source	Growth period
Cucumber	Huming	Japan	17th February – 1st May (Transplanting; 27th March)
	Satsukimidori	Japan	
	Toska 70	UAE	
	Damaskas	UAE	
Okra	Green star	Japan	24th February – 1st July
	Clemson spineless	UAE	
Alfalfa	Natsuwakaba	Japan	12th February – 1st August (Harvest; 1st June, 1st July and 1st Aug.)
	Dupy	Japan	
	Omani	Oman	

Growth of the tested varieties of cucumber and okra was not sufficient because they were injured by strong wind and blowing sand shortly after seeding or transplanting. Accordingly, no differences were observed among them.

Alfalfa was also damaged by wind and blowing sand early in its growth. Varieties evaluated were almost similar in the first harvest. In the second and third harvest, however, growth was better in the Omani variety than in varieties of Natsuwakaba and Dupy.

(2) Raising of Seedlings in Some Species of Trees and Shrubs

Seeds of the following species of trees and shrubs were collected from Japan, China and USA:

No.	Scientific name	Japanese name or Common name	Origin	Life form
1	*Pinus hellepensis*	Aleppo pine	USA	tree
2	*Pinus luchuensis*	Ryukyumatsu	Japan	tree
3	*Pinus densiflora*	Akamatsu	Japan	tree
4	*Casuarina equisetifolia*	Mokumaou	Australia, Africa	tree
5	*Simmondsia chinensis*	Jojoba	USA	tree
6	*Myrica rubura*	Yamamomo	Japan	tree
7	*Quercus phillyraeoides*	Ubamegashi	Japan	tree
8	*Robinia pseudoacacia*	Niseakashia	Japan	tree
9	*Thespecia populnea*	Sakishima-hamabou	Japan, Africa South Asia	tree
10	*Elaeagnus umbellata*	Akigumi	Japan	shrub
11	*Lespedeza bicolor f. actifolia*	Yamahagi	Japan	shrub
12	*Lespedeza cuneata*	Medohagi	Japan	shrub
13	*Amorpha fruticosa*	Itachihagi	USA	shrub
14	*Colligonus leucocladum*	—	China	shrub
15	*Hedysarum mongolicum*	—	China	shrub
16	*Hedysarum scoparium*	—	China	shrub
17	*Haloxylon ammodendron*	—	China	shrub

Seeds were sowed in pots in September and December 1986. *Elaeagnus umbellata* and *Pinus densiflora* seeds did not germinate. Seeds of *Myrica rubura, Lespedeza cuneata* germinated but plants did not grow. *Thespesia populnea* and *Casuarina equisetifolia* seeds germinated and plants are still growing well.

VI. METEOROLOGICAL DATA

Daily meteorological data are summarized in monthly meteorological tables. Instruments used were as follows:

(1) Air temperature	Thermo-hygrograph, Maximum and minimum thermometer	set in shelter
(2) Humidity	Thermo-Hygrometer	set in shelter
(3) Wind velocity & wind direction	Mechanical wind recorder	height of 2 m
(4) Evaporation	Evaporation gauge (Piche type)	set in shelter
(5) Precipitation	Rain gauge	mgeasuring glass

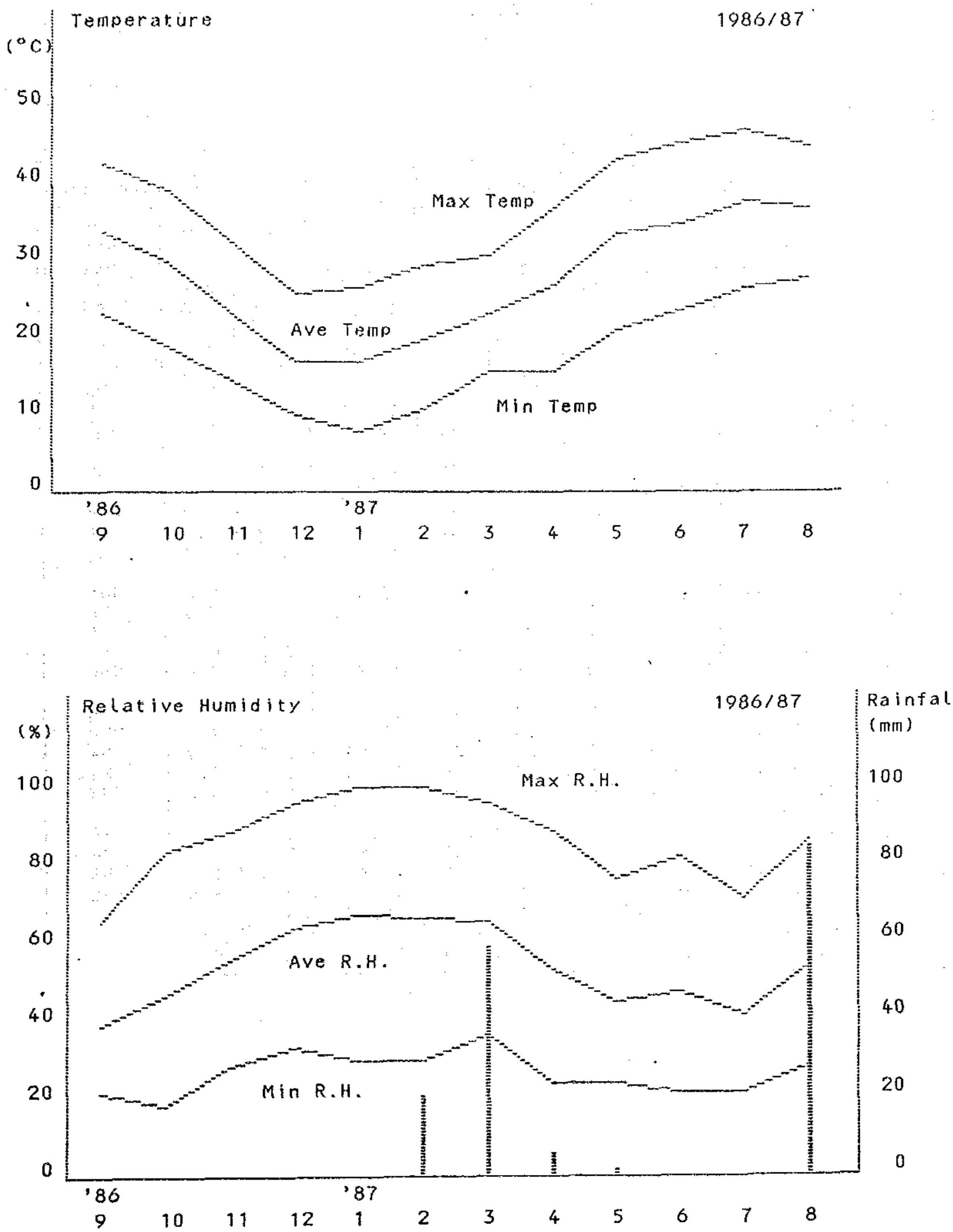
NOTES : Rules for summarization were as follows:

I. Whole daily data exept for evaporation data were based on 24 hours period beginning from 0:00 am. Evaporation data was based on 24 hours period beginning from 8:00 am.

II. Daily average : Average of 8 readings out of the recorder's chart at 3 hours interval beginning from 0:00 am.

III. Monthly data : Following elements are given in monthly average ; Air temperature, Humidity and Wind velocity. Following elements are given in monthly total amount ; Evaporation and Precipitation.

IV. Time used in the meteorological tables is UAE local standard time (G.M.T. + 4 hours).



Temperature
1986/87
(°C)
50
40
30
20
10
0
Max Temp
Ave Temp
Min Temp
'86
'87
9
10
11
12
1
2
3
4
5
6
7
8
Relative Humidity
1986/87
Rainfal
(mm)
(%)
100
80
60
40
20
0
Max R.H.
Ave R.H.
Min R.H.
'86
'87

Fig. VI-1.

Table VI-1-1.

SEPTEMBER, 1986

Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind		
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direction
1	41.8	26.3	34.3	52	22	36	13.96	3.3	7.7	ENE
2	41.8	24.4	34.1	70	23	42	14.17	2.9	5.5	ESE
3	40.7	25.9	33.8	70	22	34	13.18	3.6	6.8	WNW
4	40.4	20.8	31.7	79	20	45	13.56	2.9	4.8	SSW
5	41.6	21.2	32.6	62	20	37	14.06	2.7	5.9	SW
6	41.9	25.4	-	50	19	34	15.50	2.3	4.1	SSE
7	41.6	27.9	-	45	20	29	14.76	3.5	6.2	SSE
8	42.0	25.7	34.5	40	22	31	13.78	3.3	6.0	NW
9	42.0	22.0	33.1	-	23	-	14.21	2.8	7.3	SE
10	41.0	22.7	33.1	53	20	37	15.70	3.1	5.6	SSE
11	40.5	27.9	34.6	44	27	33	14.44	4.1	7.0	ENE
12	41.7	24.8	34.3	47	23	34	14.10	3.1	6.9	SSE
13	40.9	24.1	33.8	42	23	31	13.04	2.5	4.0	SSE
14	41.7	20.0	32.4	50	18	30	14.49	2.2	5.8	NE
15	41.7	19.3	32.4	32	17	24	16.83	2.9	5.2	E
16	39.1	23.2	31.9	56	26	37	11.15	3.0	6.2	SSE
17	39.2	21.0	30.3	70	25	46	10.85	3.8	7.3	SSE
18	38.8	23.1	31.1	72	27	50	11.01	3.9	7.8	SSE
19	39.5	20.5	31.1	75	26	50	11.20	3.3	6.9	SSE
20	39.6	23.0	31.9	80	25	49	11.97	3.7	6.6	SSE
21	40.2	22.7	31.9	65	22	43	11.07	3.0	5.3	SSE
22	42.3	20.3	32.5	80	15	38	15.96	2.8	4.9	NNW
23	41.5	20.4	32.1	56	17	32	14.54	3.0	6.0	NW
24	40.8	19.0	31.0	85	17	49	11.13	2.6	6.0	NW
25	41.1	20.2	32.2	88	12	41	12.85	2.5	5.8	NNW
26	40.8	20.7	31.7	62	17	37	13.03	3.3	7.0	SSE
27	40.7	20.3	31.1	68	19	41	12.67	3.4	6.8	SSE
28	40.6	18.7	30.7	76	20	43	11.62	3.2	7.1	SSE
29	40.4	19.2	30.3	78	22	45	12.17	2.8	6.8	SSE
30	40.7	23.4	31.6	68	19	35	12.17	3.3	6.7	S
Ave.	40.9	22.5	32.3	63	21	38	13.31	3.1	6.2	-

Table VI-1-2.

OCTOBER, 1986										
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind		
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direction
1	40.7	20.2	31.1	78	18	38	11.58	2.6	5.9	SSE
2	40.6	18.7	30.8	68	17	38	12.47	2.3	4.3	SSE
3	40.3	18.9	30.5	60	17	36	12.83	2.3	4.2	NNW
4	40.5	18.4	30.7	83	17	46	10.53	2.2	4.5	NW
5	40.5	19.7	30.8	90	12	52	9.93	2.4	6.0	NW
6	40.9	21.2	31.2	90	12	47	11.40	2.6	6.2	NW
7	42.0	18.8	31.9	86	9	39	14.07	2.6	4.8	SSE
8	40.0	19.3	31.1	74	14	26	11.80	2.2	4.4	NW
9	39.9	18.9	31.1	84	14	38	15.58	3.1	5.8	NNW
10	39.8	19.3	30.6	45	17	26	14.36	3.2	5.8	NNW
11	39.2	20.1	29.8	85	18	36	11.14	2.8	5.4	WNW
12	39.1	17.2	29.1	88	12	48	10.18	2.3	4.2	W
13	39.7	18.3	30.4	70	14	37	12.74	2.3	3.6	NNW
14	37.3	18.3	30.8	58	23	30	9.32	3.2	6.4	SSE
15	37.2	16.7	28.1	84	17	50	9.11	2.7	5.7	NW
16	36.5	21.8	28.6	89	20	58	7.59	2.7	5.8	NW
17	36.6	17.3	27.4	87	17	49	7.67	1.9	3.9	WSW
18	37.5	17.4	27.4	90	12	51	8.18	2.0	3.9	SSW
19	37.0	16.4	27.9	89	12	45	9.70	2.0	3.6	WNW
20	37.4	17.6	28.6	83	15	44	9.80	2.6	6.2	SSE
21	36.5	19.4	28.4	72	16	36	10.25	3.0	6.7	S
22	36.0	16.0	27.1	81	16	39	10.30	2.2	3.9	NNW
23	35.0	15.6	26.4	88	19	53	8.75	2.6	4.8	NW
24	35.1	17.0	26.4	90	20	55	6.75	2.2	5.7	NW
25	33.9	17.7	26.1	88	26	56	6.20	2.0	3.8	NW
26	33.5	16.1	25.1	84	25	56	5.76	1.8	4.0	NW
27	34.8	17.3	26.1	88	26	58	6.17	2.1	4.2	WSW
28	35.5	18.7	26.3	90	23	58	5.95	2.4	5.5	N
29	33.7	17.8	26.4	85	24	51	7.38	2.1	4.5	NW
30	34.2	18.2	26.4	85	27	51	7.05	2.0	4.0	NNE
31	34.8	15.9	25.9	79	21	46	8.62	2.0	4.2	ENE
Ave.	37.6	18.4	28.7	81	18	45	9.78	2.4	4.9	-

Table VI-1-3.

NOVEMBER, 1986										
Date	Temperature (°C)			R.H. (%)			Evaporation (mm)	Wind		
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direction
1	35.5	13.9	24.3	85	23	50	6.95	2.0	4.0	NW
2	33.9	14.2	24.4	90	17	50	7.92	2.0	3.5	W
3	34.4	17.2	26.1	83	17	38	8.46	2.1	3.0	SW
4	34.6	15.0	25.1	71	17	39	8.99	2.5	6.0	SSE
5	33.6	12.7	23.9	86	20	42	8.44	2.1	4.3	NW
6	31.1	16.9	23.1	90	25	63	5.49	2.5	5.8	WNW
7	30.5	16.6	22.3	88	28	60	5.57	2.8	6.4	WNW
8	32.5	13.2	23.3	86	25	50	6.77	1.8	3.2	NNW
9	34.5	15.1	25.4	76	18	41	8.32	2.1	3.6	S
10	35.2	14.8	25.7	64	20	37	8.83	2.1	3.9	SSE
11	32.4	14.7	23.6	87	39	56	5.07	2.3	4.0	NW
12	30.4	15.4	21.7	91	25	60	4.84	-	-	-
13	30.6	12.9	21.5	90	28	60	4.65	-	-	-
14	28.8	14.1	20.6	92	37	64	4.19	-	-	-
15	26.6	13.5	19.5	88	32	57	4.28	2.7	4.5	W
16	29.9	10.4	19.8	90	22	50	5.61	1.7	3.3	N
17	30.0	10.9	20.4	83	30	53	5.27	2.2	5.0	SSE
18	30.2	13.1	21.5	85	33	56	4.80	2.3	6.2	SSE
19	29.8	14.1	22.1	87	35	57	5.35	2.4	5.5	SSE
20	30.6	14.0	23.4	88	30	58	5.04	2.1	4.6	SSE
21	32.2	14.2	22.9	91	21	58	5.83	1.9	4.1	NW
22	31.4	12.6	22.1	88	27	54	5.51	2.4	6.2	SSE
23	31.7	13.7	22.3	92	25	56	5.22	2.2	5.3	SSE
24	30.3	13.9	22.0	83	27	53	5.53	2.3	5.2	SSW
25	27.7	14.3	20.6	87	42	63	3.57	2.1	4.5	W
26	27.3	12.9	19.9	90	27	62	3.97	2.0	3.6	WNW
27	28.2	11.7	19.9	91	24	58	4.46	1.8	3.2	NNW
28	30.2	11.9	21.3	93	23	56	5.03	1.7	2.9	NNW
29	29.6	13.0	21.9	89	32	59	5.36	3.1	6.7	SSE
30	29.2	15.0	21.9	80	33	53	5.48	2.4	5.5	S
Ave.	31.1	13.9	22.4	86	27	54	5.83	2.2	4.6	-

Table VI-1-4.

DECEMBER, 1986										
Date	Temperature (°C)			R.H. (%)			Evaporation (mm)	Wind		
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direction
1	29.8	16.0	22.2	72	30	50	6.82	4.2	6.5	SSE
2	29.3	16.0	22.2	75	32	55	6.30	4.3	7.5	SSE
3	28.0	16.8	21.5	87	37	65	3.99	4.0	6.9	S
4	27.6	14.0	20.4	100	38	68	3.16	2.0	3.9	NW
5	26.5	15.0	19.6	90	38	69	2.50	1.8	3.2	SSE
6	20.9	16.0	15.8	100	75	87	0.65	3.8	6.4	WSW
7	17.9	8.0	12.5	90	43	69	1.33	2.0	3.4	WSW
8	21.8	9.0	15.5	100	38	66	2.65	2.1	3.9	NNW
9	22.5	7.5	14.6	91	32	64	3.16	2.2	4.2	NNW
10	23.1	10.0	15.4	100	39	68	2.60	2.0	4.5	NW
11	23.7	10.6	16.1	100	33	67	2.63	1.8	4.2	WNW
12	23.8	10.8	15.8	90	31	66	2.97	2.2	5.6	W
13	23.6	8.8	15.3	92	28	61	3.03	1.4	2.8	NNW
14	23.5	8.3	15.0	100	27	59	3.24	1.9	4.8	SSE
15	23.5	9.5	15.5	95	35	58	3.85	2.1	3.4	NNW
16	24.0	8.4	15.5	100	17	57	3.82	2.2	4.9	W
17	21.7	8.6	15.1	95	29	58	3.26	1.9	4.0	NNW
18	24.6	6.6	14.6	90	29	59	3.27	1.8	4.3	S
19	25.0	8.3	15.3	94	24	56	4.21	2.4	5.4	S
20	25.8	8.1	16.9	89	31	57	4.75	2.7	5.8	SSE
21	25.0	10.6	16.9	87	42	61	3.10	2.3	3.6	WSW
22	22.0	6.3	13.7	94	28	65	2.83	1.6	3.1	NW
23	23.0	6.0	14.3	100	25	59	3.73	2.0	3.3	NNW
24	26.0	7.5	15.9	90	20	58	3.43	1.7	4.0	S
25	27.1	7.7	16.3	100	24	61	3.67	1.6	3.6	W
26	26.0	7.8	15.8	91	27	62	3.45	1.9	5.7	SSE
27	25.7	7.4	15.2	94	27	60	3.65	1.9	5.1	SSE
28	25.6	8.5	15.7	91	30	59	3.35	1.9	4.8	SSE
29	25.6	9.2	16.3	92	32	60	3.43	1.9	5.1	SSE
30	27.7	7.6	16.8	90	18	55	4.01	1.6	3.1	WSW
31	26.4	9.0	17.3	90	27	62	4.24	2.2	4.5	WNW
Ave.	24.7	9.8	16.4	93	32	62	3.45	3.1	6.2	-

Table VI-1-5.

JANUARY, 1987											
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Precip-tation (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	22.7	11.4	16.1	92	39	68	2.46	2.0	4.5	WNW	
2	22.5	8.6	14.4	93	40	70	2.44	1.8	3.4	WNW	
3	23.4	10.7	16.0	100	47	75	2.70	1.8	3.7	NW	
4	23.4	8.2	15.1	100	35	74	3.14	2.0	3.9	NNW	
5	22.5	7.0	14.8	100	37	73	2.56	1.5	3.0	W	
6	24.6	6.4	14.9	100	33	70	3.12	1.7	4.5	SW	
7	25.3	6.4	15.3	98	25	61	4.84	2.6	6.6	SW	
8	24.0	5.8	15.9	97	37	67	3.32	1.7	3.1	NW	
9	22.8	8.8	16.2	100	37	70	3.13	1.8	3.7	NW	
10	25.4	6.4	15.9	99	30	67	3.41	1.6	2.6	W	
11	24.6	7.0	15.9	100	27	64	3.82	1.8	3.9	WNW	
12	25.4	9.8	17.0	100	25	67	4.56	2.3	4.0	NNW	
13	25.4	7.4	16.8	97	29	63	4.29	1.6	3.2	ESE	
14	25.0	7.6	16.7	91	29	57	4.81	2.2	4.0	SSW	
15	23.4	7.7	15.9	94	40	66	4.09	2.4	4.5	NW	
16	25.7	6.1	15.8	100	20	62	4.75	2.1	3.5	N	
17	26.0	4.4	15.8	98	22	62	5.32	2.1	4.6	NW	
18	28.4	4.2	16.5	100	14	63	5.24	1.9	5.3	NW	
19	28.3	5.2	17.6	100	15	63	5.43	1.9	5.2	NW	
20	28.8	5.5	17.7	100	17	62	5.31	2.2	4.6	NNW	
21	25.0	8.2	16.2	99	32	76	2.66	1.9	3.3	NW	
22	25.5	9.2	15.8	100	26	75	2.71	2.0	3.0	WSW	
23	29.0	6.3	16.6	100	16	59	5.41	2.4	5.4	SW	
24	27.8	7.3	17.4	98	25	62	4.98	2.0	5.4	SSE	
25	28.0	9.4	18.8	98	25	64	4.19	2.0	4.4	SSE	
26	28.3	8.7	18.7	99	23	58	5.33	2.0	4.3	SSE	
27	29.9	6.4	18.6	85	20	48	6.79	1.7	3.3	NNW	
28	30.3	11.2	19.6	80	32	51	6.66	2.8	5.4	NNW	
29	26.8	13.7	19.4	100	21	62	5.22	2.6	4.7	NNW	
30	24.5	8.8	16.0	100	35	74	3.36	2.4	5.0	W	
31	25.3	8.2	16.7	100	39	74	3.15	1.9	3.5	NW	
Ave	25.7	7.8	16.6	97	29	65	4.17	2.0	4.2	-	0.0*

* : Monthly total of preciptation (mm).

Table VI-1-6.

FEBRUARY, 1987											
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Preci-tati (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	28.1	10.2	18.8	99	34	74	3.30	1.7	3.3	WNW	
2	28.3	9.8	19.6	99	33	67	4.29	2.1	4.9	W	
3	30.3	9.8	20.3	98	22	61	4.93	1.6	2.9	W	
4	31.6	10.2	21.1	96	21	55	6.88	2.2	4.4	SW	
5	31.0	11.3	20.6	94	23	51	6.37	2.7	5.5	SSE	
6	26.6	9.1	17.7	100	32	70	3.88	2.1	3.7	WNW	
7	25.5	6.0	15.8	100	27	67	3.59	1.6	2.9	WNW	
8	28.1	6.6	16.4	100	23	66	4.25	1.7	3.6	SW	
9	30.1	5.8	17.9	96	18	53	6.81	2.1	4.9	SW	
10	30.4	9.6	20.9	88	28	47	11.61	5.7	10.4	SSE	
11	26.4	15.4	20.4	95	48	64	3.48	3.9	6.2	SSW	
12	29.3	8.9	18.9	100	32	70	4.26	2.1	3.9	NW	
13	28.3	12.1	19.9	100	28	72	4.08	2.5	4.9	NW	
14	26.5	12.7	19.0	100	27	71	4.38	2.6	4.9	WNW	
15	26.0	7.8	16.7	100	27	69	3.80	2.0	3.6	WNW	
16	27.0	9.2	17.0	100	19	67	4.43	1.7	3.5	WNW	
17	30.3	6.4	18.7	98	13	57	6.24	2.0	4.0	SW	
18	31.2	8.4	20.1	90	23	51	7.94	3.3	8.0	SSE	
19	31.2	13.6	23.2	92	35	64	7.25	4.0	7.6	SSE	
20	31.4	19.6	24.1	92	33	65	7.24	5.8	10.2	SSE	
21	24.5	18.5	19.5	100	58	84	2.05	3.9	9.6	SSE	20.0
22	24.5	12.4	17.0	100	56	85	1.95	2.1	4.3	W	
23	25.5	9.2	17.3	100	30	67	4.17	2.3	4.6	N	
24	25.3	7.8	17.0	98	32	67	3.60	1.9	4.3	SSW	
25	26.5	8.4	17.7	100	26	62	5.31	2.1	4.5	NNW	
26	30.0	8.4	19.2	100	22	60	5.83	2.4	5.8	SSE	
27	30.8	10.4	20.6	99	23	61	6.28	2.0	6.6	S	
28	33.0	13.1	22.4	93	29	58	7.79	2.9	7.9	SSE	
Ave	28.5	10.4	19.2	97	29	64	5.21	2.6	5.4	-	20.0*

*: Monthly total of preciptation (mm).

Table VI-1-7.

MARCH, 1987											
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Preci-tati(on) (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	31.9	18.7	25.0	76	33	50	8.52	3.8	6.7	SSE	
2	30.1	20.6	24.7	85	39	60	5.59	3.1	6.0	SSE	
3	33.0	14.9	23.7	95	29	59	7.58	1.8	4.4	SSE	
4	27.0	19.2	23.1	98	38	55	4.92	3.5	7.8	SSE	0.2
5	30.0	12.4	21.8	100	28	65	5.28	2.0	4.0	WNW	
6	29.7	14.7	21.4	100	27	61	5.45	2.2	3.7	WNW	
7	30.7	9.5	21.3	91	17	49	7.23	2.0	4.0	NNW	
8	31.8	11.9	22.6	92	25	52	7.32	2.0	4.5	NNW	
9	34.3	18.3	25.3	80	25	49	7.42	2.2	5.0	WSW	
10	33.0	14.7	24.8	91	23	54	7.13	2.2	4.6	NW	
11	32.0	11.0	22.8	94	21	52	8.80	2.3	6.1	NNW	
12	34.5	13.3	24.1	81	28	49	8.41	2.3	5.1	W	
13	31.9	17.9	24.5	98	34	65	8.56	3.8	8.9	SSE	0.8
14	29.7	19.8	22.9	98	53	75	4.41	7.0	11.9	SSE	9.2
15	23.6	14.4	18.4	98	38	75	2.95	3.0	5.0	WNW	
16	28.5	10.7	19.4	98	24	61	5.91	2.4	4.0	N	
17	33.4	12.9	23.1	96	18	53	11.01	3.6	6.5	SSE	
18	32.6	19.4	26.9	62	22	34	7.91	3.2	5.4	S	
19	35.0	13.1	24.9	86	20	45	9.81	2.5	5.5	WSW	
20	35.0	17.8	27.1	82	22	39	9.29	3.6	6.0	WSW	
21	30.8	14.8	23.1	93	35	63	6.87	2.8	4.7	NW	
22	26.6	17.0	21.4	98	33	71	4.54	3.0	4.8	NNW	0.9
23	23.5	16.2	18.4	100	59	88	1.25	2.8	5.2	W	7.6
24	25.5	14.7	19.4	100	37	73	3.57	2.5	6.0	WNW	
25	29.4	12.3	20.2	98	24	65	5.20	2.0	4.3	S	
26	31.8	12.5	23.4	98	28	57	9.76	3.7	8.8	SSE	
27	20.3	16.8	20.1	100	48	82	1.09	4.6	9.4	SSE	33.0
28	25.2	15.8	20.1	99	72	90	1.59	2.4	3.7	WNW	
29	24.3	14.6	18.0	98	70	92	2.16	2.4	6.3	S	1.2
30	25.6	17.2	21.3	98	62	79	3.42	6.9	11.7	SSE	3.8
31	23.7	16.8	19.2	98	48	79	2.78	3.4	5.0	W	
Ave	29.5	15.3	22.3	93	35	63	5.99	3.1	6.0	-	56.7*

* : Monthly total of preciptation (mm).

Table VI-1-8.

APRIL, 1987											
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Precip-tatio (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	25.2	10.7	17.8	98	34	67	3.97	2.3	4.2	WNW	
2	26.3	10.6	18.4	98	36	68	4.05	2.0	4.1	NW	
3	30.0	10.8	20.3	99	29	70	5.03	2.7	5.3	NW	
4	33.3	12.9	23.1	100	16	59	6.98	2.3	4.4	SSW	
5	35.2	15.2	25.6	95	20	55	10.18	4.5	9.3	S	0.3
6	30.5	19.4	24.1	95	46	73	3.96	4.6	9.8	SSE	5.0
7	27.7	20.0	23.1	97	55	79	2.50	2.4	3.4	SSE	
8	29.0	14.6	21.0	100	24	70	4.53	2.3	4.5	WNW	0.1
9	29.5	13.7	21.5	99	28	64	5.12	1.8	4.0	WNW	
10	32.6	14.8	23.3	97	22	56	7.95	2.2	5.6	NW	
11	33.5	15.8	24.4	86	22	51	8.36	2.5	5.8	WNW	
12	34.3	13.7	24.2	94	19	49	9.86	2.4	5.5	NW	
13	35.0	12.6	24.9	80	22	46	9.12	2.2	4.1	NW	
14	36.9	11.8	25.4	90	15	46	9.29	1.8	3.2	WNW	
15	39.0	13.2	27.0	87	14	47	10.33	2.0	3.6	SW	
16	39.8	16.3	28.9	88	19	45	12.72	2.7	6.0	SSE	
17	39.4	18.6	30.3	78	21	39	12.44	3.7	8.3	SSE	
18	39.5	17.8	29.6	78	22	42	12.10	2.7	6.1	SSE	
19	39.5	18.4	29.9	63	23	38	12.41	3.4	7.4	SSE	
20	40.3	17.9	30.1	67	19	39	11.66	3.3	7.0	S	
21	36.6	17.8	27.2	97	18	54	8.10	2.6	6.0	WNW	
22	35.7	16.4	26.3	95	16	51	9.06	2.5	6.2	NW	
23	38.0	13.0	26.4	91	17	46	9.53	2.1	4.8	NW	
24	39.6	15.4	28.6	86	19	48	11.99	2.8	5.9	NW	
25	40.6	16.3	29.0	67	17	38	12.74	2.4	5.6	NW	
26	40.8	16.3	29.0	70	17	37	12.08	2.0	3.6	NW	
27	41.8	15.1	30.0	60	16	32	12.75	2.2	4.4	NNW	
28	41.6	17.2	30.9	71	20	35	13.01	2.7	6.0	NW	
29	41.0	17.4	30.0	77	24	41	11.53	2.6	6.8	WNW	
30	42.8	18.0	31.1	81	22	45	14.81	2.7	5.5	NNW	
Ave	35.8	15.3	26.0	86	23	51	9.27	2.6	5.5	-	5.4*

* : Monthly total of preciptation (mm).

Table VI-1-9.

MAY, 1987											
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Precip-tatio (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	42.1	20.8	32.4	65	17	34	21.92	3.8	8.9	E	
2	42.9	22.5	33.3	57	20	27	15.39	2.1	4.0	SSE	
3	42.0	23.6	33.5	53	24	34	14.15	4.0	8.0	SSE	
4	42.5	20.8	32.8	65	25	41	13.35	2.9	6.4	SSE	
5	42.5	21.1	33.4	58	22	37	14.45	2.9	5.3	S	
6	42.2	19.0	32.0	64	22	36	14.59	2.9	6.5	NW	
7	39.5	19.0	30.4	60	26	36	13.21	3.4	7.1	WSW	
8	38.3	14.5	28.0	93	22	51	9.83	1.9	3.7	W	
9	40.6	17.9	30.3	98	15	52	12.65	2.4	5.4	WNW	
10	40.7	19.5	31.8	86	21	42	16.02	3.8	8.7	S	
11	41.0	21.4	32.3	70	28	45	14.54	4.0	8.2	SSE	
12	40.9	23.1	32.7	60	25	41	12.84	4.1	8.0	WNW	
13	40.2	18.4	30.7	71	23	44	12.34	2.7	5.6	W	
14	40.8	19.0	30.3	75	23	46	14.25	3.1	5.7	SW	
15	41.8	21.0	32.3	73	22	45	14.98	3.4	6.6	SSW	
16	42.2	20.8	31.9	92	22	47	14.39	2.7	6.1	NW	
17	42.4	20.9	33.6	66	22	38	13.41	2.9	4.8	WSW	
18	43.0	19.7	32.9	78	22	47	11.90	2.7	6.5	NW	
19	43.1	20.5	33.2	95	17	51	13.50	2.5	5.7	WNW	
20	43.0	22.0	33.7	89	23	51	13.29	3.4	6.5	SSE	1.3
21	40.6	22.3	32.4	93	23	49	11.72	2.3	4.5	W	
22	41.1	21.4	32.4	60	25	41	12.00	2.5	5.1	WNW	
23	42.1	19.5	33.4	74	21	42	13.75	2.8	5.6	SSE	
24	42.6	24.1	34.6	58	23	40	16.78	3.3	7.8	SSE	
25	42.6	23.7	34.7	60	25	39	15.20	3.8	7.6	S	
26	42.9	19.9	33.1	66	22	41	12.09	2.4	5.6	WNW	
27	43.0	21.0	33.2	81	22	46	12.16	2.5	6.3	WNW	
28	42.3	21.1	33.6	91	24	50	14.15	2.8	5.8	SW	
29	41.5	21.2	32.0	83	26	49	12.97	2.8	6.7	WNW	
30	42.0	19.7	31.8	69	24	42	13.32	2.5	5.5	WNW	
31	41.7	20.3	32.4	80	30	51	13.58	4.3	8.0	SSE	trace
Ave	41.7	20.6	32.4	74	23	43	13.83	3.0	6.3	-	1.3*

* : Monthly total of preciptation (mm).

Table VI-1-10.

JUNE, 1987

Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Precipi-tation (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	37.3	22.5	31.0	89	41	57	10.98	3.2	6.1	SSW	
2	38.9	25.2	30.8	85	41	64	10.84	3.0	5.9	SSE	0.2
3	42.5	21.8	32.2	93	30	60	11.96	2.7	6.6	NNW	
4	45.0	23.7	35.3	83	24	50	15.65	3.6	7.2	NNW	
5	46.1	24.9	36.1	66	18	44	15.93	3.1	6.7	NNW	
6	46.2	24.9	36.2	92	25	49	13.02	3.7	7.5	SSE	
7	44.2	25.2	34.5	98	15	58	11.73	3.1	7.0	NW	
8	43.6	23.3	34.5	96	25	57	10.01	2.9	5.3	NNW	
9	44.1	25.3	36.0	96	25	58	10.63	3.0	5.0	SSE	
10	44.9	26.9	36.4	95	17	53	11.73	3.3	5.4	W	
11	42.3	21.8	32.6	96	16	51	10.64	2.6	6.0	W	
12	40.5	16.9	28.8	96	22	57	8.13	2.5	6.3	W	
13	41.2	21.4	30.6	99	14	50	12.32	2.7	6.2	WNW	
14	42.1	18.3	30.6	74	14	35	12.70	2.4	6.7	NW	
15	43.2	19.1	31.6	87	17	44	12.60	2.5	6.1	WNW	
16	45.4	19.9	32.5	92	14	48	13.55	2.5	7.2	NW	
17	45.6	22.4	34.3	77	15	41	16.61	3.0	7.0	NNW	
18	45.5	23.4	34.1	55	17	32	16.09	2.9	7.2	NW	
19	44.0	21.4	33.9	57	18	34	15.91	3.3	8.0	NW	
20	41.4	20.4	31.4	80	27	51	10.08	2.9	5.3	W	
21	44.6	21.0	33.6	94	19	53	13.37	2.6	6.7	NW	
22	46.0	24.2	35.7	78	19	47	15.84	3.1	5.8	NW	
23	44.8	28.7	37.4	72	17	39	18.56	4.6	8.9	SSE	
24	44.5	24.9	35.9	85	18	46	14.59	2.5	4.8	NNW	
25	44.5	22.1	34.1	55	20	33	15.31	2.5	5.6	NW	
26	44.4	22.4	-	55	18	32	19.31	3.5	5.7	NNW	
27	44.9	23.4	-	45	18	26	17.45	2.9	6.3	NW	
28	45.6	23.5	36.1	51	17	32	16.28	3.0	6.5	NNW	
29	45.5	23.3	36.0	65	18	39	16.25	2.8	6.6	NNW	
30	45.2	21.2	35.2	52	20	34	14.97	2.8	4.7	SSE	
Ave	43.8	22.8	33.8	79	21	46	13.77	3.0	6.3	-	0.2*

* : Monthly total of preciptation (mm).

Table VI-1-11.

JULY, 1987											
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Precip-tation (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	46.2	22.0	36.2	92	13	41	13.98	2.8	5.6	WNW	
2	46.6	22.3	36.0	77	18	48	14.26	3.0	7.9	NNE	
3	45.5	23.3	35.3	91	15	48	15.04	3.1	6.7	W	
4	42.8	20.4	33.1	67	18	39	14.37	3.1	6.9	W	
5	43.1	19.8	33.1	83	15	43	13.79	2.2	4.6	NW	
6	45.2	24.0	35.6	76	17	43	16.59	2.9	5.3	SW	
7	44.9	24.9	36.0	84	23	44	15.07	2.5	4.8	SE	
8	44.7	26.8	36.6	58	25	35	15.58	3.1	6.2	SSE	
9	45.4	25.3	36.6	48	22	35	16.50	3.1	6.3	NW	
10	45.1	23.2	35.3	73	22	35	15.29	2.9	6.8	WNW	
11	44.2	21.7	34.8	77	17	39	14.69	2.4	4.5	SW	
12	46.3	23.2	35.9	70	17	41	15.26	2.3	4.5	SSW	
13	46.5	24.5	36.8	59	18	32	17.00	2.4	5.5	NW	
14	45.7	24.1	36.9	60	21	32	13.70	2.2	3.9	W	
15	46.5	24.2	36.6	77	22	48	15.04	2.7	5.6	NW	
16	46.4	27.0	37.9	95	13	42	15.07	2.8	5.8	NNW	
17	46.5	24.9	36.7	55	15	34	14.73	2.3	5.9	NNW	
18	46.9	25.0	37.1	50	16	29	15.33	2.4	6.2	NNW	
19	47.5	25.5	37.8	60	16	34	15.59	2.7	5.9	NW	
20	47.3	25.9	38.4	74	17	41	17.99	2.8	5.3	ENE	
21	46.9	31.1	40.4	62	20	33	19.99	4.3	7.4	SSE	
22	44.8	31.4	38.9	55	25	36	14.80	3.5	5.3	SSE	
23	44.9	27.6	37.8	54	27	39	16.95	3.0	5.5	SSE	
24	44.9	29.3	38.6	52	28	39	17.95	4.9	7.8	SSW	
25	43.6	30.6	37.8	52	29	38	18.20	5.3	7.6	S	
26	45.2	31.3	38.6	60	25	36	17.17	4.4	7.3	SSE	
27	45.6	26.5	37.3	62	22	41	18.32	4.2	7.7	SSE	
28	43.9	29.9	35.3	83	28	52	12.99	5.0	9.6	N	trace
29	41.7	25.7	33.8	85	35	58	11.26	4.5	8.4	SSW	
30	42.2	26.9	35.6	75	34	52	14.39	3.8	6.4	SSE	
31	42.6	29.2	36.1	64	33	47	-	3.7	8.1	SSE	
Ave	45.1	25.7	36.5	69	21	40	15.56	3.2	6.3	-	trace*

* : Monthly total of preciptation (mm).

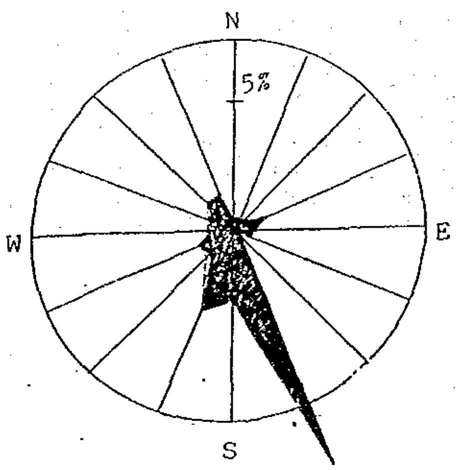
Table VI-1-12.

AUGUST, 1987												
Date	Temperature (°C)			R.H. (%)			Evapo-ration (mm)	Wind			Precip-tation (mm)
	Max	Min	Ave	Max	Min	Ave		Ave	Max	Direct.	
1	42.8	29.3	36.9	68	31	46	-	3.5	7.0	SSE	
2	44.5	31.1	38.3	47	25	38	-	3.7	6.8	SSE	
3	43.8	33.1	39.1	44	28	35	-	5.1	8.6	E	
4	46.0	31.5	38.1	65	27	40	14.46	3.2	5.2	SSE	0.5
5	44.2	26.2	34.1	73	32	55	10.54	3.1	9.4	NE	
6	42.5	24.3	34.9	90	31	52	12.00	3.2	6.8	SSE	
7	43.7	25.3	34.2	79	30	49	11.89	3.4	8.3	N	
8	45.5	24.8	35.4	86	23	53	12.72	2.8	7.4	NE	
9	46.8	25.8	37.4	80	23	45	17.28	2.4	4.4	E	
10	46.0	27.1	38.3	50	25	35	14.99	2.8	5.3	SSE	
11	45.8	27.7	38.0	60	27	42	15.00	2.9	5.9	NNW	
12	46.5	26.6	37.9	80	25	42	13.35	3.0	6.8	SSE	
13	46.9	27.4	38.6	94	19	48	16.15	2.8	6.4	SSE	
14	47.9	29.3	38.3	80	22	44	14.60	4.4	9.2	SSE	10.9
15	44.0	26.8	35.8	86	28	59	10.00	3.3	5.5	SE	
16	42.6	19.4	33.3	100	36	64	8.45	2.7	7.8	SE	47.7
17	41.0	26.4	31.4	96	28	64	6.66	2.9	9.7	SSE	9.3
18	41.8	25.9	32.8	94	24	60	10.87	3.2	6.5	SSE	
19	43.2	27.0	35.2	85	25	48	12.22	3.1	5.1	NNW	
20	42.0	26.1	35.6	88	27	50	9.67	3.2	4.7	WNW	
21	41.7	26.7	34.1	95	25	61	8.38	2.5	5.6	ESE	
22	44.0	27.7	36.7	95	21	48	12.69	2.2	5.2	ESE	
23	44.8	27.1	36.8	87	18	48	13.70	2.6	5.3	NNW	
24	42.4	26.1	34.6	87	22	52	11.97	3.5	7.9	W	
25	38.4	25.0	32.6	87	35	60	8.22	3.1	5.3	WSW	
26	41.2	25.6	34.0	94	23	60	9.54	2.6	4.5	SSE	
27	42.0	28.2	33.4	97	29	64	7.00	2.8	8.7	WNW	12.9
28	39.0	23.0	32.4	97	38	74	4.57	2.0	3.5	WNW	
29	39.2	26.7	32.4	96	30	69	6.47	2.6	6.0	W	
30	38.5	24.4	31.7	96	25	60	7.69	2.2	4.2	NW	
31	39.5	26.6	33.6	87	34	56	11.45	2.7	4.7	NE	
Ave	43.2	26.7	35.4	83	27	52	11.16	3.0	6.4	-	81.3*

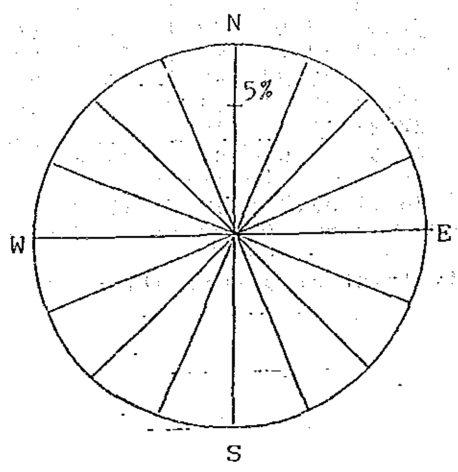
* : Monthly total of preciptation (mm).

Table VI-2-1.

SEPTEMBER, 1986						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	0.1	3.8	0.6			4.5
NNE	0.7	6.0	0.6			7.3
NE	0.6	4.2	0.6			5.4
ENE	0.7	3.1	1.3			5.1
E	0.1	1.5	0.8			2.4
ESE	0.3	1.5	0.7			2.5
SE	0.4	1.9	0.3			2.6
SSE		11.7	10.1			21.8
S		0.8	2.8			3.6
SSW		2.8	3.3			6.1
SW		2.9	1.5			4.4
WSW		2.2	1.5			3.7
W	0.1	3.1	1.1			4.3
WNW	0.3	2.6	1.1			4.0
NW		2.9	1.5			4.4
NNW		8.8	1.5			10.3
variable	2.2	5.4				7.6
Total(%)	5.5	65.2	29.3			100.0



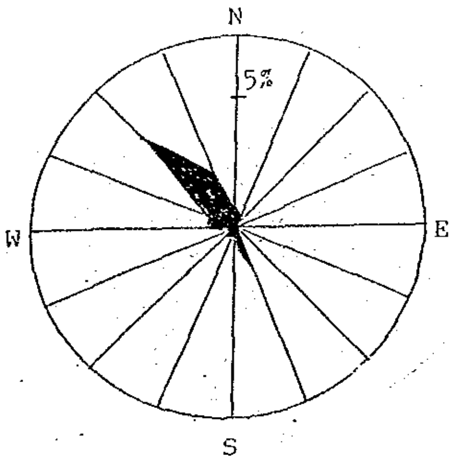
4 ≦ V < 8 m/sec



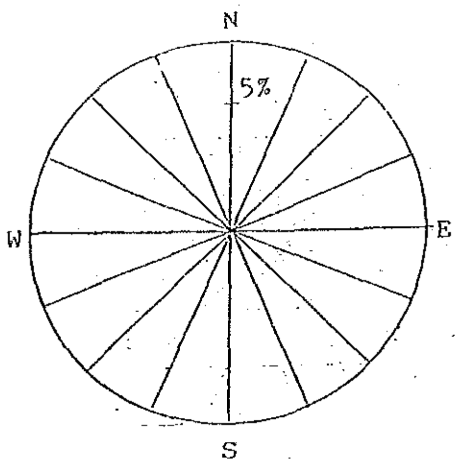
V ≧ 8m/sec

Table VI-2-2.

OCTOBER, 1986						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	0.5	10.8	0.7			12.0
NNE	0.8	6.5	0.5			7.8
NE	2.2	7.9				10.1
ENE	1.6	4.8	0.1			6.5
E		1.2				1.2
ESE	0.1	1.1				1.2
SE		0.9				0.9
SSE	0.1	4.0	1.6			5.7
S		1.7	0.7			2.4
SSW		1.9	0.4			2.3
SW		1.3	0.5			1.8
WSW		3.0	0.3			3.3
W	0.1	4.6	1.1			5.8
WNW	0.4	6.6	1.3			8.3
NW	0.8	6.6	5.0			12.4
NNW	0.1	9.1	2.4			11.6
variable	2.8	3.6				6.4
Total(%)	9.5	75.6	14.6			99.7



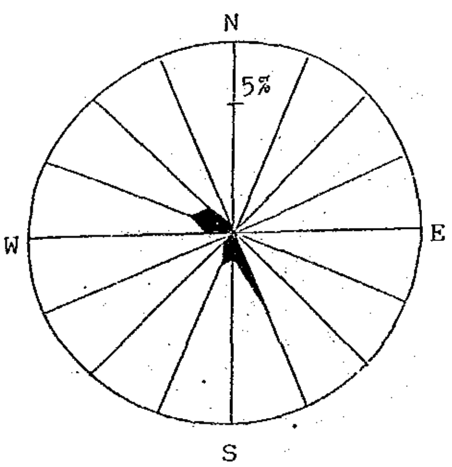
4 ≦ V < 8 m/sec



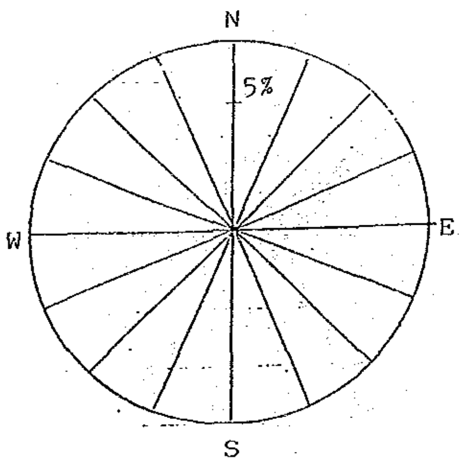
V ≧ 8m/sec

Table VI-2-3.

NOVEMBER, 1986						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	1.3	7.2				8.5
NNE	1.6	6.8				8.4
NE	3.0	9.9				12.9
ENE	0.5	3.0				3.5
E	0.3	2.4				2.7
ESE	0.3	0.8				1.1
SE	0.3	2.1				2.4
SSE	0.2	5.2	3.3			8.7
S	0.2	2.4	1.0			3.6
SSW		3.5	1.3			4.8
SW	0.3	4.0	0.5			4.8
WSW		3.3				3.3
W		2.5	1.1			3.6
WNW	0.2	4.9	1.9			7.0
NW		6.8	1.4			8.2
NNW	0.3	11.3	0.2			11.8
variable	2.1	2.7				4.8
Total(%)	10.6	78.8	10.7			100.1



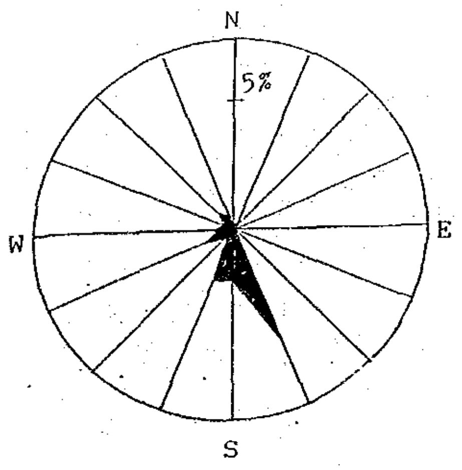
4 ≤ V < 8 m/sec



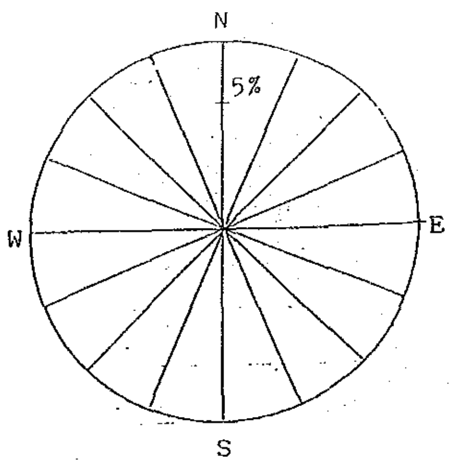
V ≧ 8m/sec

Table VI-2-4.

DECEMBER, 1986						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	1.5	6.3	0.1			7.9
NNE	1.9	3.6	0.1			5.6
NE	3.4	7.8				11.2
ENE	2.8	1.1				3.9
E	1.2	1.2				2.4
ESE	0.3	1.9				2.2
SE	0.1	1.5				1.6
SSE	0.1	4.3	4.6			9.0
S	0.3	3.0	2.0			5.3
SSW		1.6	2.2			3.8
SW	0.1	3.2	0.3			3.6
WSW	0.1	4.2	1.2			5.5
W		3.9	0.7			4.6
WNW	0.4	5.9	0.5			6.8
NW	0.3	4.6	0.8			5.7
NNW	0.7	10.1	0.5			11.3
variable	5.6	4.0				9.6
Total(%)	18.8	68.2	13.0			100.0



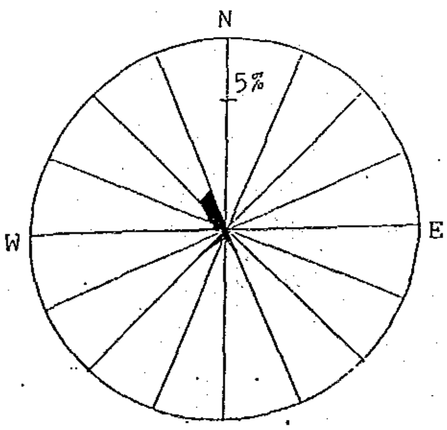
4 ≦ V < 8 m/sec



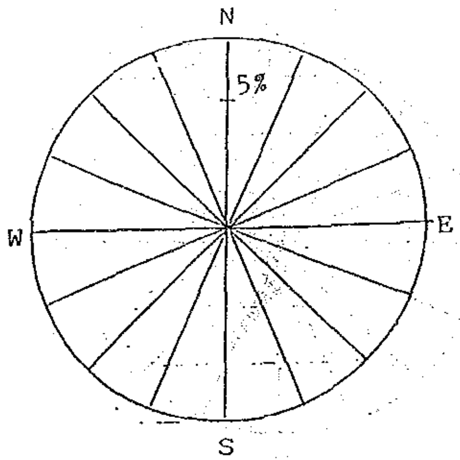
V ≧ 8m/sec

Table VI-2-5.

JANUARY, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	0.8	8.9				9.7
NNE	0.7	12.0				12.7
NE	2.4	16.3				18.7
ENE	1.9	2.3				4.2
E		2.0				2.0
ESE	0.1	0.8				0.9
SE		0.5				0.5
SSE		2.3	0.8			3.1
S		0.5	0.3			0.8
SSW		0.7	0.4			1.1
SW		0.8	1.5			2.3
WSW		2.3	0.1			2.4
W	0.1	3.5	0.5			4.1
WNW	0.1	4.3	0.7			5.1
NW		9.4	1.5			10.9
NNW	0.3	10.3	1.7			12.3
variable	4.3	4.8				9.1
Total(%)	10.7	81.7	7.5			99.9



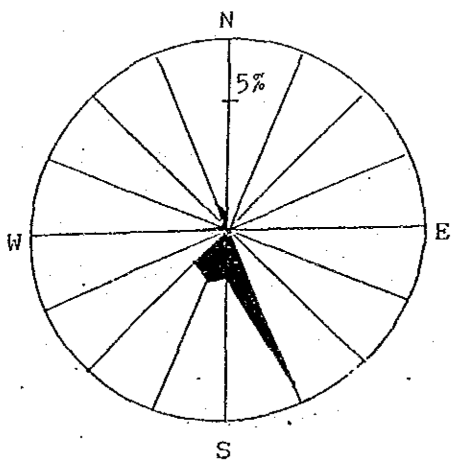
4 ≦ V < 8 m/sec



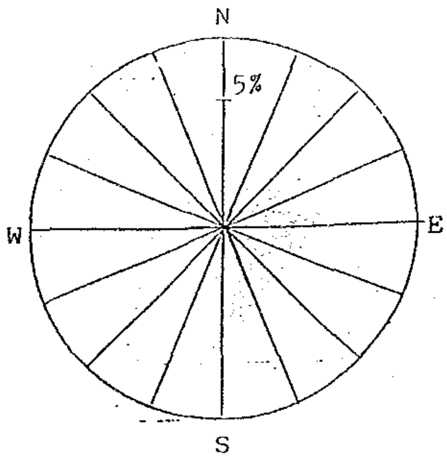
V ≧ 8m/sec

Table VI-2-6.

FEBRUARY, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	1.2	7.7	0.6			9.5
NNE	0.6	6.0				6.6
NE	3.1	11.0	0.1			14.2
ENE	1.9	3.0	0.1			5.0
E	0.7	2.2				2.9
ESE		1.2				1.2
SE		2.7				2.7
SSE	0.3	3.0	6.7	2.4		12.4
S		1.3	1.9			3.2
SSW		1.9	2.1			4.0
SW	0.3	3.3	1.8			5.4
WSW	0.3	2.7				3.0
W	0.3	4.8	1.2			6.3
WNW	0.1	7.3	0.3			7.7
NW	0.6	3.9	0.3			4.8
NNW	1.0	6.1	1.2			8.3
variable	1.6	1.0				2.6
Total(%)	12.0	69.1	16.3	2.4		99.8



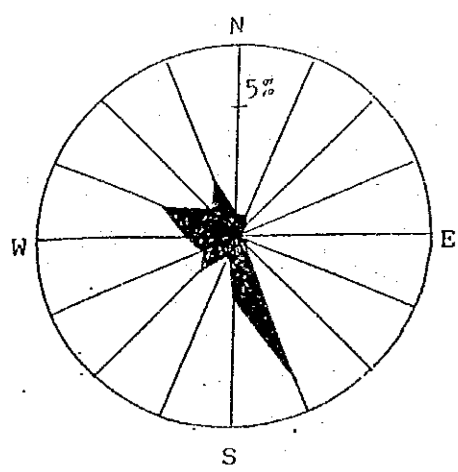
4 ≦ V < 8 m/sec



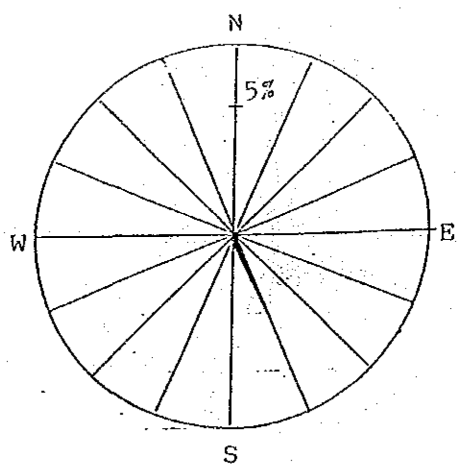
V ≧ 8m/sec

Table VI-2-7.

MARCH, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	0.1	7.1	0.9			8.1
NNE	0.9	5.6	0.8			7.3
NE	1.2	8.2	0.4			9.8
ENE	1.1	2.4	0.1			3.6
E	0.5	2.2				2.7
ESE	0.1	2.2	0.4			2.7
SE		1.9	0.5			2.4
SSE	0.1	3.2	6.2	3.4		12.9
S		1.6	2.4	0.3		4.3
SSW		1.5	0.8			2.3
SW	0.1	2.0	1.9	0.3		4.3
WSW		2.3	1.5			3.8
W	0.1	2.2	2.0			4.3
WNW	0.3	7.1	3.2			10.6
NW	0.1	4.0	1.5			5.6
NNW	0.1	7.9	2.4			10.4
variable	1.3	3.2				4.5
Total(%)	6.0	64.6	25.0	4.0		99.6



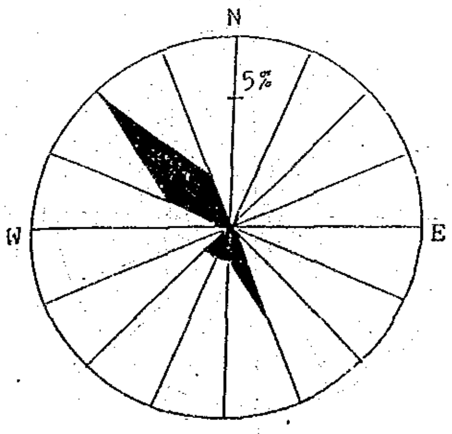
4 ≦ V < 8 m/sec



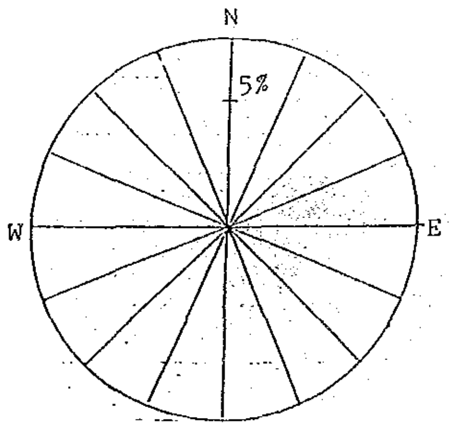
V ≧ 8m/sec

Table VI-2-8.

APRIL, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	1.0	6.0				7.0
NNE	0.8	5.4				6.2
NE	3.2	8.2	0.4			11.8
ENE	4.0	1.4	0.1			5.5
E	1.4	1.0				2.4
ESE		0.4				0.4
SE	0.1	1.7	0.3			2.1
SSE		2.9	4.0	0.4		7.3
S		1.7	1.3	0.1		3.1
SSW		0.7	1.3			2.0
SW		1.7	1.3			3.0
WSW	0.1	1.4	0.1			1.6
W	0.8	2.6	0.3			3.7
WNW	1.5	7.5	2.6			11.6
NW	0.3	8.8	7.2			16.3
NNW	0.6	10.8	2.1			13.5
variable	1.0	1.5				2.5
Total(%)	14.8	63.7	21.0	0.5		100.0



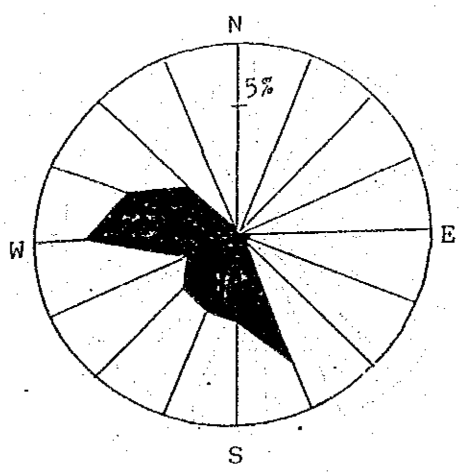
$4 \leqq V < 8$ m/sec



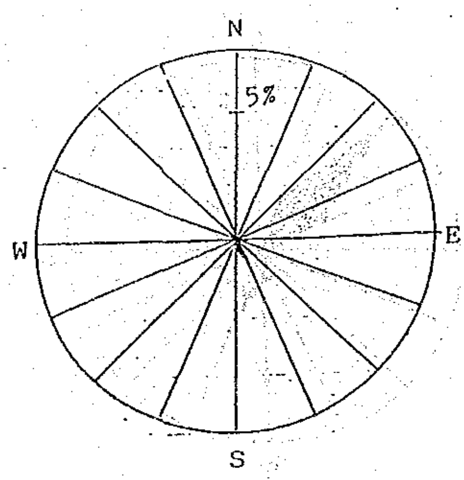
$V \geqq 8$m/sec

Table VI-2-9.

MAY, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	1.6	3.1	0.1			4.8
NNE	0.7	3.6				4.3
NE	2.2	10.3				12.5
ENE	1.9	5.5	0.1			7.5
E	0.8	3.2	0.5	0.4		4.9
ESE	0.1	1.2	0.4			1.6
SE	0.4	3.1	0.3			3.8
SSE	0.4	3.8	5.4	0.7		10.3
S		1.7	3.4	0.3		5.4
SSW	0.1	1.5	3.2			4.8
SW	0.3	1.7	3.0			5.0
WSW	0.7	3.0	2.2			5.9
W		4.4	5.8			10.2
WNW	0.1	3.9	4.6	0.1		8.7
NW	0.3	2.2	2.6			4.9
NNW	0.4	3.2	0.1			3.7
variable	0.5	0.9				1.4
Total(%)	10.5	56.3	29.3	1.5		99.6



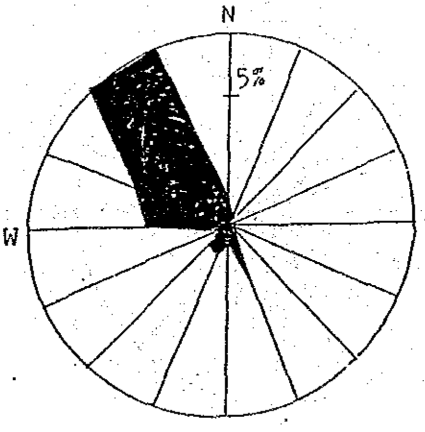
$4 \leq V < 8$ m/sec



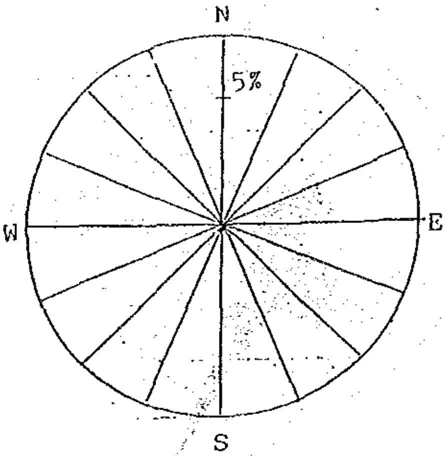
$V \geq 8$m/sec

Table VI-2-10.

JUNE, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	0.1	6.5	1.0			7.6
NNE	0.1	4.6	0.3			5.0
NE	1.4	4.9				6.3
ENE	1.1	1.3	0.3			2.7
E	0.7	2.1				2.8
ESE	0.3	2.2	0.1			2.6
SE	0.1	2.5	0.1			2.7
SSE		3.8	2.1	0.1		6.0
S		2.5	0.8	0.3		3.6
SSW		1.8	1.3			3.1
SW	1.0	2.8	1.0			4.8
WSW	0.1	3.9	0.3			4.3
W	0.6	4.0	3.1			7.7
WNW	0.3	5.1	4.0			9.4
NW		6.0	7.6	0.1		13.7
NNW		6.0	7.5			13.5
variable	0.4	3.9				4.3
Total(%)	6.2	63.9	29.5	0.5		100.1



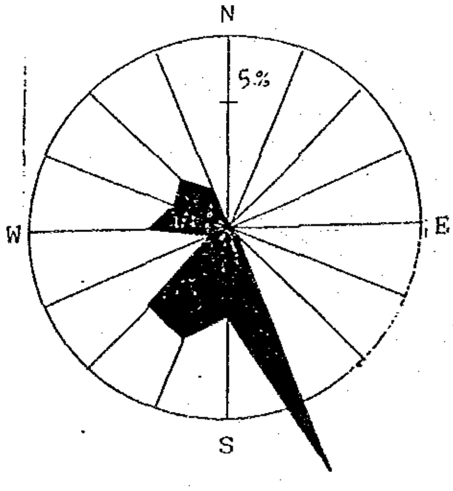
4 ≦ V < 8 m/sec



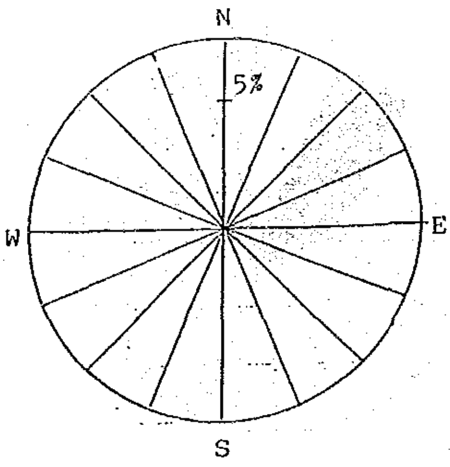
V ≧ 8m/sec

Table VI-2-11.

JULY, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	0.3	3.0	0.1	0.1		3.5
NNE	0.4	2.6	0.1			3.1
NE	0.5	5.4				5.9
ENE	1.2	2.6	0.1			3.9
E	0.7	1.9	0.4			3.0
ESE	0.3	1.2		0.1		1.6
SE	0.3	3.6	0.5			4.4
SSE	0.1	9.4	10.3	0.1		19.9
S	0.3	2.4	3.5			6.2
SSW		3.2	4.6			7.8
SW		3.9	4.4			8.3
WSW	0.3	2.3	0.9			3.5
W	0.3	5.2	3.0			8.5
WNW		2.8	2.4			5.2
NW	0.3	2.6	2.7			5.6
NNW	0.3	4.3	1.7			6.3
variable	0.7	2.6				3.3
Total(%)	6.0	59.0	34.7	0.3		100.0



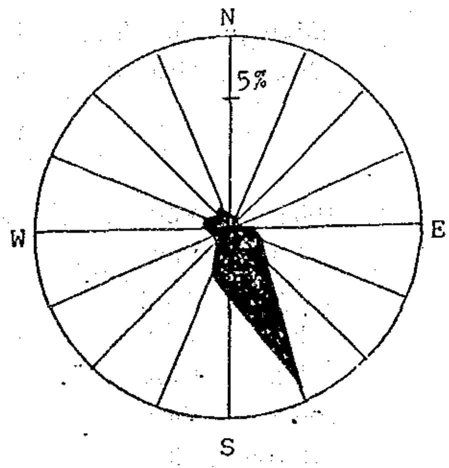
4 ≦ V < 8 m/sec



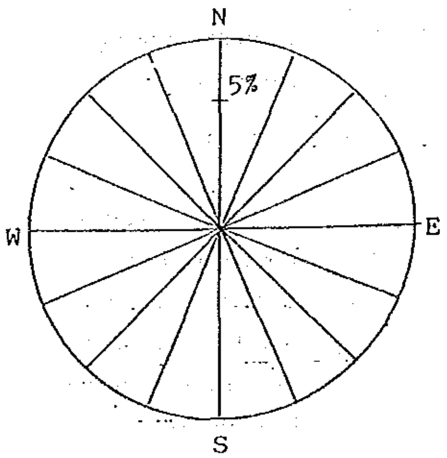
V ≧ 8m/sec

Table VI-2-12.

AUGUST, 1987						
Wind Direction	Wind Velocity (m/sec)					Total (%)
	<1.0	1.0-4.0	4.0-8.0	8.0-12.0	12.0<	
N	0.3	3.8	0.5	0.1		4.7
NNE	0.4	1.3	0.4			2.1
NE	0.4	4.0	0.4	0.1		4.9
ENE	0.5	2.7	0.3			3.5
E	0.7	3.5	0.9	0.1		5.2
ESE	0.3	3.0	1.3			4.6
SE	0.1	6.5	1.9			8.5
SSE	0.3	9.3	6.9	0.4		16.9
S	0.3	2.7	2.7			5.7
SSW		3.1	2.0			5.1
SW	0.4	3.9	0.9			5.2
WSW		4.0	0.9			4.9
W	0.3	6.5	1.2			8.0
WNW	0.4	5.2	1.2	0.1		6.9
NW	0.4	5.5	0.8			6.7
NNW	0.3	3.6	1.1			5.0
variable	0.7	1.3				2.0
Total(%)	5.8	69.9	23.4	0.8		99.9



4 ≤ V < 8 m/sec



V ≥ 8m/sec

VII. LIST OF EQUIPMENTS PROVIDED BY JAPANESE GOVERNMENT

No.	Date	Equipment	Amount	Store	Price (US$)
J- 57	8609	pH meter	1 set	Villa	
J- 58		Balance (Mettler PE3600)	1 pc	Villa	
J- 59		Permeability meter	1 set	Univ. Lab.	
J- 60		Large mallet (2.5 kg)	2 pcs	Farm	39
J- 61		Sprayer small type	1 pc	Fram	128
J- 62		Metal box for shifting sand	50 pcs	Villa	1,445
J- 63		Thermometer (Max. and min.)	2 pcs	Villa	93
J- 64		Increment bores	1 pc	Villa	283
J- 65		Tape measure	2 pcs	Villa	44
J- 66		Hatchet with belt	3 sets	Villa	193
J- 67		Cylindrical sampler	1 pc	Villa	495
J- 68		Cylinder for gathering soil	12 pcs	Villa	324
J- 69		Carriage for J-68	2 pcs	Villa	488
J- 70		Drill lod for hand auger	2 pcs	Villa	109
J- 71		Funnel for absorption	10 pcs	Villa	193
		Glass bottle for absorption	10 pcs	Villa	122
J- 72		Books	10 vols	Villa	164
					4,119
J- 73	8610	Asphalt emulsion	25 drum	Univ. St.	7,622
J- 74		Kuricoat C-720	78 cans	Univ. St.	4,083
					11,705
J- 75	8611	Scale (1 m length)	100 pcs	Villa	1,035
J- 76		Binoculars (7 x 50 IF)	1 pc	Villa	258
J- 77		Tensiometer (Sensor)	3 pcs	Farm	312
J- 78		Balance (EK-1200A)	1 set	Villa	283
J- 79		Ink for recorder (6 colors)	1 set	Farm	13
J- 80		Envelopes	6,500 pcs	Villa	121
J- 81		Report pad	100 vols	Villa	104
J- 82		Field note	100 vols	Villa	61
J- 83		Seedling rear pot	30 pcs	Farm	25
J- 84		Insecticide (ORTHORAN)	50 bags	Villa	250
					2,461

No.	Date	Equipment	Amount	Store	Price (US$)
J- 85	8612	Nozzles for sprayer	3 pcs	Villa	102
J- 86		Cable	300 m	Villa	132
J- 87		Filton FG-3	60 kg	Villa	240
		Glasspower G-200	30 kg	Villa	468
J- 88		Power sprayer	1 set	Farm	1,220
J- 89		Books	1 lot	Villa	80
					2,242
J- 90	8703	Stopper (sand catch)	75 pcs	Villa	1,607
J- 91		Evaporation bottle	50 pcs	Farm	3,474
J- 92		Sand catch apparatus	24 sets	Villa	2,462
J- 93		Spare bag (sand catch)	100 pcs	Villa	649
J- 94		Leaf puncher	1 set	Villa	434
J- 95		Balance (AE 166)	1 set	Villa	1,591
J- 96		Muffle furnace	1 set	Cent. Lab.	2,428
J- 97		Super polometer	1 set	Villa	22,011
					34,656
J- 98	8704	Balance (FA2000)	1 set	Villa	831
J- 99		Shield (electronic balance)	1 pc	Villa	130
J-100		Weight (AD-1600-2K)	1 pc	Villa	185
J-101		Crasher (SK-M-10)	1 set	Villa	1,015
J-102		Nozzle (MARUYAMA Sprayer)	5 pcs	Villa	258
J-103		Cable (Hydrograph)	12 pcs	Villa	1,302
J-104		Portable anemometer	2 sets	Villa	3,268
J-105		Books	2 volts	Villa	161
					7,150
J-106	8705	Memory sensor	1 set	Villa	
		Memory sensor (MES 801)	1 set	Villa	5,634
		Battery pack	1 set	Villa	236
		AC adaptor	1 set	Villa	129
		Solar battery	1 set	Villa	1,031
		Fitting base	1 set	Villa	365
		Case for outdoor	1 pc	Villa	1,718
		Cable (MES 892)	1 pc	Villa	86
		Program (floppy disk)	1 pc	Villa	143
J-107		Soil moisture sensor	8 pcs	Farm	8,590
J-108		Hand held computer	1 set	Villa	1,611
J-109		Transformer (YSA-500)	1 set	Villa	644

No.	Date	Equipment	Amount	Store	Price (US$)
J-110		Area meter (AAM-8)	1 set	Villa	7,481
					27,668
J-111	8706	Recorder (MX-865)	1 pc	Farm	8,078
		Wind vane sensor	1 pc	Farm	1,208
		Cable (L7S-100)	1 set	Farm	366
		Cable (L4S-100)	5 pcs	Farm	1,277
		Stand	5 pairs	Farm	932
		Anemograph sensor	5 pcs	Farm	4,764
J-112		Thermometer (w/Hand Held C)	1 set	Farm	10,627
J-113		Atomic absorption sp.	1 set	Cent. Lab.	11,046
		Compressor (SC-72)	1 set	Cent. Lab.	1,284
		Hollow cathode lamp	3 pcs	Cent. Lab.	608
		Regulator	1 pc	Cent. Lab.	145
		Recorder	1 pc	Cent. Lab.	870
		Chart paper	10 pcs	Cent. Lab.	62
J-114		Kjeldhal digestors	1 set	Univ. Lab.	1,588
J-115		Earth resistance meter	1 set	Villa	1,691
J-116		Oven (WFO 10000D)	1 set	Villa	3,680
J-117		Light intensity meter	2 sets	Villa	1,705
J-118		Jiffy pot (No. 517)	5 boxes	Farm	621
J-119		Plastic tray	100 pcs	Villa	262
J-120		Clean bench (HITACHI)	1 set	Cent. Lab.	4,412
J-121		Biotron (NK system)	1 set	Villa	11,033
J-122		Light intensity meter	1 set	Villa	987
J-123		Tensiometer	12 pcs	Farm	1,160
J-124		Flame photometer	1 set	Villa	5,388
J-125		Rain gauge	1 pc	Farm	338
J-126		Recorder (rain gauge)	1 set	Farm	2,651
					76,783
J-127	8707	Sand catch system	10 sets	Villa	1,124
					1,124
J-128	8702	Land cruiser (TOYOTA)	1 pc	Farm	17,241
J-129		Hilux (TOYOTA)	1 pc	Farm	9,579
					26,820

No.	Date	Equipment	Amount	Store	Price (US$)
J-130	8701	Copy machine	1 pc	Villa	4,105
					4,105
TOTAL					198,831

VIII. DISPATCH OF EXPERTS

Experts mentioned below were dispatched by JICA to conduct the Joint Study Project in the period of Phase 2.

Short-term Experts

Name	Speciality	Duration of Dispatch
Dr. Keiichiro Matsuda	Team Leader Soil Science and Plant Nutrition	4 Sep. 1986 – 19 Sep. 1986 18 Nov. 1986 – 29 Nov. 1986 4 Apr. 1987 – 15 Apr. 1987
Dr. Hiroshi Murai	Forest Hydrology	4 Sep. 1986 – 19 Sep. 1986 19 Dec. 1986 – 29 Dec. 1986 4 Apr. 1987 – 15 Apr. 1987
Dr. Hitoshi Sawada	Crop Science	4 Sep. 1986 – 19 Sep. 1986 19 Dec. 1986 – 29 Dec. 1986 23 Jun. 1987 – 4 Jul. 1987

Long-term Experts

Name	Speciality	Duration of Dispatch
Mr. Hiromi Yokota	Plant Nutrition	20 Aug. 1985 – 17 Aug. 1987
Mr. Akira Koto	Soil Science and Soil Conservation	20 Aug. 1985 – up to now
Mr. Shinji Yoshizaki	Silviculture	11 Apr. 1987 – up to now
Mr. Hiroyasu Onuma	Plant Nutrition	1 Aug. 1987 – up to now

IX. OBSERVATION AND RESEARCH WORKS BY COUNTERPARTS

Counterparts mentioned below were invited to Japan for observation and research works on the arid land agriculture in the period of Phase 2.

Name	Period of visit / Institutions visited
Dr. Abdur-Rhaman Saghir	14 Jan. 1987 – 27 Jun. 1987 JICA Headquarters (TOKYO) Shizuoka University (SHIZUOKA) Kyoto University (KYOTO) Tokyo University (TOKYO) Ministry of Agriculture (TSUKUBA) – Tropical Agriculture Research Center – National Institute of Agro-Environmental Sciences – National Institute of Agrobiological Resources
Dr. Mahmoud A. Al Afifi	28 Oct. 1986 – 8 Nov. 1986 JICA Headquarters (TOKYO) Shizuoka University (SHIZUOKA) Tottori University (TOTTORI) Tsukuba University (TSUKUBA) Ministry of Agriculture (TSUKUBA) – Tropical Agriculture Research Center – National Institute of Agro-Environmental Sciences – National Institute of Agrobiological Resources
Mr. Suhayl A. Itani	24 May 1987 – 21 Aug. 1987 JICA Headquarters (TOKYO) Shizuoka University (SHIZUOKA) Kyoto University (KYOTO) Tokyo University (TOKYO) Tottori University (TOTTORI) Ministry of Agriculture (TSUKUBA) – Tropical Agriculture Research Center – National Institute of Agro-Environmental Sciences – National Institute of Agrobiological Resources – Forestry And Forest Products Research Institute

X. ACKNOWLEDGEMENT

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