SCHEDULING OF IRRIGATION FOR CUCURBITACEOUS VEGETABLES

By

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THESIS

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the requirement for the degree

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Department of Agronomy

COLLEGE OF HORTICULTURE

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DECLARATION

I hereby declare that this thesis entitled "Scheduling of irrigation for cucurbitaceous vegetables" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellanikkara,
28.3.85

(RADHA LAKSHMANAN)

CERTIFICATE

Certified that the thesis entitled "Scheduling of irrigation for cucurbitaceous vegetables" is a record of research work done by Kum. RADHA LAKSHMANAN, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Chairman, Advisory Board,
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Karamana,
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CERTIFICATE

We, the undersigned, members of the Advisory Committee of Kum. RADHA LAKSHMANAN, a candidate for the degree of Master of Science in Agriculture with major in Agronomy, agree that the thesis entitled the "Scheduling of irrigation for cucurbitaceous vegetables" may be submitted by Kum. RADHA LAKSHMANAN, in partial fulfilment of the requirement for the degree.

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Introduction

INTRODUCTION

Vegetable growing is one of the most important branches of agriculture. Cucurbits are the largest group of summer vegetable crops. They belong to the family Cucurbitaceae and are grown for their ripe and unripe fruits. Cucurbits are good sources of carbohydrates, Vitamin A, Vitamin C and minerals (Yawalker, 1980). The growing of cucurbitaceous vegetables like pumpkins and melons in summer rice fallows is a common practice in Kerala, especially in areas with an assured supply of water.

Summer vegetables cannot be grown if proper irrigation facilities are not available. When water is at a premium vegetables of all crops will usually get first priority. This is because they give high returns. Moreover, the useful product is usually a leaf, stem, fruit or seed which is sold on the basis of its fresh weight and appearance, two attributes which are particularly sensitive to shortages of water.

Water being relatively scarce in summer, it should be managed so as to maximise crop productivity for each unit of water used by the plants. Research on vegetable improvement in India has been mainly centered on breeding aspects and use of fertilizers. Irrigation research is scanty and relatively little work has been done to find out the water requirements of vegetable crops. Heavy irrigations have been found to adversely affect crop yield besides resulting in an excessive wastage of water. Literature on the optimum moisture regimes and water requirements of cucurbitaceous vegetables in our country is meagre. The optimum quantity of water to be applied without adversely affecting the yield of the crop needs to be investigated.

Scheduling of irrigation based on soil moisture regimes though accurate is very tedious and time consuming. Hence a method of schedule irrigations based on the available evaporation data if devised, will be relatively simple and can be implemented with ease. The optimum cummulative pan evaporation values for the period of optimum percentage of depletion of available soil moisture can be determined and irrigations can then be scheduled based on the cummulative pan evaporation values. The high cost of class A type pan evaporimeters and their installation requirement limits its wide scale use and can be maintained only in meteorological observatories. Hence the utility and reliability of can evaporimeters, which are smaller in size and relatively cheap has to be explored.

The installation of can evaporimeters in farmers fields would then serve as an useful guide in scheduling irrigations.

With these considerations in view, investigations on the "Scheduling of irrigation for cucurbitaceous vegetables" was initiated. The study was conducted at the Agricultural Research Station, Mannuthy during the summer season of 1983-'84 in three cucurbitaceous vegetables viz. pumpkin, oriental pickling melon and ashgourd, with the following objectives.

1. To find out the optimum moisture regimes for cucurbitaceous vegetable crops.

2. To find out the optimum pan/can evaporimeter values and to evaluate the evaporative demand of the atmosphere for scheduling irrigations.

3. To compare can and pan evaporimeter values for quantifying the evaporative demand of the atmosphere and to schedule irrigation.

4. To work out the soil moisture extraction pattern of different cucurbitaceous vegetable crops for scheduling irrigation.

Review of Literature

REVIEW OF LITERATURE

A brief review on the scheduling of irrigation for Cucurbitaceous vegetables is given hereunder. The literature reviewed are classified under the following sections.

2.1. Consumptive use and water requirement,

2.2. Critical growth stages,

2.3. Influence of soil moisture on growth attributes,

2.4. Influence of soil moisture on yield and yield attributes,

2.5. Root growth and moisture extraction pattern,

2.6. Irrigation scheduling based on moisture depletion method,

2.7. Irrigation scheduling based on evaporation data.

2.1. Consumptive use and water requirement

According to Whitaker and Davis (1962) irrigation water required for watermelons and cucumber was 150 ha mm each and that for pumpkins and summer and winter squashes was 180 ha mm each. Dunkell (1966) showed that optimal yields of cucumber could be obtained, when 600 - 750 mm of water was applied.

Neil and Zunino (1972) reported that the maximum evapotranspiration in irrigated cantaloups was 60 per cent of potential evapotranspiration and between flowering and fruit formation it was 55 per cent of potential evapotranspiration. The water uptake increased during fruit enlargement. At harvest, water uptake was 85 per cent of potential evapotranspiration which declined to 55 per cent by midharvest. The water uptake at successive growth stages of the melon crop was 560 m^3 ha^{-1} between germination and fruitset, 1008 m^3 ha^{-1} upto fruit enlargement, 882 m^3 ha^{-1} upto prematurity and 280 m^3 ha^{-1} upto harvest.

In an investigation to find out the relationship between development and water utilisation in cucumbers, Cselotel and Varga (1973) reported that during the period upto the beginning of flowering, the water uptake was small, amounting to five litres per plant. In a 30 days period following the beginning of flowering the water uptake amounted to 30-31 litres per plant. In the subsequent 30 day period corresponding to full development of the fruits and the beginning of seed maturity the water uptake was 10-20 litres per plant. Tomitaka (1974) in studies with cucumber observed that the evapotranspiration rate declined with a decrease in the soil moisture level.

In a study to find out the amount and nature of water consumption in muskmelon plants, Konishi (1974) found that the total water consumption by a fruit bearing plant with a leaf area of about 11000 cm^2 was 85-90 litres. As the plants grow the ratio of total water consumption per plant to pan evaporation increased to a maximum at the netting stage and then declined with aging. He also observed that young leaves transpired faster than old leaves and most of the transpiration occurred when soil pF was 1.6 to 2.0. Water consumption was less for the plants without fruits. Pavlov (1976) observed that the highest yield of cucumbers (26.6 kg m^{-2}) was obtained when 70-100 l m^{-2} of water was applied during the plant growing phase in 20-32 individual irrigations, followed by 480-570 l m^{-2} during fruiting in 92-94 individual irrigations.

Loomis and Crandall (1977) in studies on the water consumption of cucumbers, observed that the consumptive use increased during flowering and early fruiting and then levelled off during late harvest. The total amount of water used during the later two month period of crop growth ranged from 300-400 mm over each of the four years of the experiment. The ratio (Ko) of consumptive use to evaporation from a pan evaporimeter increased to a maximum of 1.5, 10 days after first picking and then declined but still

remained high when picking was terminated. Thomas (1984) found that the consumptive use increased with increase in the level of irrigation in the case of bittergourd.
It can thus be seen that consumptive use depends on the physiological stages of the crop, evaporative demand of the atmosphere and duration of the crop.

2.2. Critical growth stages

Varga (1973) observed that in cucumbers the period between flowering and fruit ripening was critical for fruit development. During this period, it was necessary to supply the crop with 40 mm of water. However excessive application of water was found to be deleterious.
Hammett *et al.* (1974) found that a constant supply of moisture is necessary during the growth of cucumbers especially during flowering and fruting.

Rudich *et al.* (1978) in drip irrigation studies on muskmelon and watermelon found that, neither crop was affected by irrigation applied during the vegetative phase, flowering or fruit set. However, irrigation given during the fruit development stage resulted in average yield increases of 24.5 and 13.5 tons ha^{-1}, but did not affect the fruit quality. It could be seen from the above review that flowering and fruiting are the critical stages in cucumbers and melons and irrigation given during these stages will bring about a marked increase in yield.

2.3. <u>Influence of soil moisture on growth attributes</u>

Belik (1961) found that optimum conditions for cucumber development during the early growth phase was 80-90 per cent of full moisture capacity. Flocker <u>et</u> <u>al</u>. (1965) reported that frequent heavy irrigation increased the vine growth and succulence in melons. Borna (1969) reported that irrigation during the entire growing season was more effective in cucumbers than irrigation upto or after cropping started.

Escobar and Gausman (1974) noticed that in mexican squash the leaves of the plants under higher water stress were thicker and smaller, containing less water than the plants under lower water stress. Cummins and Kretchman (1974) found that leaf area in cucumbers was greatly reduced under water stress.

Tomitaka (1974) reported highest plant growth of cucumbers at a medium soil moisture level of pF 2.0. Michael (1978) reported that for good growth of vegetable crops the soil moisture at about 15 cm depth should not be allowed to drop below 70 per cent of total available moisture. Pai and Hukkeri (1979) observed that for good growth of vegetables the soil moisture should be maintained at or above 75 per cent of availability in the active root zone.

The effects of water stress on cucumber plants cv. premier were studied by Ortega and Kretchman (1982). They noticed a reduction in the rate of vine growth and the number of nodes when plants were subjected to stress for a period of one week. Growth was found to be completely inhibited after two weeks of stress. Thomas (1984) found that bittergourd responded well to frequent irrigations and higher levels of fertilizers. Biometric characters like leaf area index and dry matter production was favourably influenced by frequent irrigation and higher levels of fertilizers. Frequent irrigations at low depletion of available soil moisture was congenial for growth and development of cucurbits. However heavy irrigations at frequent intervals was found to be detrimental for crop growth.

2.4. Influence of soil moisture on yield and yield attributes

Mac Gillivray (1951) reported that yields of cantaloups was increased by irrigation. However, the size of fruits or total soluble solids were not greatly affected by irrigation. In glass house pot experiments, Belik (1961) found that cucumbers required a soil moisture content of about 60-70 per cent of full moisture capacity during the fruiting period. Flocker et al.(1965) obtained satisfactory yields of melon by irrigating when soil moisture tensions at the 45 cm depth reached three bars. They observed that yield increase by irrigation was mainly by increase in fruit size.

Molnar (1965) found that fruitset in melons was not improved but fruit drop was reduced by irrigation. He also observed that the dry matter content of the fruits was not reduced, and a favourable ratio of sugars resulted which enhanced the quality of the fruits. Also a higher water requirement at the beginning of flowering was noticed. Downes (1966) reported that the average yield of melons was increased when sprinkler irrigation at frequent intervals was practised.

Vittum and Flocker (1967) found that yields of cantaloups remained unaffected upto soil water suctions of two atmospheres and only a slight reduction in yield was noticed at soil water suctions of seven atmospheres at a depth of two feet. They concluded that the plants were capable of utilising water stored at the lower depths. However, excessive irrigation, maintaining a suction of less than 0.5 atmospheres was found to reduce the yield, quality and shelf life of marketable melons.

Bradley and Rhodes (1969) found that irrigation at intervals of 7, 14 and 21 days did not affect the yield of summer squash, when the fruits were harvested frequently, but at the 21 day interval, the once over yield was markedly reduced. Jassal et al.(1970) reported that fruit weight and fruit yield were significantly increased in muskmelon by weekly irrigation compared with fortnightly irrigation. Varga (1971) showed that the relationship between yield and soil moisture content was parabolic and the optimum soil moisture content was 68 to 75 per cent of field capacity.

Neil and Zunino (1972) reported that in doublon melons increasing the irrigation rate from 850 to 2600 m^3 ha^{-1} produced more and heavier melons, but the dry matter content was however unaffected. Varga (1973) observed highest plant growth and fruit yield of cucumbers at pF 2.0. He concluded that the optimum number of irrigations for cucumber is 3 to 5. Elkner and Radzikowska (1976) reported that irrigation in cucumbers, reduced the percentage of hollow fruits and decreased the dry matter content, sugar, total nitrogen and nitrate nitrogen in the fruit.

Krynska *et al.* (1976) observed that best quality sour cucumbers was obtained with lowest NPK rates and irrigation. They also reported that irrigation lowered fruit dry matter, Vitamin C and sugar content in both fresh and processed cucumbers.

Caro and Linsalata (1977) observed that furrow irrigation increased the yield and mean fruit weight in melons but did not affect the number of fruits per plant. Motoki and Kurokawa (1977) applied irrigation to melons at different soil moisture regimes ranging from pF 2.7 to 2.0 and obtained optimum plant growth and yield with irrigation at pF 2.5. Loomis and Crandall (1977) observed that moderate moisture stress in cucumbers had no significant effect on the grade or on the number of poorly developed fruits. Singh and Singh (1978) reported that the yield increase by irrigation in crops like bottlegourd, roundgourd and watermelon was associated with increased number of fruits per plant and increased fruit weight.

Doorenbos and Kassam (1979) found that in dry climates with moderate evaporation and little rainfall, watermelons produce an acceptable yield (15 tons ha^{-1}) with one heavy irrigation in the beginning of the growing period, when the soil water over the full root zone is brought to field capacity.

Haynes and Herring (1980) reported that irrigation at 0.7 bar produced the highest yields of marketable squash. However, the number of marketable fruits was maximum with irrigation at 0.3 bar. Chernovel (1980) reported that in cucumber the night irrigated plants gave the highest yield followed by evening, morning and midday irrigation. According to Katyal (1980) during dry weather, weekly irrigations should be given in case of pumpkin and cucumbers.

Heurickson (1980) found that in ridge cucumbers twice as many fruits per plant and upto three times greater weight of fruit per plant was obtained by irrigation. He also observed that there was no significant difference in yield and quality between drip irrigation and overhead manual watering.

Goto _et al_.(1981) reported that greatest fruit yield of cucumbers was obtained when watering was done at pF 2.3. Ortega and Kretchman (1982) observed that in cucumbers the rate of fruit growth was severely reduced in waterstressed plants. Work done in ashgourd at the Agronomic Research Station, Chalakudy revealed that the number of fruits per plant and the weight of a single fruit increased with increase in the level of irrigation (Anon, 1982). Pew and Gardner (1983) in trials with muskmelons obtained higher yields, larger fruit size and earlier maturity by irrigating when soil moisture tensions at the 25 cm depth reached 50 or 75 k Pa compared with 25 k Pa.

Mannimi and Roncozzi (1983) reported that the yields of cucumbers were not affected by the method of irrigation (drip or perforated pipe) and the interval of irrigation (3 or 6 days) but the volume of water applied was important. Restoration of 50 per cent, 100 per cent and 150 per cent of evapotranspiration required 1380, 2760 and 4140 m^3 ha^{-1} water and gave fruit yields of 985, 1248 and 1385 q ha^{-1}. Chauhan (1983) recommended that during the summer season cucumbers and pumpkin should be irrigated after every third and fourth day and ashgourd at intervals of 8-10 days for optimum yields. Thomas (1984) found that in bittergourd the contributing characters like number of fruits per plant, mean length of fruit and mean weight of fruit were favourably influenced by frequent irrigations and higher levels of fertilizers. Total fruit yields were also higher in frequently irrigated and well fertilized plots. It can thus be concluded from the above review that irrigation profoundly influences the yield and yield attributes in cucurbits.

2.5. Root growth and moisture extraction pattern

Whitaker and Davis (1962) reported that the root system of all the economic cucurbits is extensive but shallow. They found that root growth often equals or exceeds vine growth laterally and is very rapid and extensive in the upper 12-18 inches of soil. Vittum and Flocker (1967) pointed out that cucurbits are with medium or deep root systems that require large amounts of water. Belik and Veselovskii (1975) reported that under irrigation, the main root mass in watermelons was found in the 8.5-17 cm soil layer. Loomis and Crandall (1977) indicated that cucumbers extracted 50 per cent of the total amount of water consumed from the upper 30 cm of the soil profile, 30 per cent from the next 30 cm and 10 per cent from the next 30 cm.

Zabara (1978) observed that in irrigated cucumbers the root distribution at bearing was 64.5 per cent at 0-10 cm depth, 28.5 per cent at 10 to 20 cm depth and 6.2 per cent at 20 to 30 cm depth. In the case of unirrigated cucumbers the figures were 53.7 per cent at 0-10 cm, 29 per cent at 10 to 20 cm and 14.9 per cent at 20 to 30 cm.

Doorenbos and Kassam (1979) reported that watermelons can deplete soil water to a soil water tension of over two atmospheres, without the yield being affected. They found that the root system of watermelons can be deep and extensive upto a depth of 1.5 to 2 m. The active root zone where most of the water is extracted under adequate water supply is limited to the upper 1 to 1.5 m.

Pumpkins and squashes have a spreading but rather shallow root system while cucumbers are shallow rooted (Choudhury, 1983). Thomas (1984) reported that in bittergourd the top 15 cm of the soil layer accounted for 42-48 per cent of the total moisture depleted. The moisture use from the 15 to 30 cm layer was as high as that from the next 30 cm soil layer below. The top 30 cm layer contributed about 66-71 per cent of total water use. Moisture depletion decreased rapidly with soil depth. He also observed that in comparison with wet regimes, dry regimes extracted more soil water from the lower soil layers.

These works reveal that the root system of the cucurbits is extensive. The soil moisture extraction was also found to be highest from the top 30 cm of the soil profile. Such a high rate of moisture depletion from the surface may be attributed to the excessive evaporation losses besides loss of moisture by way of transpiration.

2.6. Irrigation scheduling based on moisture depletion method

Dastane *et al.*(1970) pointed out that the proper approach to schedule irrigation is on the basis of soil moisture deficit in the root zone.

Frohlich and Henkel (1961) found that irrigation before flowering at a soil moisture content of 50 per cent of field capacity and after flowering at a soil moisture content of 60-65 per cent of field capacity increased the yields of cucumbers. He also observed that the yields were reduced by irrigation at 60-65 per cent of field capacity throughout the growth of the crop. Dunkel (1966) showed that the highest yields of cucumbers were obtained when the soil moisture did not drop below 70 per cent of field capacity.

Dimitrov (1973) in trials with watermelons observed that a field capacity of 70-80 per cent maintained over the entire season was most economic, giving a total yield of 26160 kg ha^{-1}. In glass house trials with cucumber Dimitrov (1974) pointed out that a field capacity of 70 per cent was most suitable for the prepickling period. The highest yield was produced at 70 per cent field capacity before pickling and 90 per cent during the pickling period.

Jagoda and Kaniszewski (1975) reported that yield and fruit quality of cucumber was appreciably improved when irrigated at 50 per cent field capacity. According to Loomis and Crandall (1977) the best irrigation schedule for pickling cucumbers involved removal of between 48 to 64 per cent of available water in 90 cm of the soil profile between irrigations. They also observed that crop yields were not significantly affected at any of the depletion levels, but there was a downward trend as the water use between irrigations was increased from 7.5 to 10 cm (48 to 64 per cent of available moisture).

Michael (1978) reported that irrigation to vegetables must be scheduled by observing the soil moisture level and not by observation of the crop. The soil moisture at 15 cm depth should not be allowed to fall below 70 per cent of available soil moisture. Doorenbos and Kassam (1979) reported that irrigation to watermelons must be given when depending on the level of evaporation, the soil water has been depleted to 50 to 70 per cent of available soil water.

Tarr et al. (1983) reported that irrigation scheduling substantially increased the yield and improved the grades of both multiharvest and once over harvest pickling cucumbers. Highest yields from the multiharvest operation was obtained with irrigation at 60 per cent available soil moisture level, while in the once over harvest operation highest yields were obtained with irrigation at 25 per cent available soil moisture level.

The above results are contradictory in nature and therefore, no definite conclusions can be drawn. However from the above review it is clear that excessive irrigation adversely affects the yield of cucurbits.

2.7. Irrigation scheduling based on evaporation data

An evaporimeter is an instrument which integrates the effect of all the different climatic elements furnishing them their natural weightage (Dastane, 1967). Evaporation values measured from a standard USWB class A open pan evaporimeter are extensively used for scheduling of irrigation using a suitable IW|CPE ratio (Sharma and Dastane, 1969; Sharma *et al.* 1975; Vamadevan, 1980).

Singh and Singh (1978) reported high total yields with drip irrigation, at 65 per cent of the evaporation from a class A pan in crops like bottlegourd, roundgourd and watermelon in loamy sand soils of hot arid regions. Studies on scheduling irrigation to bittergourd and cucumber, at the Agronomic Research Station, Chalakudy indicated that 3 cm irrigation at IW|CPE ratio of 0.4 was optimum for both the crops in summer rice fallows (ICAR, 1981). Similar studies in ashgourd recorded the highest yield at IW|CPE ratio of 1.0 which was on par with the IW|CPE ratio of 0.7. Both these were significantly superior to the IW|CPE ratio of 0.4 (ICAR, 1982). The crops were however raised under shallow water table conditions. Thomas (1984) reported that for bittergourd, irrigation at the IW|CPE ratio of 1.2 recorded the maximum net profit and net return per rupee invested followed by IW|CPE ratio of 0.8.

Due to the high cost and field inaccessability of class A pans, evaporation values from a can evaporimeter can be used for scheduling of irrigations (Sharma and Dastane, 1969; Sharma *et al*. 1975; Vamadevan, 1980; Rao *et al*. 1983).

Evaporation values measured from such cans have a high and significant correlation of 0.91 to 0.98 with values from class A pan evaporimeter under crops like wheat, groundnut, soybean and maize (Sharma and Dastane, 1969; Reddy *et al*. 1973; Reddy and Reddy, 1982; Reddy *et al*. 1983). In the case of vegetables like ashgourd, watermelon and amaranthus, the cummulative can evaporation values at 50 per cent of the field capacity ranged from 11 to 16 mm (Rao *et al*. 1983).

It is clear from the above review that heavy irrigations throughout the growth of the crop is detrimental to crop growth and development. Literature on the optimum moisture regimes and water requirements of cucurbitaceous vegetables in our country is meagre. Much work has also not been carried out on the use of evaporimeters in scheduling irrigation in these crops. The optimum moisture regimes for cucurbitaceous vegetables and the optimum pan/can evaporation values at which irrigation is to be scheduled, so as to get high returns is to be investigated.

Material and Methods

MATERIAL AND METHODS

The details of the materials used and the techniques adopted during the course of this investigation are presented in this chapter.

3.1. Experimental site

The experiment was conducted in the rice fallows of the Agricultural Research Station, Mannuthy, Trichur district. The station is situated at 10° 32' N latitude and 76° 10' E longitude and at an altitude of 22.25 m above the mean sea level.

3.2. Season and weather conditions

The experiment was conducted during the summer season of 1982-83. The details of the meteorological observations recorded at the District Agricultural Farm, Mannuthy, for the crop period are presented in Appendix I and Fig.1(a) and 1(b).

3.3. Cropping history

The experimental site was double cropped wet land. The land was usually left fallow during the summer season.

3.4. Soil characteristics

Composite soil samples from 0-60 cm depth, taken before commencement of the experiment, were used for the determination of physiochemical properties. The data are

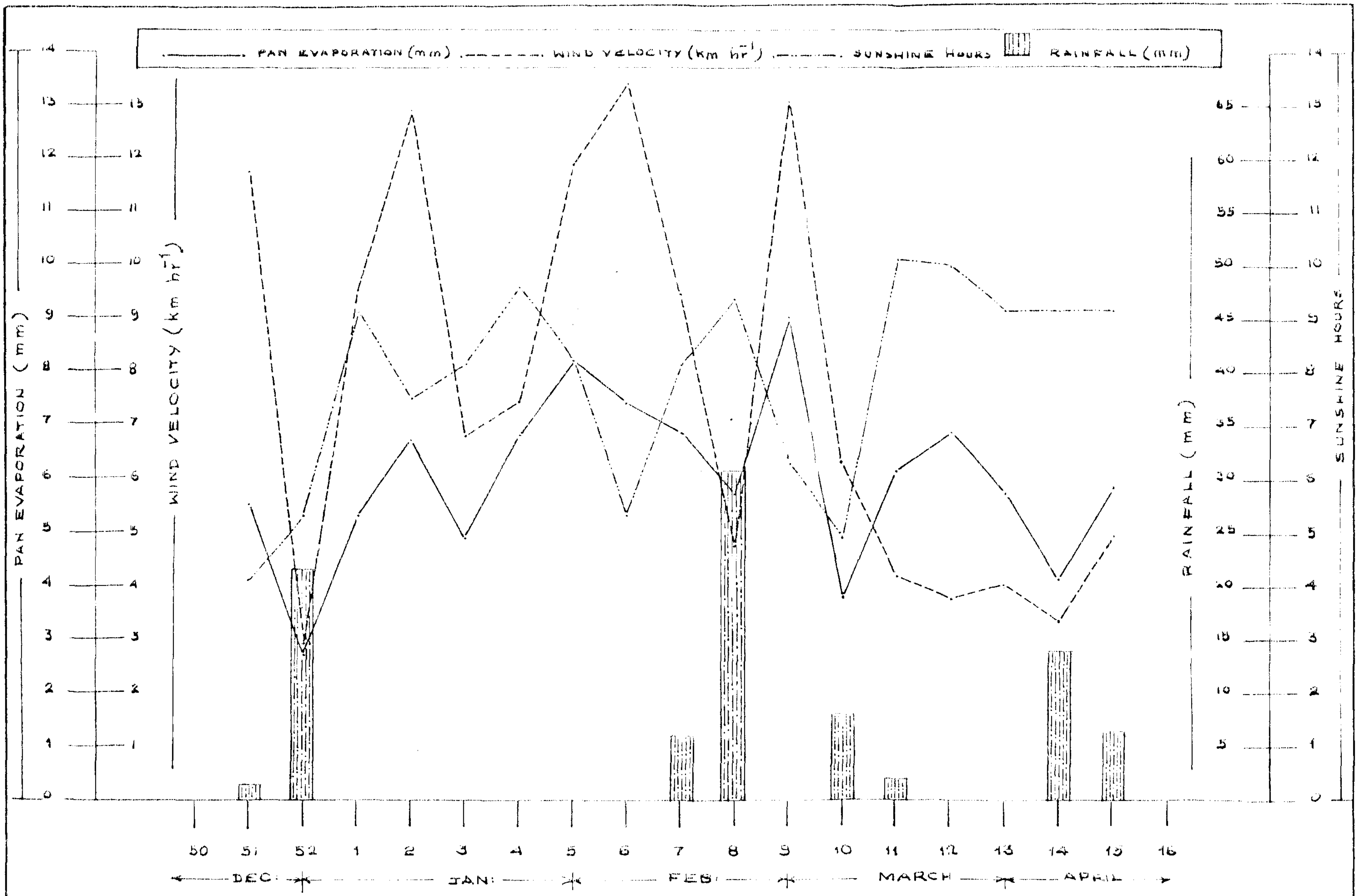

FIG. 1 (a). WEATHER CONDITIONS DURING CROP SEASON

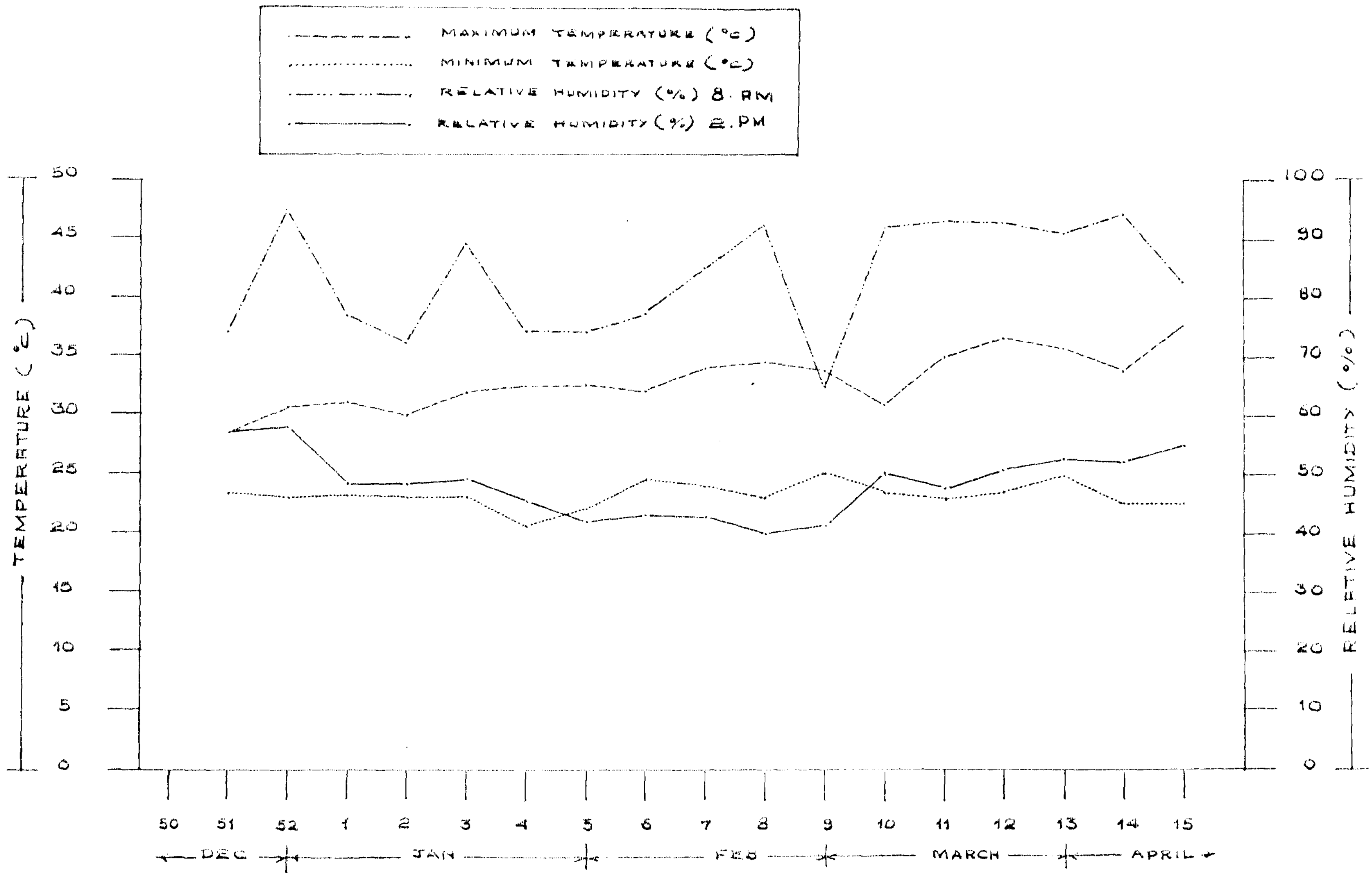

FIG. 1 (b) WEATHER CONDITIONS DURING CROP SEASON

Table 1. Soil characteristics of the experimental area

1.1. Mechanical composition

Fraction	Per cent composition	Procedure adopted
Course sand	26.4	
Fine sand	23.8	Robinson's international
Silt	22.4	pipette method (Piper, 1950)
Clay	27.2	
Texural class	Sandy clay loam	I.S.S.S.System

1.2. Physical constants of the soil

Constant	Value	Procedure adopted
Field capacity (0.3 bars)	19.38	Pressure plate apparatus (Richards, 1947)
Moisture percentage at 15 bars	11.12	Pressure plate apparatus (Richards, 1947)
Bulk density ($g\ cm^{-3}$)	1.34	Core method (Blake, 1965)
Particle density ($g\ cm^{-3}$)	2.16	Pycnometer method (Blake, 1965)

Contd.2

Table 1. (Contd)

1.3. Chemical properties

Description of the properties	Value	Method employed
Organic carbon(%)	0.331	Walkley and Black rapid titration method (Jackson, 1958)
Available nitrogen (kg ha^{-1})	233.8	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	124.8	Chlorostannous reduced molybdophosphoric blue colour method in hydrochloric acid system (Jackson, 1958)
Available potassium (kg ha^{-1})	67.84	Flame photometry. Neutral normal ammonium acetate extraction (Jackson, 1958)
Soil reaction (pH)	5.5	Soil water suspension of 1:2.5 (Jackson, 1958)
Electrical conductivity (mmhos cm^{-1})	0.41	Soil water extract of 1:2.5 (Jackson, 1958)

given in Table 1. The soil moisture characteristic curve is depicted in Fig.2.

3.5. Ground water level

Two observation wells of 3.5 metres deep were dug in the experimental area to check the ground water level within a depth of 3 metres.

3.6. Crop and variety

Three cucurbitaceous vegetables viz., pumpkin, oriental pickling melon and ashgourd were used for the study. The details of the cultivars are furnished in Table 2.

3.7. Experimental technique

3.7.1. Layout

The layout plan of the experiment is given in Fig.3. The details are presented below.

Design	-	Randomised block design
Replications	-	4
Treatments	-	5
Total number of plots	-	20
Plot size	-	7.5 m x 3 m
Spacing	-	3.75 m x 1.5 m
Number of pits per plot	-	4 pits having 3 plants in each pit.

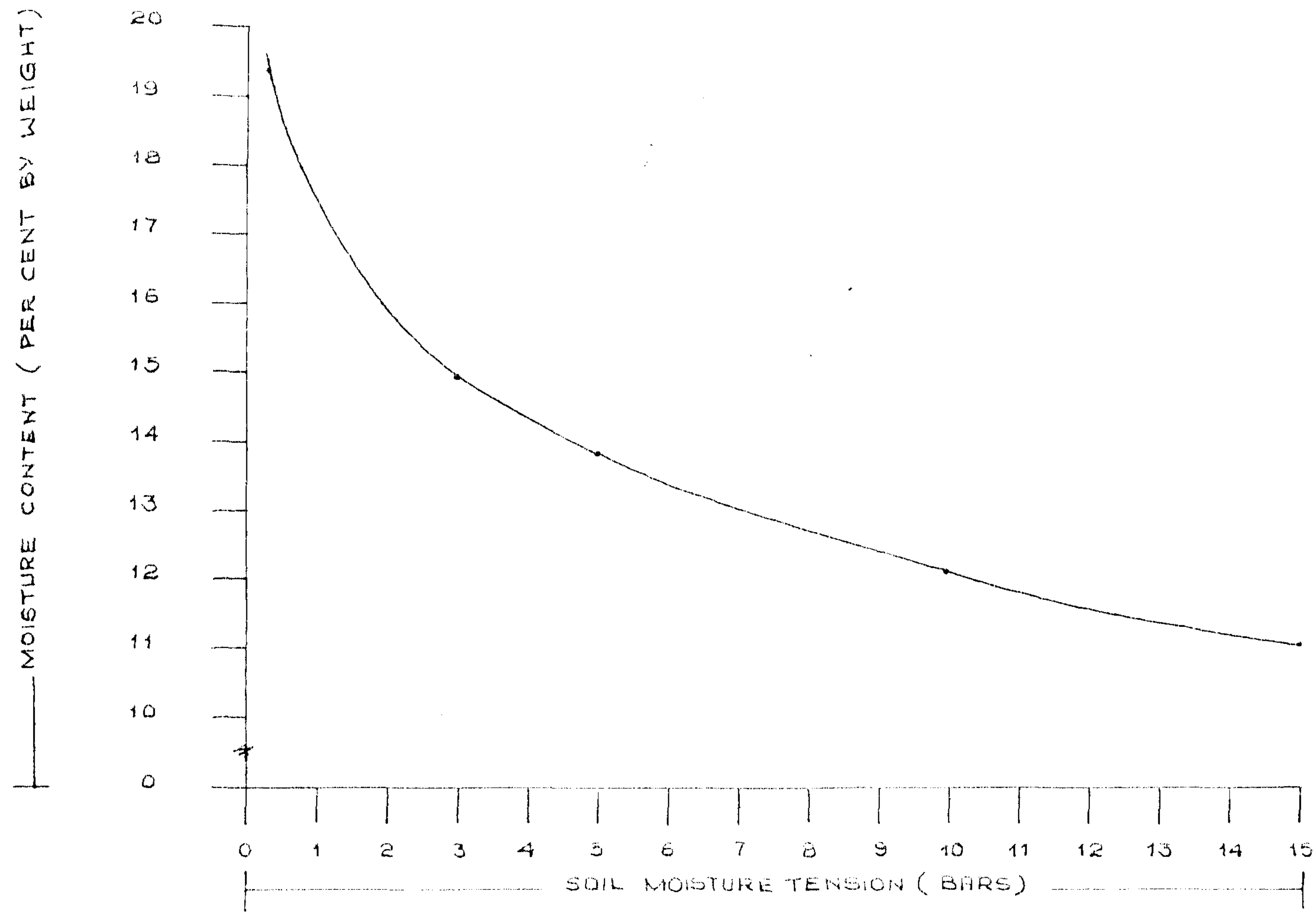

FIG. 2. SOIL MOISTURE CHARACTERISTIC CURVE

Table 2. Crop characteristics

Crop	Scientific name	Variety	Characteristics of the variety
Pumpkin	*Cucurbita moschata* Poir.	CM 14	Vigorous plant with white spots on the leaves. Fruits are big and round in shape.
Oriental pickling melon	*Cucumis melo* var. Conomom Mak.	Mudikode local	The plants have green pubescent angular stems. The leaves are orbicular with slightly serrated margin and blunt tip. The fruits are long and oval golden yellow in colour.
Ashgourd	*Benincasa hispida* (Thumb) Cogn.	BH-32 Vellanikkara local	Moderately spreading plant with medium branching habit. The fruits are oval shaped and medium in size.

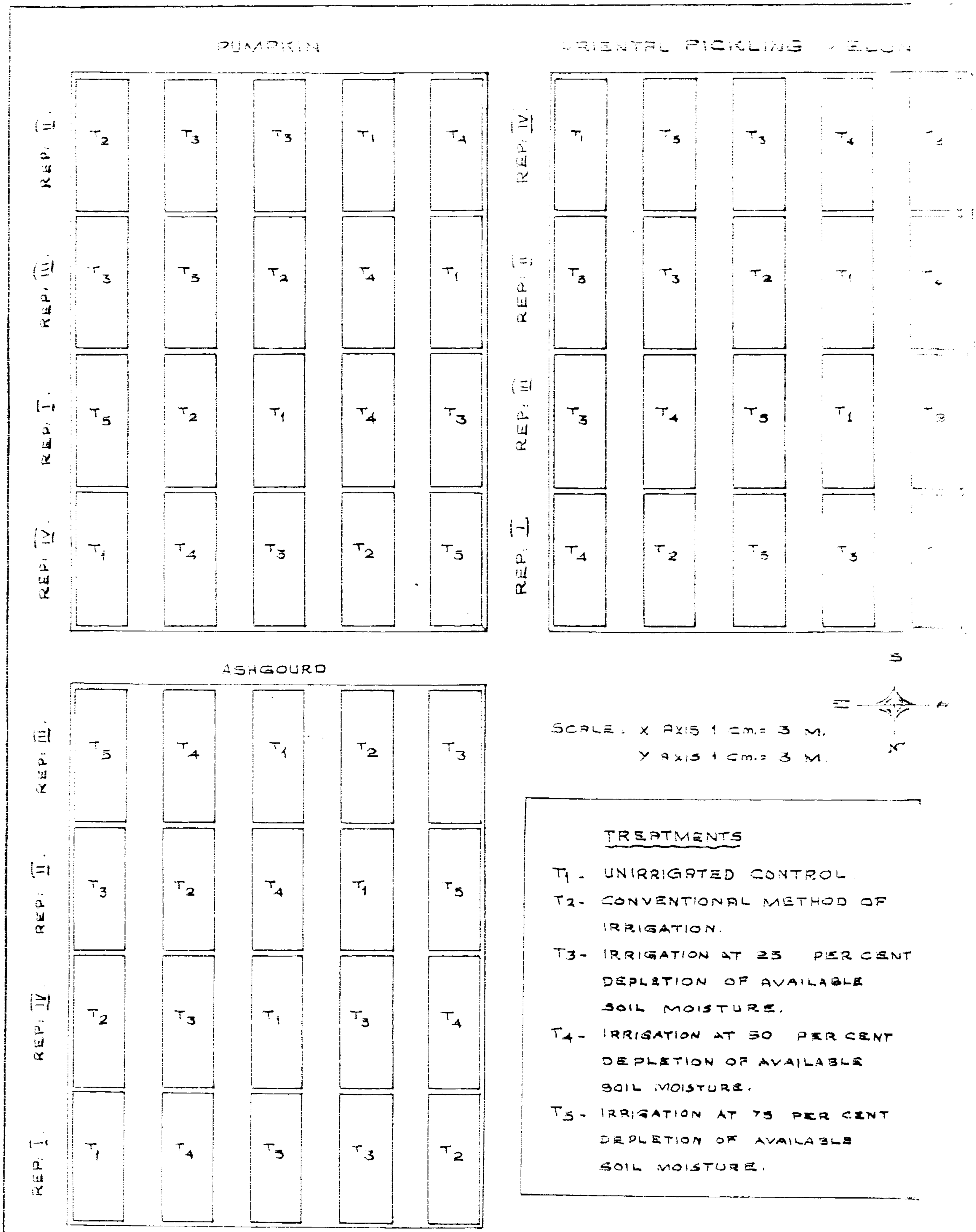

FIG: 3. LAYOUT PLAN

3.7.2. Treatments

The treatments consisted of five moisture regimes. The details are as follows.

Serial number	Treatments	Notation*
1	Unirrigated control	T_1
2	Conventional method of irrigation	T_2**
3	Irrigation at 25 per cent depletion of available soil moisture	T_3
4	Irrigation at 50 per cent depletion of available soil moisture	T_4
5	Irrigation at 75 per cent depletion of available soil moisture	T_5

* These notations will be used to represent the treatments hereafter, wherever necessary in this thesis.

** The treatment T2 was standardised after surveying the farmers local practice of irrigation (One pot @ 13 litres per day).

3.8. Irrigation

A presowing irrigation with two pots of water (26 litres) was given uniformly to all the basins. Thereafter one pot of water was given uniformly to all the basins on alternate days upto the 26th day after sowing. On rainy days, the crop was not watered. Irrigation according to the treatments was started from the 27th day of sowing, when the plants were well established. Pot watering was adopted in all the cases.

3.9. Quantity of water per irrigation

The effective radius of wetting and the depth of the root zone were taken as 75 cm and 60 cm respectively. Based on these values, the volume of water to be applied to bring the soil to field capacity was calculated. When the moisture regime in the basin dropped to 25, 50 and 75 per cent of the available soil moisture level, the specified quantity of water as per the treatment was applied. The details of the total quantity of water supplied to the three crops are given in Table 3.

3.10. Land preparation

The experimental area was ploughed well and levelled. Buffer strips of two metres width were left in between the treatments. Basins of 30 cm depth and 60 cm diameter were taken. Border rows were not provided due to the large spacing involved.

3.11. Manurial application

Dried and powdered farmyard manure at the rate of 20 t ha^{-1} was applied uniformly in all the basins as basal dose. Fertilisers were applied at the rate of 70:25:25 kg ha^{-1} each of N, P_2O_5 and K_2O in the form of Urea, Superphosphate and Muriate of potash. N was applied in two split doses, half as basal and the other half at the time of vining, while the whole of P and K were applied basally.

Table 3. Details of the total quantity of water supplied to pumpkin, oriental pickling melon and ashgourd

Treatment		Number of irrigations	Quantity of water applied per irrigation (litres)	Pretreatment irrigation (including effective rainfall) (litres)	Effective rainfall after start of experiment (litres)	Total quantity of water applied	
						Litres per basin	ha-mm
Pumpkin							
	T1	Control	—	171.29	60.41	231.70	39.39
	T2	70	13	171.29	33.74	1115.03	189.56
	T3	32	29	171.29	26.21	1125.50	191.34
	T4	18	59	171.29	48.38	1281.67	217.88
	T5	12	88	171.29	45.64	1272.93	216.39
Oriental Pickling melon							
	T1	Control	—	169.71	76.74	246.45	41.89
	T2	69	13	169.71	53.73	1120.44	190.47
	T3	27	29	169.71	51.61	1004.32	170.73
	T4	16	59	169.71	70.37	1184.08	201.29
	T5	10	88	169.71	70.72	1120.43	190.47
Ashgourd							
	T1	Control	—	195.00	71.78	266.78	45.35
	T2	52	13	195.00	32.73	903.73	153.64
	T3	17	29	195.00	61.80	749.80	127.47
	T4	10	59	195.00	65.07	850.07	144.51
	T5	7	88	195.00	63.79	874.79	148.71

3.12. Sowing

The dates of sowing of pumpkin, oriental pickling melon and ashgourd were 20-12-1983, 23-12-1983 and 13-1-1984, respectively. The seeds soaked in water overnight were dibbled in each basin. The seedlings were thinned to three per basin, 25 days after sowing.

3.13. After cultivation

The basins were kept free of weeds throughout the crop growth period. When the plants started to vine, the space in between the basins was mulched with dry twigs and coconut leaves.

3.14. Plant protection

Furadan was applied 15 to 20 days after sowing as a prophylactic control measure against the attack of red pumpkin beetle (*Aulacophora* sp.).

3.15. Harvesting

Fruits were harvested when they were fully mature. The maturity for vegetable purpose was judged by visual appearance. The dates of harvest of the three crops are as given below.

Crops	Harvest dates
Pumpkin	9-3-1984, 22-3-1984 and 7-4-1984
Oriental pickling melon	5-3-1984, 22-3-1984 and 5-4-1984
*Ashgourd	28-3-1984 and 6-4-1984

* Though the crop was of 4½ months duration the treatment effects could be studied only upto 90 days after sowing as there were frequent rains after this period.

3.16. Soil moisture studies

3.16.1. Soil sampling

Soil samples were collected by using a screw auger. Sampling was done at a distance of 10-15 cm away from the base of the plant from four depths viz., 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm. Soil samples collected from different replications of a treatment were pooled separately for the different depths. Samples were then dried inside the hot air oven at 105°C for 24-36 hours. After taking the weights of dry-soil, the loss of moisture was estimated and expressed as percentage of oven dry soil. The moisture percentage was found out for the entire layer 0-60 cm, by taking the mean of the soil moisture percentages of the four layers and the same was used to find out the extent of depletion and to decide the time of irrigation.

3.16.2. Consumptive use

Consumptive use was worked out from the soil moisture depletion data (Michael *et al*. 1977). Following each irrigation, soil moisture determination was done after 24 hours. For this period potential evapotranspiration, obtained by multiplying pan evaporation value with the crop factor 0.8 was taken for the calculation of consumptive use (Dastane, 1967). The effective rainfall determined based on the soil moisture content and the potential evapotranspiration rates (Dastane, 1974) was also taken into account, for the determination of consumptive use. Seasonal consumptive use was calculated by summing the consumptive use values for each sampling interval. The daily moisture depletion was worked out by dividing the total consumptive use by the duration of the crop in days. Consumptive use is expressed in litres per basin and also in hectare-millimeter.

3.16.3. Crop coefficient

The ratio (kc) of consumptive use to evaporation from an evaporation pan was worked out by dividing the consumptive use during a given period by the pan evaporation values during that period.

3.16.4. Moisture extraction pattern

The soil moisture depletion of each soil layer in the root zone was worked out upto 60 cm depth for each irrigation interval. The depletion patterns at intervals of 15 days for the three crops and the overall extraction during the crop period from each soil layer, expressed as a percentage of the total quantity extracted were also worked out. The potential evapotranspiration values for the

24 hours after each irrigation were added to the moisture depletion in the first layer.

5.16.5. Crop water use efficiency

Crop water use efficiency was worked out by dividing the total crop yield by the amount of water depleted by the crop in the process of evapotranspiration (Michael *et al.* 1977) and is expressed in kg ha mm^{-1}.

3.16.6. Field water use efficiency

Field water use efficiency was worked out by dividing the total crop yield by the amount of water used in the field (Michael *et al.* 1977) and is expressed in kg ha mm^{-1}.

3.17. Evaporimeter

Two can evaporimeters of 14.3 cm height and 10.5 cm diameter with a pointer at 1.5 cm below the rim (Fig.4) to facilitate the recording of water levels were installed in the field at 30 cm height from the ground level. The cans were painted white and had a screen cover of 6/20 mesh. The quantity of water added daily to bring the tip of the pointer in level with the water in the can was noted. The daily evaporation values were measured as mm day^{-1} by dividing the volume of water added by the surface area of the can. Evaporation values were noted twice daily at 8 AM and 2.30 PM.

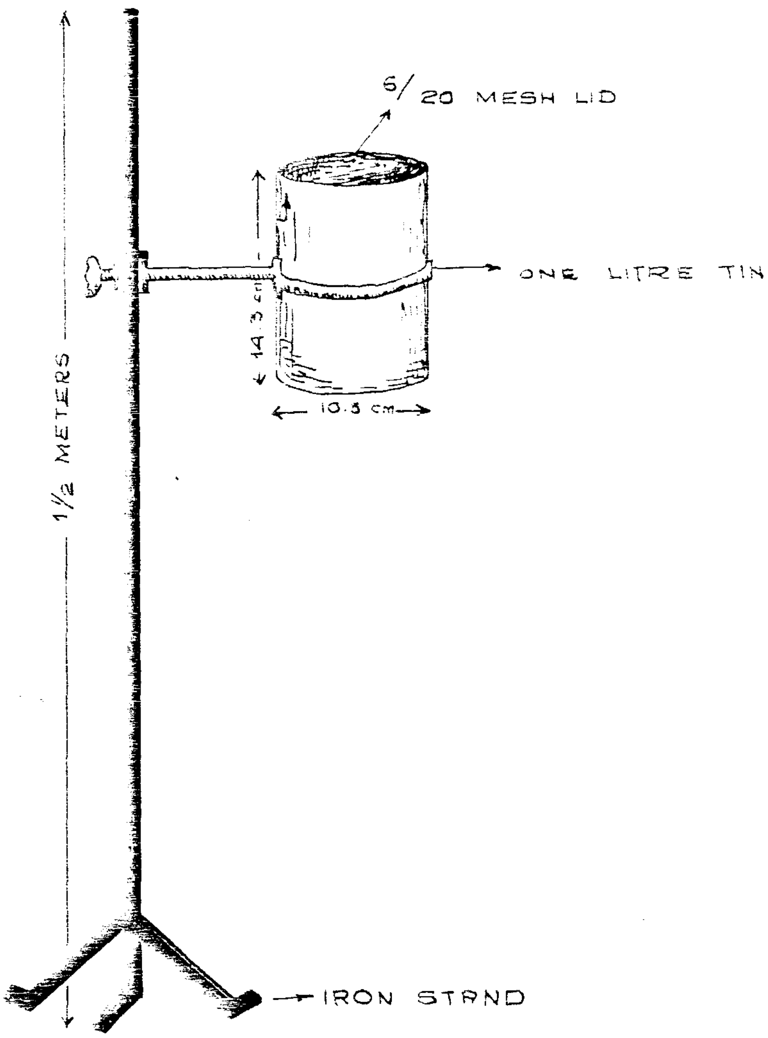

FIG: 4. CAN EVAPORIMETER

Correlation coefficient was worked out between pan and can evaporation values. Cummulative pan and can evaporation values, at intervals of 15 days was also worked out for the different moisture regimes.

3.18. Biometric observations

3.18.1. Length of vine

The length of vine was recorded from four plants per plot at 45 and 75 days after sowing and at the time of harvest. The length of main vine was measured from the base to the growing tip of the vine and the mean length of vine per plant worked out.

3.18.2. Number of leaves

The total number of leaves from three plants per pit was recorded at 45 and 75 days after sowing and at the time of harvest of the crop. The mean number of leaves per plant was worked out.

3.18.3. Dry matter production

The dry matter content of the vegetative parts was recorded at the time of harvest. Four plants per plot were randomly chosen and cut close to the ground. This was then separated into leaves and shoots and oven dried at $80 \pm 5^{0}C$ to a constant weight. The dry matter content was expressed as g plant^{-1}.

3.18.4. Leaf area

Since destructive sampling was not possible, on the spot determination of leaf area was done. A set of 100 leaves was picked randomly at three stages of plant growth viz., 30, 60 and 90 days after sowing from different points along the vine length. The maximum width of the leaves chosen was measured. The area of these leaves was also found out by the graph paper method (Kvet and Marshall, 1971). Correlation coefficients were worked out between actual leaf area and maximum width of the leaves. Regression equations were fitted to find out the relationship between actual area and maximum width of the leaf, using equations of the type $A = ax + b$, $A = ax$ and $A = ax^2$ where A is the leaf area and x the maximum width of the leaf.

3.18.5. Leaf area index

For the determination of leaf area index, the average leaf diameter of 20 leaves from each plant was measured randomly at different points along the vine length. This was then converted to the average leaf area values using the regression equations developed. The average leaf area values were multiplied by the total number of green leaves, to get the total leaf area which when divided by the land area gave the leaf area index

(Watson, 1947). The leaf area index values were worked out at three stages, viz., 45 and 75 days after sowing and at harvest.

3.19. Yield

The fruits harvested from all the plants of a treatment were counted and the average number of fruits per plant was worked out. Yield of fruits in Kilogram per plant and tonnes per hectare were also worked out.

3.19.1. Mean length of fruit

The length of three fruits harvested from each pit was recorded in centimeters and the mean length worked out.

3.19.2. Mean girth of fruit

The girth at the centre of the fruit was recorded from three fruits per pit and the mean girth for a fruit calculated.

3.19.3. Dry matter content of fruit

Uniform quantity of flesh was taken from three randomly selected fruits per plot and dried to constant weight in an air oven at 80 ± 5°C. The weight of the dry matter obtained was expressed as percentage of the fresh weight.

3.19.4. Weight per fruit

Weight of fruits harvested from all the plants of a treatment from the various harvests was recorded and the mean weight determined.

3.20. Rooting pattern

The rooting patterns of the crop were studied by the excavation method (Bohm, 1979). The roots of the crops were traced out by removing the surface layer of soil beginning at the stem, to determine the horizontal spread of the lateral roots. The entire root system was dug out. Two plants of a treatment, one from each replication was used for the study. The maximum lateral spread of the roots, the maximum depth upto which roots were found and the number of roots per tap root were noted. Core sampling was not feasible since the density of roots per unit area was not high. The dry weight of the roots was determined after careful washing to remove the adhering soil, by drying in an oven at 80 $\pm$ 5°C.

3.21. Statistical analysis

The results obtained were statistically analysed as described by Snedecor and Cochran (1967).

Results and Discussion

RESULTS AND DISCUSSION

As there are three crops involved in the present study, the results and discussion are given separately for the individual crops. A brief summary of the major conclusions drawn out of the study succeeds each discussion.

Pumpkin

PUMPKIN

(*Cucurbita moschata*. Poir)

RESULTS

The results of the field experiment conducted to evaluate the response of cucurbitaceous vegetables to different soil moisture regimes are presented in this chapter.

4.1. Growth characters

4.1.1. Length of main vine

The mean length of the main vine recorded at three stages viz. 45 and 75 days after sowing and at the time of harvest is presented in Table 4 and their analysis of variance in Appendix II.

The unirrigated control (T1) recorded the least length of main vine during all the stages of plant growth. The rest of the treatments T2, T3, T4 and T5 were on par and were significantly superior to T1 at 45 and 75 days after sowing. At the time of harvest T5, T4 and T3 were on par and were significantly superior to T2 and T1. Though T3 was on par with T2 both were significantly superior to T1.

4.1.2. Number of leaves per plant

The data relating to the number of leaves recorded at the three stages of crop growth are given in Table 4 and the analysis of variance in Appendix II.

At 45 days after sowing, leaf production was found to be maximum in T2 which was on par with T3 and T4, and all these were significantly superior to T5 and T1. The unirrigated control recorded the lowest number of leaves and was significantly inferior to the other levels of irrigation.

At 75 days after sowing, though T4 recorded the maximum number of leaves, there were no significant differences among the treatments. At the harvest stage the treatments T2, T3, T4 and T5 were at par but were significantly superior to T1.

4.1.3. Leaf area

Correlation coefficients were worked out between actual leaf area and maximum width of the leaves. A high positive significant correlation of 0.97 was obtained between the actual leaf area and the maximum width of the leaves. Regression equations were then fitted to find out the relationship between the actual leaf area (A) and maximum width of the leaf (x). The three regression equations developed and their predictability are given below.

Equation	Predictability
1. $A = 25.85\ x - 219.7$	94%
2. $A = 14.1\ x$	75%
3. $A = 0.72\ x^2$	94%

Data on the predicted leaf area from the three models corresponding to the diameter values upto 28 cm are given in Table 5 and the graphical representation of these along with the scatter diagram showing actual measured leaf area values are given in Fig.5.

4.1.4. <u>Leaf area index</u>

The data on leaf area index are presented in Table 6 and the analysis of variance in Appendix II. The irrigation levels produced significant influence on leaf area index at 45 days after sowing. T2 was found to have the maximum leaf area index and was significantly superior to all the other treatments. T3 and T4 were on par and were significantly superior to T5 and T1. T5 on the other hand was significantly superior to T1 which recorded the lowest leaf area index.

At 75 days after sowing the levels of irrigation did not show any significant influence on leaf area index. All the treatments except T1 were on par. T1 recorded the lowest value.

At harvest the treatments T2, T3, T4 and T5 were on par and significantly superior to T1 which recorded the least value.

Table 4. Length of vine and number of leaves in pumpkin as affected by the levels of irrigation

Treatments	Length of main vine (m)			Number of leaves per plant		
	45 days after sowing	75 days after sowing	Harvest	45 days after sowing	75 days after sowing	Harvest
T1	2.09	2.97	3.55	35.47	57.09	45.74
T2	3.29	3.86	4.39	57.68	57.43	100.26
T3	3.29	4.15	4.97	54.63	66.51	74.39
T4	3.14	4.31	5.18	53.98	70.23	86.44
T5	3.19	4.29	5.21	44.59	64.25	91.15
SEm±	0.1350	0.1808	0.2286	2.9835	6.1613	8.3437
CD(5%)	0.4160	0.5572	0.7044	9.1939	NS	25.7117

Table 6. Leaf area index and dry matter production in pumpkin as affected by levels of irrigation

Treatments	Leaf area index			Dry matter production at harvest (g/plant)
	45 days after sowing	75 days after sowing	Harvest	
T1	0.337	0.456	0.244	107.375
T2	0.854	0.705	0.703	235.063
T3	0.729	0.711	0.570	206.750
T4	0.722	0.777	0.624	225.875
T5	0.600	0.651	0.605	206.250
SEm±	0.0324	0.0610	0.0628	25.5896
CD (5%)	0.0999	0.1881	0.1937	78.8563

Table 5. Predicted leaf area in pumpkin

Leaf Diameter (cm)	Predicted leaf area (cm^2)		
	$A = 25.85x - 219.7$	$A = 0.72x^2$	$14.1x$
0	-	0	0
1	-	0.72	14.10
2	-	2.88	28.20
3	-	6.49	42.30
4	-	11.53	56.40
5	-	18.02	70.50
6	-	25.95	84.60
7	-	35.32	98.70
8	-	46.14	112.80
9	12.95	58.40	126.90
10	38.80	72.10	141.00
11	64.65	87.24	155.10
12	90.50	103.82	169.20
13	116.35	121.84	183.30
14	142.20	141.32	197.40
15	168.05	162.23	211.50
16	193.90	184.58	225.60
17	219.75	208.37	239.70
18	245.60	233.60	253.80
19	271.45	260.28	267.90
20	297.30	288.40	282.00
21	323.15	317.52	296.10
22	349.00	348.48	310.20
23	374.85	380.88	324.30
24	400.70	414.72	338.40
25	426.50	450.00	352.50
26	452.40	486.72	366.60
27	478.25	524.88	380.70
28	504.10	564.48	394.80

A - Predicted leaf area (cm)

x - Measured maximum leaf diameter (cm)

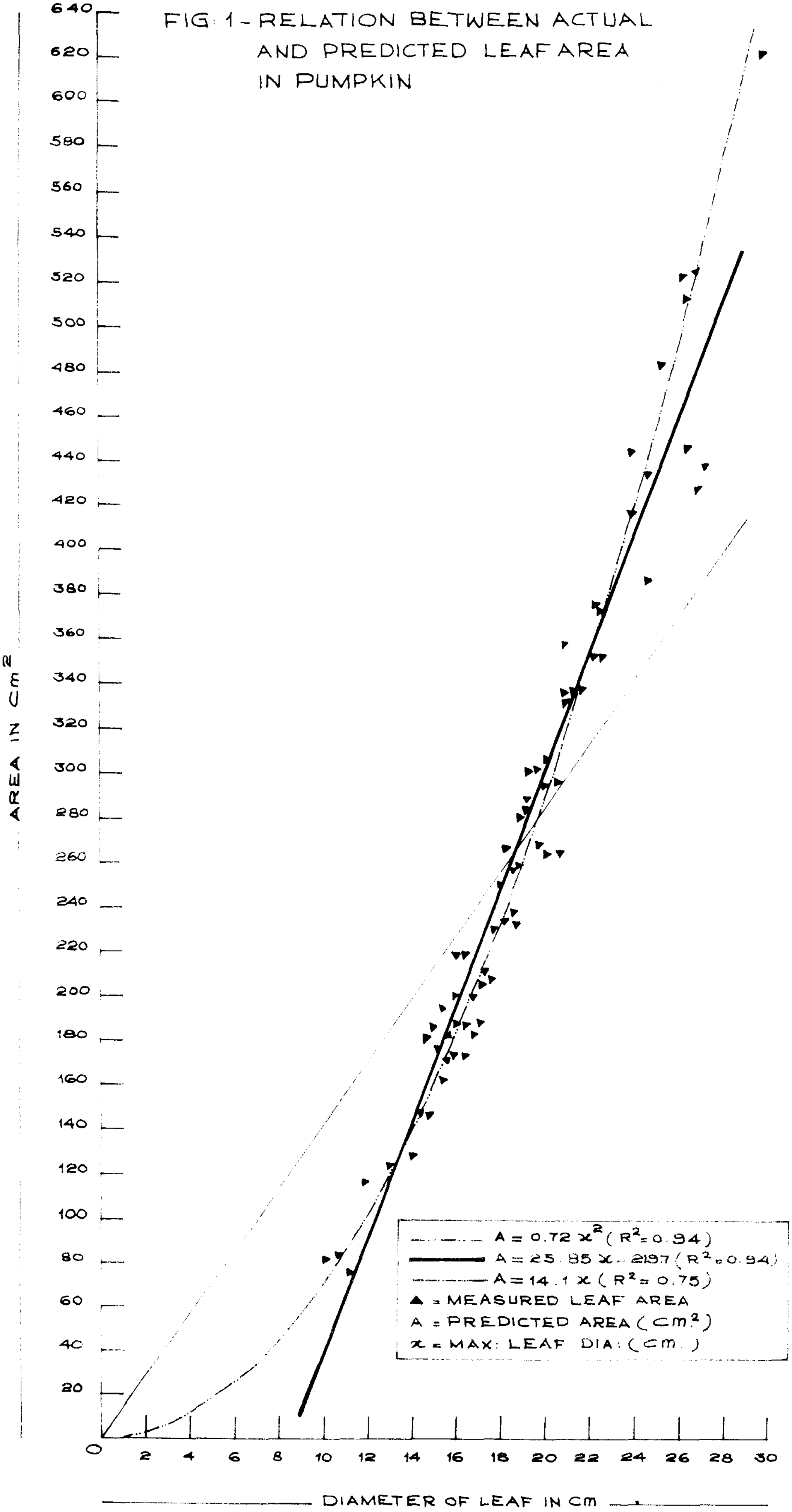

FIG 1 - RELATION BETWEEN ACTUAL AND PREDICTED LEAF AREA IN PUMPKIN

4.1.5. Dry matter production

The dry matter content of the vegetative parts determined at the time of harvest is presented in Table 6 and the analysis of variance in Appendix II. The treatments T2, T3, T4 and T5 were on par but were significantly superior to T1 with respect to the dry matter production.

4.2. Yield and yield attributes

Data relating to yield and yield attributes are given in Table 7 and their analysis of variance in Appendix III.

4.2.1. Number of fruits per plant

Irrigation significantly increased the number of fruits per plant. The treatment T2 which produced the highest number of fruits per plant was significantly superior to T1 and T5 but was on par with T3 and T4. The treatments T3, T4 and T5 were at par but were significantly superior to T1. T1 produced the lowest number of fruits per plant.

4.2.2. Fruit yield per plant and per hectare

The levels of irrigation T2, T3, T4 and T5 were on par and were significantly superior to T1, with respect to fruit yield.

Table 7. Yield and yield attributes of pumpkin as affected by levels of irrigation

Treatment	Number of fruits per plant	Yield		Mean fruit weight (kg)	Mean length of fruit (cm)	Mean girth of fruit (cm)	Per cent dry matter of fruit
		Per plant (kg)	Per hectare (t)				
T1	0.725	1.316	6.713	1.817	11.400	43.785	10.408
T2	1.793	4.633	23.628	2.595	15.235	54.265	8.713
T3	1.513	4.809	24.566	3.222	16.578	59.520	8.163
T4	1.458	5.183	26.435	3.582	17.875	64.977	9.240
T5	1.278	4.274	21.794	3.351	18.140	61.530	9.143
SEm±	0.1151	0.3902	1.9846	0.2434	0.4448	2.6779	0.4328
CD (5%)	0.3550	1.2027	6.1156	0.7506	1.3706	8.2521	1.3338

4.2.3. Mean length of fruit

The treatment T5 which recorded the maximum fruit length was on par with T4 and was significantly superior to T3, T2 and T1. T4 which was on par with T3 was significantly superior to T2. There was no significant difference between T3 and T2. The treatment T1 recorded the lowest length of fruit.

4.2.4. Mean girth of fruit

With respect to mean girth of fruit, T4 was significant superior to T2 and T1 but was on par with T5 and T3. The treatments T5, T3 and T2 were at par but were significantly superior to T1.

4.2.5. Mean weight of fruit

The treatment T4 was significantly superior to T2 and T1, but was on par with T5 and T3 with respect to mean fruit weight. T5 which was on par with T3 was superior to T2 and T1. There was no significant difference between T3 and T2. T1 recorded the least value.

4.2.6. Per cent dry matter of fruit

T1 which recorded the maximum dry matter content of fruit was on par with T4 and T5 and was significantly superior to T2 and T3. However, the treatments, T4, T5, T2 and T3 did not exhibit significant differences.

4.3. Moisture studies

4.3.1. Consumptive use

Seasonal consumptive use from 27 days after sowing to the end of the crop growth and the average consumptive use per day are given in Table 8(a). In treatment T2 since daily irrigation was practiced consumptive use determination from soil moisture data was not feasible and hence not calculated. The consumptive use calculated at intervals of 15 days is presented in Table 8(b) and Fig.6.

The seasonal consumptive use was maximum for T3 (232.70 ha mm) followed by T4 (190.17 ha mm), T5 (151.69 ha mm) and T1 (26.46 ha mm). With respect to the average per day consumptive use also the same trend was observed. The consumptive use calculated at 15 days interval showed that the peak consumptive use occurred at 57 days after sowing in all the treatments. Thereafter a steady decline in consumptive use was observed. Though this decline was rapid in T3 and T4, it was not so in T5.

4.3.2. Crop coefficients

The data on crop coefficients are presented in Table 8(a) and 8(b). The highest values of crop coefficients were found to occur at 50-60 days after sowing and thereafter it declined in the case of all the treatments (Fig.7). T3 showed the highest value of crop coefficient

Table 8(a). Consumptive use and crop coefficients of pumpkin as affected by levels of irrigation

Treatments	Seasonal consumptive use (litres per basin)	Seasonal consumptive use (ha-mm)	Per day consumptive use (litres per basin)	Crop coefficient
T1	155.64	26.46	2.08	0.052
T2	--	--	--	--
T3	1368.84	232.70	18.251	0.459
T4	1118.62	190.17	14.915	0.376
T5	892.29	151.69	11.897	0.299

Table 8(b). Cumulative consumptive use and crop coefficient values of pumpkin at intervals of 15 days

Particulars	Treatments	Period (days after sowing)				
		27-42	42-57	57-72	72-87	87-102
Consumptive use (litres)	T3	158.54	444.77	322.06	233.79	209.68
Consumptive use (ha-mm)	T3	26.95	75.61	54.75	39.74	35.65
Crop coefficients	T3	0.291	0.605	0.463	0.509	0.385
Consumptive use (litres)	T4	176.39	401.89	209.68	174.63	156.03
Consumptive use (ha-mm)	T4	29.99	68.32	35.65	29.69	26.53
Crop coefficients	T4	0.324	0.547	0.301	0.380	0.287
Consumptive use (litres)	T5	121.16	242.04	210.92	187.26	130.91
Consumptive use (ha-mm)	T5	14.99	46.76	35.86	31.83	22.25
Crop coefficients	T5	0.162	0.374	0.303	0.408	0.241

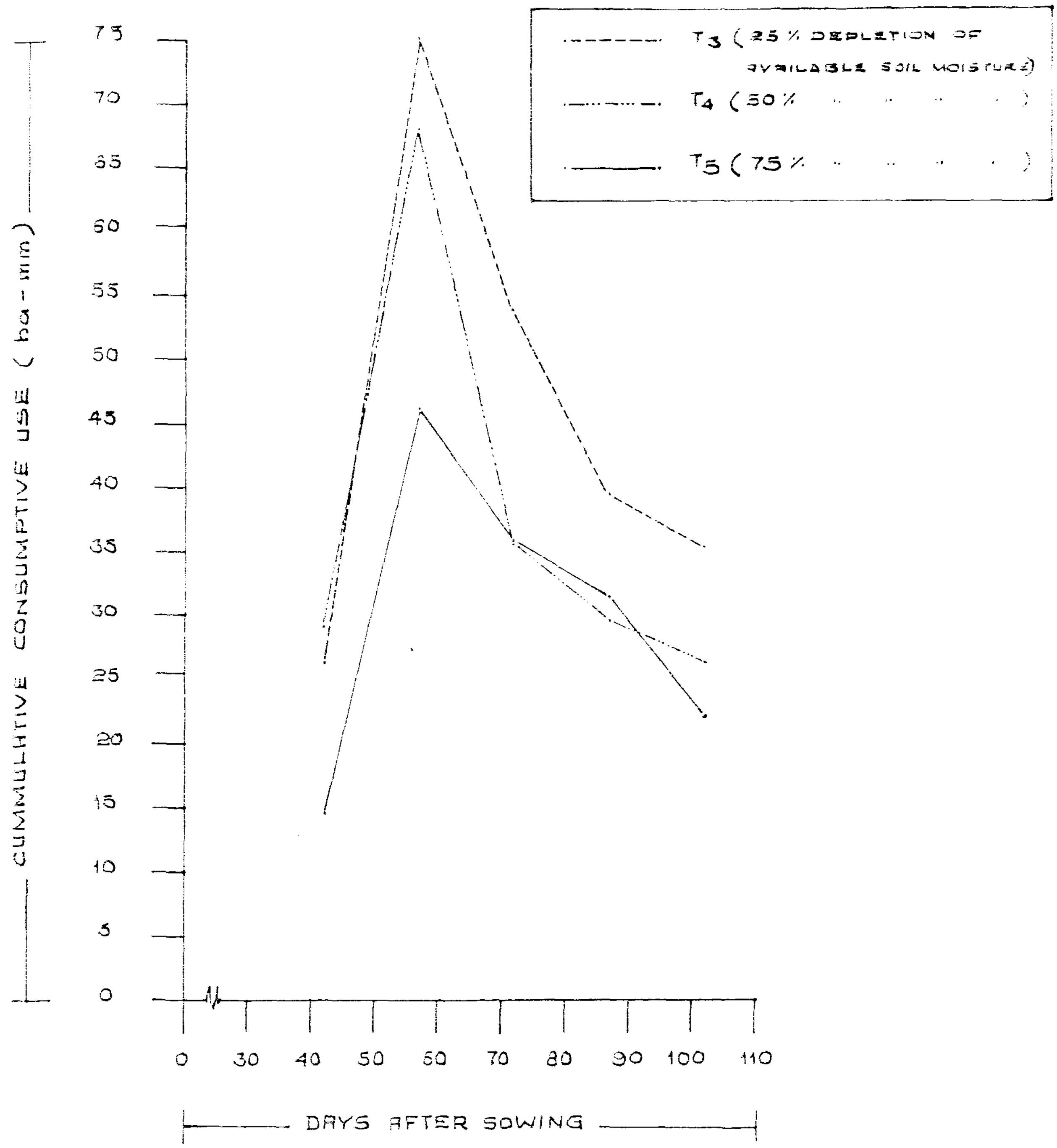

FIG: 6. CUMMULATIVE CONSUMPTIVE USE OF PUMPKIN AT INTERVALS OF 15 DAYS

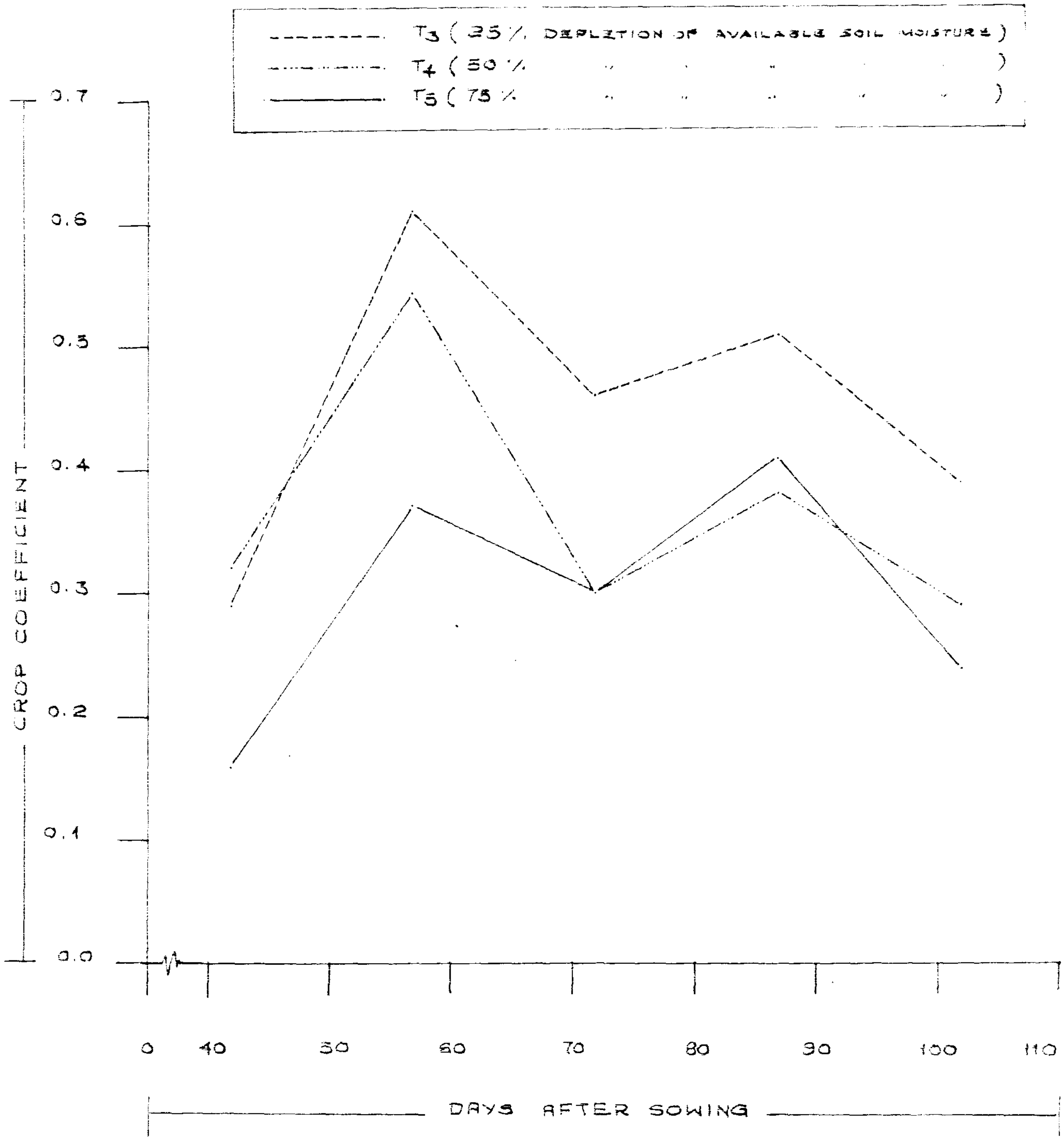

FIG. 7. CROP COEFFICIENTS FOR PUMPKIN AT INTERVALS OF 15 DAYS

(0.459) followed by T4 (0.376), T5 (0.299) and T1 (0.052). At 87 days after sowing a second peak in crop coefficient values was observed and it was pronounced in the case of T4 and T5.

4.3.3. Field water use efficiency

The data on field water use efficiency are given in Table 9(a) and depicted in Fig.8. The analysis of variance is presented in Appendix II.

Field water use efficiency was maximum for T1 (170.423 kg ha mm^{-1}). The treatments T2, T3, T4 and T5 were on par. Though not significant T5 recorded the least field water use efficiency with 100.716 kg fruits ha mm^{-1} of water used.

4.3.4. Crop water use efficiency

The data on crop water use efficiency are given in Table 9(b) and graphically represented in Fig.8.

Crop water use efficiency was maximum for T1 followed by T5, T4 and T3. T3 recorded the lowest value. In treatment T2 since daily irrigation was practised, the crop water use efficiency could not be calculated.

Table 9(a). Field water use efficiency of pumpkin as affected by levels of irrigation

Treatment	Yield (kg ha^{-1})	Total water applied (ha-mm)	Field water use efficiency (kg-ha mm^{-1})
T1	6713	39.39	170.423
T2	23628	189.56	124.647
T3	24566	191.34	128.389
T4	26435	217.88	121.328
T5	21794	216.39	100.716
SEm$\pm$	--	--	10.2069
CD (5%)	--	--	31.4536

Table 9(b) Crop water use efficiency of pumpkin as affected by levels of irrigation

Treatment	Yield (kg ha^{-1})	Total consumptive use (ha-mm)	Crop water use efficiency (kg-ha mm^{-1})
T1	6713	26.46	253.704
T2	23628	--	--
T3	24566	232.70	105.569
T4	26435	190.17	139.007
T5	21794	151.69	143.675

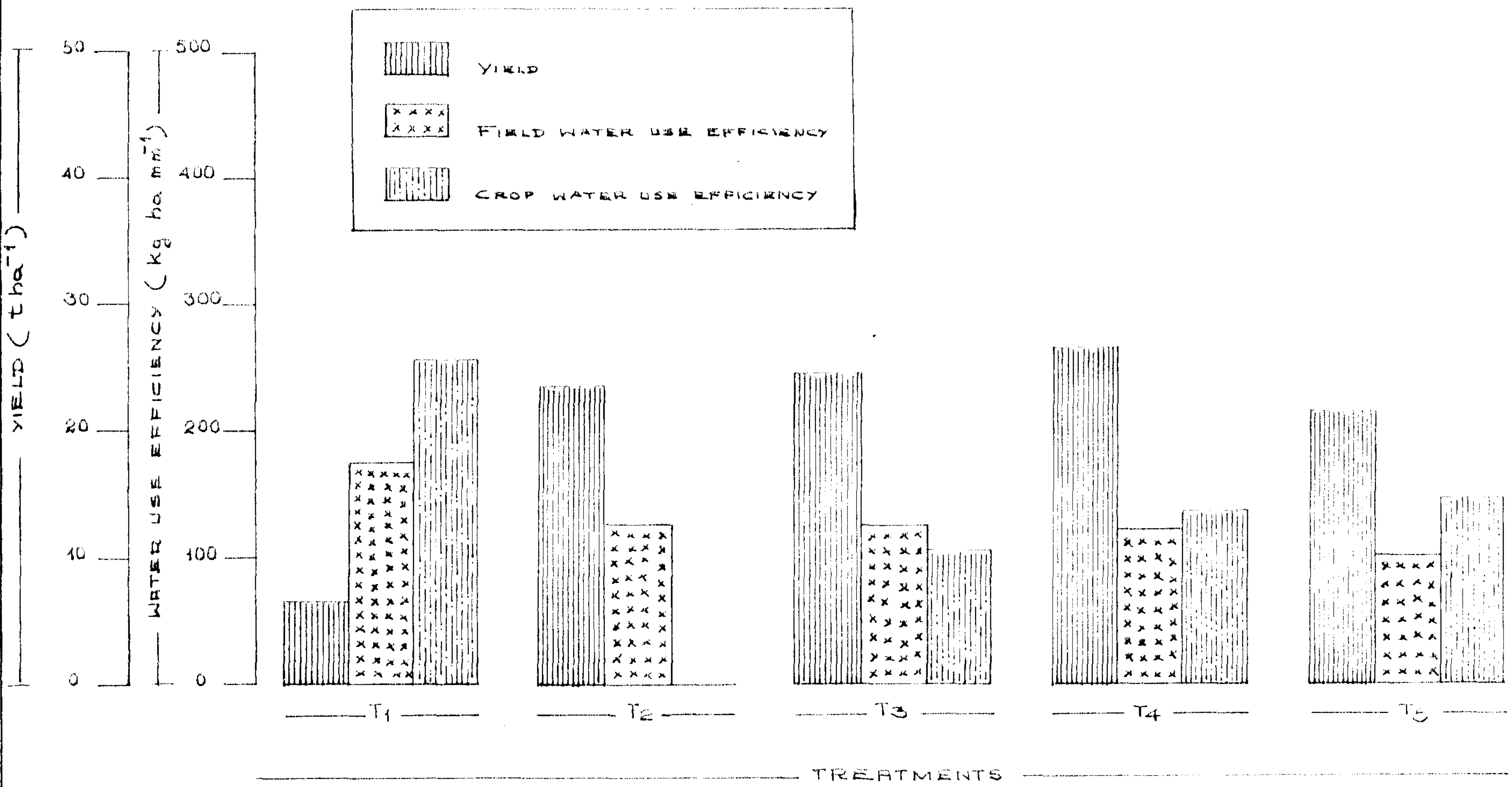

FIG. 8. YIELD AND WATER USE EFFICIENCY OF PUMPKIN AT DIFFERENT MOISTURE REGIMES

4.3.5. Soil moisture extraction pattern

The overall soil moisture extraction pattern (Fig.9) showed that from the top 0-15 cm depth, the highest extraction was observed for T3 (51%) followed by T4 (40%), T5 (38%) and T1 (27.5%). A rapid decrease in the soil moisture extraction with increase in depth was observed for the treatments T3, T4 and T5. But for T1 the soil moisture extraction was more or less uniform for all the different depths.

4.4. Rooting pattern

The data relating to root observations are presented in Table 10. The lateral spread of the roots was highest in T1 followed by T5, T4, T2 and T2. The depth of the root zone was maximum for T4 followed by T2, T3, T1 and T5. The number of primary roots on the tap root was found to be maximum for T2 followed by T4, T3, T5 and T1. Dry weight of roots was lowest in the control plot. T4 and T5 showed a higher dry weight compared to T2 and T3. The root-shoot ratio was found to be the highest in the case of T1 and the least in the case of T2. The treatments T3, T4 and T5 recorded more or less the same root-shoot ratio.

4.5. Evaporimetry

Correlation coefficient was worked out between the values of evaporation from a oan evaporimeter and the values

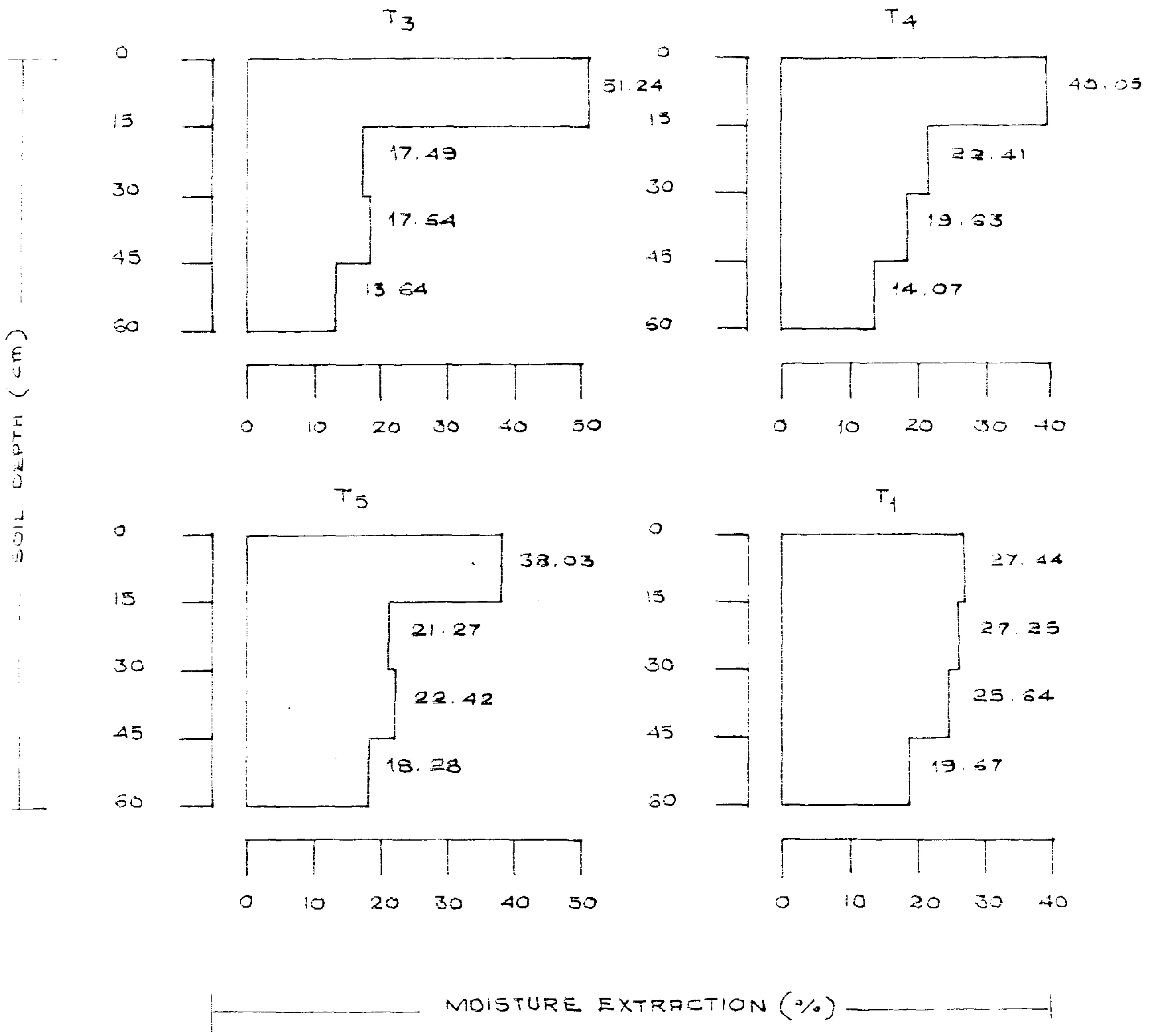

FIG: 9. OVERALL SOIL MOISTURE EXTRACTION PATTERN OF PUMPKIN AT DIFFERENT MOISTURE REGIMES

Table 10. Rooting pattern of pumpkin as influenced by the treatments (at harvest)

Treatment	Leteral distance (cm)	Vertical distance (cm)	Number of roots per tap root	Total dry weight of roots (g)	Root/ Shoot ratio
T1	235.8	53.2	14.8	18.00	0.6185
T2	174.0	59.2	28.3	20.88	0.3678
T3	164.4	58.0	19.8	18.56	0.4547
T4	196.8	81.48	21.0	24.04	0.4552
T5	229.5	51.5	18.0	24.10	0.4842

of evaporation from a USWB Class A open pan evaporimeter. A high positive and significant correlation of 0.94 between the two evaporation values was obtained. The relationship between the can and pan evaporation values found out on weekly mean basis is graphically represented in Fig.10. The can evaporimeter values were always slightly higher than the pan evaporation values (Fig.10). When the evaporative demand of the atmosphere was very high as evidenced by the pan evaporation values which recorded a high mean value of 8.2 mm and 10 mm during the 5th and 9th week (Fig.10), a corresponding increase in can evaporimeter values was also observed (12.5 mm and 13.5 mm respectively). The average pan and can evaporation per day ranged from 6-10 mm and 6-12 mm respectively.

To have a better understanding of the relative merits of the two types of evaporimeters, correlation coefficients were worked out between the meteorological elements and the evaporation data. The correlation coefficients worked out for periods of 7 days each during the crop growing season is given in Table 11. From the table it is clear that a high positive significant correlation exists between wind velocity and pan/can evaporation values, while the effect of the other meteorological parameters was not much pronounced.

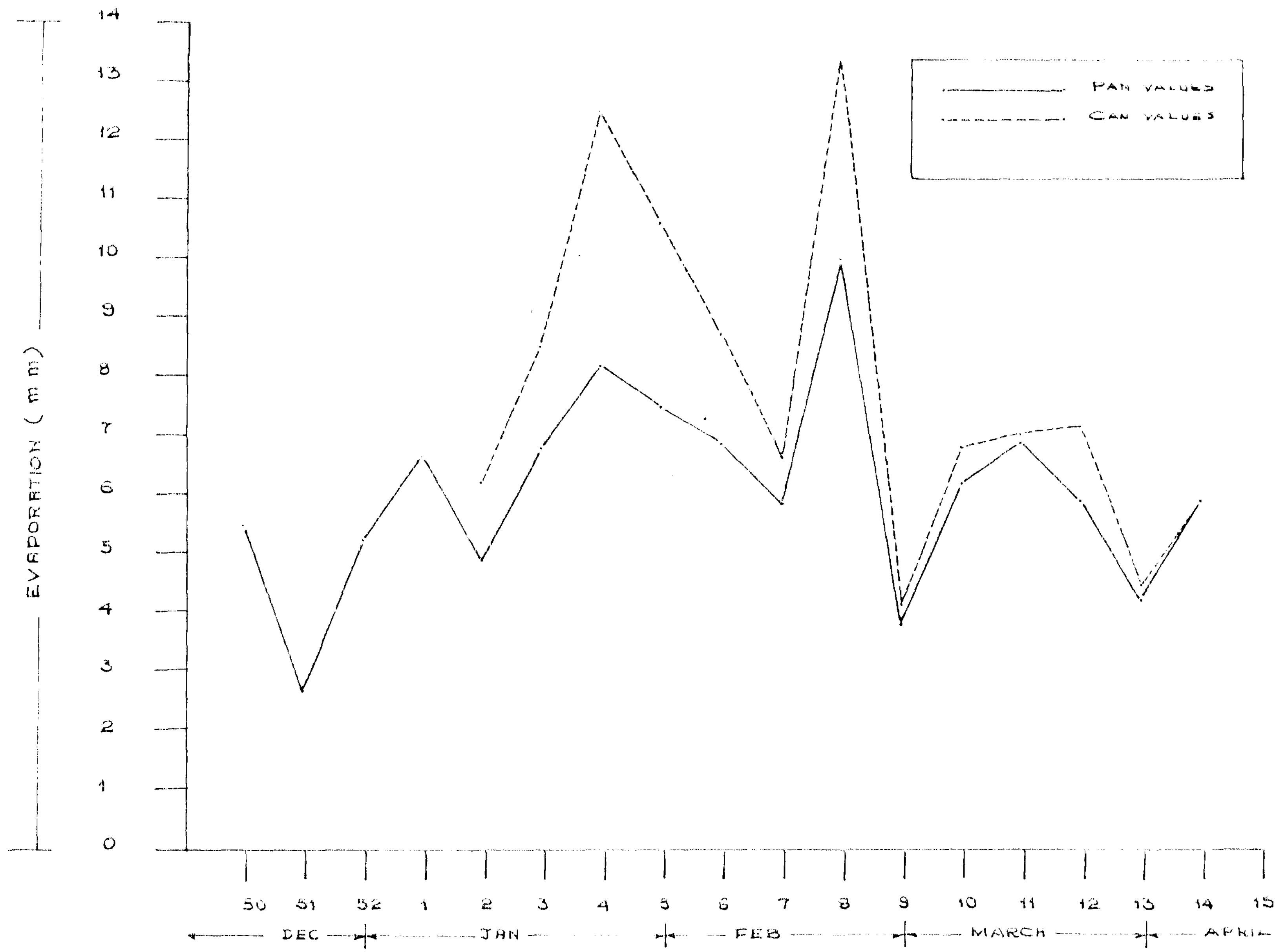

FIG 10 EVAPORATION VALUES FROM "CAN" AND "CLASS A PAN" EVAPORIMETERS

Table 11. Correlation between meteorological elements and evaporation from Class A pan and can evaporimeters

Meteorological elements	Class A pan evaporimeter	Can evaporimeter
Wind velocity	0.7753**	0.8106**
Temperature	0.302	0.291
Relative humidity	-0.544	-0.415
Sunshine hours	-0.019	-0.155

** Significant at 1 per cent level.

The average pan and can evaporimeter values and the ratios of pan/can at intervals of 15 days for the crop growth period, for the moisture regimes T2, T3, T4 and T5 are given in Table 12. The cummulative pan evaporation values per irrigation interval for T2, T3, T4 and T5 were found to range from 5-9 mm, 11-23 mm, 24-31 mm and 39-47 mm; while the cummulative can evaporation values ranged from 6-12 mm, 14-32 mm, 29-42 mm and 43-63 mm respectively for the crop growing season. The ratio of pan/can evaporation values increased with increasing age of the crop and showed a slight decline during the final stages of crop growth.

Table 12. Average pan and can evaporation values and pan/can ratio's for the different intervals in pumpkin

Treatment	Interval (days after sowing)	Average pan evaporation for an irrigation interval(mm)	Average can evaporation for an irrigation interval (mm)	Pan/Can
T2	27-42	6.17	8.43	0.73
	42-57	8.86	12.39	0.72
	57-72	8.45	11.56	0.73
	72-87	5.58	6.27	0.89
	87-102	7.12	8.36	0.85
T3	27-42	23.13	31.60	0.73
	42-57	17.71	24.79	0.71
	57-72	11.83	16.19	0.73
	72-87	13.02	14.63	0.89
	87-102	18.50	21.74	0.85
T4	27-42	30.83	42.13	0.73
	42-57	24.80	34.70	0.71
	57-72	29.58	40.48	0.73
	72-87	26.03	29.25	0.89
	87-102	30.83	36.23	0.85
T5	27-42	46.25	63.20	0.73
	42-57	41.33	57.83	0.71
	57-72	39.43	53.97	0.73
	72-87	39.05	43.88	0.89
	87-102	46.25	54.35	0.85

DISCUSSION

The results of the studies in pumpkin are briefly discussed below.

5.1. Growth characters

With respect to the vine length (Table 4) among the levels of irrigation tried, no significant difference was noticed at 45 days after sowing. However there was an increase in vine length with an increase in frequency of irrigation. The lack of any significant difference in growth rate among the levels of irrigation tried shows that severe water deficits did not occur in any of the treatments. Further the occurrance of rains during the later stages (50 to 60 days after sowing) of crop growth may have nullified any wide variations in growth rate among the treatments. When water becomes available after a short period of stress, growth is very rapid for a short time so that no net reduction is caused by stress (Kramer, 1983).

Out of the three models tried for the calculation of leaf area from leaf diameter measurements, the first model has a high predictability but would be applicable only for leaf diameter values in the range of 13 to 25 cm. The second model has a very low predictability and would be suitable only for leaf diameter values in the range of 14 to 16 cm. The third model ($A = 0.72x^2$) has the same predictability as that of the first model but has the advantage of being applicable for a wider range of leaf diameter values (Fig.5). Hence this equation is suggested as the most suitable one for the prediction of leaf area from leaf diameter measurements.

With regards to leaf production (Table 4) also an increase in the rate of production of leaves was observed with increasing frequency of irrigation at 45 days after sowing. Thereafter no significant difference in growth parameters was observed. It was also noticed that frequent irrigations markedly increased the leaf area index at 45 days after sowing (Table 6). However at the time of harvest, the different irrigation levels did not register significant differences. One of the consequences of water deficits in plants is a marked reduction in leaf area (Begg, 1980). The variation in total leaf area may result from the changes in leaf number or leaf size. Water deficit is likely to influence the two initial processes of growth viz. cell division and cell enlargement of which cell enlargement is more affected, resulting in poor growth (Begg and Turnor, 1976). Low leaf water potential also results in a reduction in the existing area. Escobar and Gausman (1974) reported a reduction in leaf area of mexican squash due to moisture stress. The lack of response of the treatments at later stages of growth may have been due to the occurrance of rains during these periods.

With respect to dry matter production (Table 6) though T2, T3, T4 and T5 were at par, all these were significantly superior to T1 (control). This is due to the poor vegetative growth of the plants in the unirrigated plots, as evidenced by the short vine length and low leaf area index. Low plant water potential results in reduced tissue hydration which results in a reduction in leaf area and reduced photosynthetic and enzymatic activity (Stanhill and Vaadia, 1967). The control plants were severely inhibited by water stress and hence did not recover much with the rains received.

5.2. <u>Yield and yield attributes</u>

The number of fruits per plant (Table 7), the mean fruit weight (Table 7), the mean girth of fruit (Table 7) were influenced substantially by irrigation. The number of fruits increased with increase in the frequency of irrigation. Favourable influence of moist regime on the number of marketable fruits was reported by Haynes and Herring (1980) in squash and by Thomas (1984) in bittergourd.

The mean girth, mean length and mean fruit weight were however slightly less in the frequently irrigated plots and this may be due to the higher number of fruits in these treatments.

It may be concluded that the total yield was not much affected by the different levels of irrigation though all these treatments were significantly superior to the control. This is in accordance with the observations on leaf area index and dry matter production. The amount of dry matter production will depend on the effectiveness of photosynthesis of the crop (Arnon, 1975). The results on yield indicate that the plant was not subject to severe water stress, since water deficit if any, developed during the period of fruit enlargement would have caused a marked reduction in the size of fruits (Kaufman, 1972). Large differences among the irrigation schedules (removal of 48 to 64 per cent of available soil moisture) had minimal effect on yield (Loomis and Crandall, 1977). Lack of any significant increase in yield may be because the increase in fruit size was offset by a reduction in the number of fruits. T4 recorded the maximum yield (26.4 t ha^{-1}) followed by T3 (24.5 t ha^{-1}) and T2 (23.6 t ha^{-1}). T5 recorded a slightly lower yield (21.7 t ha^{-1}). This indicates that a slight stress is beneficial to the plant.

In may plant species it is frequently found beneficial for the plants to experience some water stress in the early stages of growth to produce a maximum harvestable yield (Peters and Runkles, 1967).

The per cent dry matter of fruits (Table 7) was higher in the unirrigated control, than in the irrigated plots. This has to be expected as there will be an increase in water content of the fruits, with higher available soil moisture. The drier regimes showed a comparatively higher percentage of dry matter. Similar studies in cucumber indicated that irrigation decreased the dry matter content (Elkner and Radzikowska, 1976). The unirrigated plots gave the lowest fruit yield. Some yields can be obtained without any application of water (Singh and Sinha, 1977).

5.3. Moisture studies

Consumptive use increased with increase in the frequency of irrigation (Table 8(a)). While the consumptive use values of T3, T4 and T5 ranged from 900 to 1400 litres (150-240 ha mm) it was only 155.64 litres (26.46 ha mm) for T1. The low consumptive use in the control plot may be due to a lower soil moisture regime and a poor crop canopy which might have resulted in lower evapotranspiration.

The peak values of consumptive use were obtained at 57 days after sowing (Fig.6). Thereafter a progressive decline in consumptive use was observed but it remained higher in the case of the wet regimes. The high rate of consumptive use from the period between 42 to 57 days after sowing may be because the crop was at the stage of peak canopy development. This stage also coincided with flowering of the crop. Flowers also result in an increase in surface area and result in more transpiration losses. Flowers also contribute increase in surface area and more transpiration. The climatic parameters like high wind speed (13.4 km hr^{-1} day^{-1}) and low relative humidity during this period also might have led to a high consumptive use. Pan evaporation values were also high during this time (8.2 mm day^{-1}). Within the next 15 days (57 days to 72 days after sowing) a sharp decline in consumptive use was observed in T4 and T3. This can be attributed to the low wind velocity (mean 4.7 km hr^{-1} day^{-1}) and high relative humidity during this period. Pan evaporation values were also low (mean 5.7 mm day^{-1}) during this period. Such a high rise or sharp decline in consumptive use was not observed in T5. This is probably due to the lower soil moisture regime. Also the number of leaves and leaf area index were low at 45 days after sowing, which would have led to comparatively lower fluctuations in consumptive use in this treatment.

The general decline in the consumptive use towards the later stages of crop growth has also been reported by Konishi (1974) and Loomis and Crandall (1977).

With respect to crop coefficients (Table 8(a)) the highest value was observed for T3 (0.5) followed by T4 (0.4) T5 (0.3) and T1 (0.1). Crop coefficients are high for the irrigated plots, because of the higher rates of evapotranspiration from these plots. Crop coefficients recorded a high value at 42-57 days after sowing and then declined (Fig.7). A second peak in crop coefficient values was observed at 87 days after sowing in all treatments. The first peak of the crop coefficient at arround 57 days coincides with the full canopy development of the crop, which might have led to a high consumptive use. The second peak may be attributed to the flowering that occurred after the first harvest of fruits and the reduction in the evaporative demand of the atmosphere as evident from the pan evaporation values. The subsequent decline in the crop coefficient would probably be due to the reduction in the crop canopy, as the crop was at its senescence stage.

The results revealed that the field water use efficiency (Table 9(a)) was highest for the control plots. Among the levels of irrigation tried, field water use efficiency did not differ significantly. Though not significant the water use efficiency increased with decrease in the quantity of water applied. The absence of any significant difference in field water use efficiency among the irrigation levels tried may be because the quantity of water added was just sufficient to fill the root zone to field capacity level. Moreover since pot watering was adopted conveyance loss of water did not occur.

Crop water use efficiency (Table 9(b)) was highest in the unirrigated plots. This is because there was a considerable increase in the consumptive use following irrigation, however a corresponding increase in yield was not observed.

Moisture extraction was highest from the surface layer in wet regimes compared to that of the dry regimes (Fig.9). Except in the control, moisture extraction decreased rapidly with depth. This has to be expected as roots generally tend to confine to the surface soil layer, if sufficient moisture is available from this layer. The higher loss of water by evaporation directly from soil, may also be another factor for the higher extraction especially in the layer upto 15 cm. In the case of the unirrigated control plots, the moisture extraction was uniform from all the different layers as there was no abundance of moisture in any particular soil layer.

5.4. Rooting pattern

The lateral spread of the roots was found to be higher in the case of the drier regimes, while the depth of penetration of roots was more or less same as those of the irrigated treatments. The higher spread of root system in the control plot is to be expected as water influences the direction of root growth, its lateral spread and depth (Peters and Runkles, 1967). The root shoot ratio's increased in the case of the dry regimes. This is due to the higher root growth and low vegetative growth in the drier regimes. These findings are in conformity with Kramer (1983) who had reported that the root shoot ratio's increase with water stress though the dry weight usually decreases.

5.5. Evaporimetry

The high value of the correlation coefficient between the pan and can evaporimeter values indicates that the can evaporimeters are as good as pan evaporimeters. Moreover from the comparative study (Table 11), it may be concluded that there appears to be no significant difference between the two type of evaporimeters. The increase in the observed values of can evaporimeters compared to that of pan evaporimeters may be due to the smaller size of the cans. Hence the influence of advective energy on can evaporimeters would be much more than that on pan evaporimeters. For this reason, Class A type pan evaporimeter is considered to be more reliable and will give best results under all conditions. However the high cost of pan evaporimeters limits its large scale use. Hence can evaporimeters which are very cheap can be substituted for pan evaporimeters.

The narrow range of ratio's between the pan and can evaporimeter also indicates that the can evaporation values was also influenced by the various meteorological parameters similar to that of the pan evaporimeters. The steady increase in the ratio's with increasing age of the crop is mainly due to season and advancing age of the crop.

From the earlier discussion it is evident that the crop need be irrigated only at 75 per cent depletion of available soil moisture. For this moisture regime, irrigation may be given when the cummulative can evaporation values reaches about 60 mm for the period from 27 to 42 days after sowing. For the interval between 42-72 days after sowing irrigation should be given when the cummulative can evaporation values range from 55-60 mm. After this stage (i.e. 72 days after sowing) irrigation may be given when cummulative can evaporation ranges from 45 to 55 mm.

The conclusions drawn from the above results and discussions are briefly given below.

1. Irrigation to pumpkin raised in summer rice fallows may be given at 75 per cent depletion of available soil moisture in 60 cm of the soil profile. This means irrigation at less frequent intervals with larger quantity of water. Frequent irrigation with smaller quantity of water will result in greater losses of moisture by way of evaporation from the surface. Irrigation at 75 per cent depletion of available soil moisture involves irrigation at intervals of 5-7 days.

2. Can evaporimeters can be used for scheduling of irrigation. With can evaporimeters irrigation can be given when the cummulative can evaporation values reach 60 mm during the vegetative stages, 55 to 60 mm during the flowering and fruit formation stages and 45 to 55 mm during the subsequent stages of crop growth.

Oriental pickling melon

ORIENTAL PICKLING MELON
(*Cucumis melo* var. Conomom Mak.)

RESULTS

The results of the field experiment conducted to evaluate the response of oriental pickling melon to different soil moisture regimes are presented hereunder.

6.1. Growth characters

6.1.1. Length of main vine

The data on mean length of main vine are presented in Table 13 and their analysis of variance in Appendix IV.

At 45 days after sowing, T2 was significantly superior to T5 and T1, but was on par with T3 and T4 with respect to vine length. The treatments T3, T4 and T5 though at par, were significantly superior to T1.

At 75 days after sowing, T2, T3 and T4 which were at par were significantly superior to T5 and T1. T5 in turn was superior to T1. At the harvest stage T2, T3, T4 and T5 were on par and were significantly superior to T1.

6.1.2. Number of leaves per plant

The data relating to the number of leaves taken at the various stages are given in Table 13 and the analysis of variance in Appendix IV.

With respect to the number of leaves, the treatments T2, T3, T4 and T5 were at par and were significantly superior to T1 at 45 days after sowing. At the 75th day stage the treatments did not show any significant difference. At the time of harvest T4 was significantly superior to T2, T3 and T1, but was on par with T5. T5 in turn was on par with T2, T3 and T1.

6.1.3. Leaf area

Correlation coefficients were worked out between actual leaf area and maximum width of the leaves. A high positive significant correlation of 0.94 was obtained between actual leaf area (A) and maximum width of the leaves (x). The three regression equations fitted and the extent of predictability are given below.

Equation	Predictability
1. $A = 17.84x - 96.99$	88%
2. $A = 10.21x$	72%
3. $A = 0.76x^2$	85%

The predicted leaf area from the three models corresponding to diameter values upto 20 cm are given in Table 14 and graphically represented in Fig.11 along with the scatter diagram showing the actual measured leaf area values.

Table 13. Length of vine and number of leaves in oriental pickling melon as affected by the levels of irrigation

Treatment	Length of main vine (m)			Number of leaves per plant		
	45 days after sowing	75 days after sowing	Harvest	45 days after sowing	75 days after sowing	Harvest
T1	1.61	2.34	2.48	59.14	51.67	43.29
T2	2.69	3.36	3.36	110.36	73.05	45.73
T3	2.48	3.46	3.26	106.06	65.72	44.89
T4	2.36	3.49	3.57	100.62	74.52	63.99
T5	2.18	3.04	3.51	104.64	64.38	59.87
SEm±	0.1477	0.1346	0.1658	5.8239	7.9739	5.4731
CD (5%)	0.4552	0.4149	0.5108	17.9469	NS	16.8657

Table 15. Leaf area index and dry matter production in oriental pickling melon as affected by levels of irrigation

Treatment	Leaf area index			Dry matter production (g/plant)
	45 days after sowing	75 days after sowing	Harvest	
T1	0.338	0.270	0.155	84.500
T2	0.883	0.397	0.171	130.313
T3	0.843	0.408	0.182	109.500
T4	0.707	0.422	0.301	187.063
T5	0.727	0.382	0.232	130.000
SEm±	0.0600	0.0620	0.0150	16.6799
CD (5%)	0.1849	NS	0.0462	51.4004

Table 14. Predicted leaf area in oriental pickling melon

Leaf diameter (cm)	Predicted leaf area (cm^2)		
	$A = 17.84x - 96.99$	$A = 0.76x^2$	$A = 10.21x$
0	0	0	0
1	-	0.76	10.21
2	-	3.04	20.42
3.	-	6.84	30.63
4	-	12.16	40.84
5	-	19.00	51.05
6	10.05	27.36	61.26
7	27.87	37.24	71.47
8	45.73	48.64	81.68
9	63.57	61.56	91.89
10	81.41	76.00	102.10
11	99.25	91.96	112.31
12	117.09	109.44	122.52
13	134.93	128.44	132.73
14	152.77	148.96	142.94
15	170.61	171.0	153.15
16	188.45	194.56	163.36
17	206.29	219.64	173.57
18	224.13	246.24	183.78
19	241.97	274.36	193.99
20	259.81	304.00	204.20

A = Predicted leaf area (cm^2)

x = Measured Maximum leaf diamter (cm).

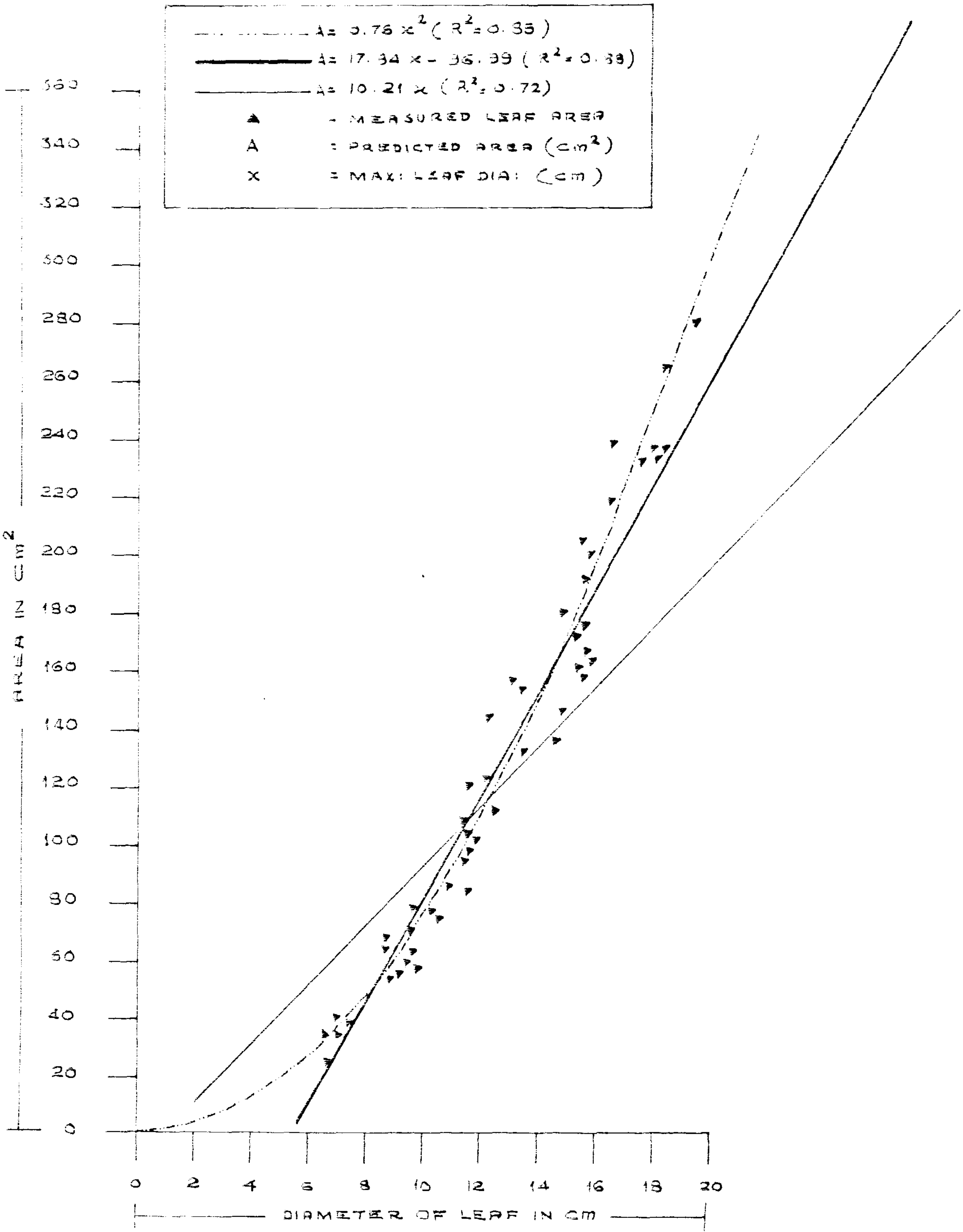

FIG: 11. RELATION BETWEEN ACTUAL AND PREDICTED LEAF AREA IN ORIENTAL PICKLING MELON

6.1.4. Leaf area index

The data on leaf area index are given in Table 15 and the analysis of variance in Appendix IV.

At the 45 day stage, the treatments, T2, T3, T4 and T5 were on par, but were significantly superior to T1 with respect to leaf area index. However at 75 days after sowing the treatments did not exhibit any significant difference. At harvest T4 was found to be significantly superior to T5 and both were superior to T3, T2 and T1 which were at par.

6.1.5. Dry matter production

The dry matter worked out at the time of harvest is presented in Table 15 and the analysis of variance in Appendix IV.

T4 was significantly superior to the rest of the treatments which were on par, with regard to the dry matter production.

6.2. Yield and yield attributes

Data relating to yield and yield attributes are given in Table 16 and the analysis of variance in Appendix V.

6.2.1. Number of fruits per plant

The treatment T2, which registered the maximum number of fruits was on par with T3, but was significantly

Table 16. Yield and yield attributes of oriental pickling melon as affected by levels of irrigation

Treatment	Number of fruits per plant	Fruit yield		Mean fruit weight (kg)	Mean length of fruit (cm)	Mean girth of fruit (cm)	Per cent dry matter of fruit
		Per plant (kg)	Per hectare (t)				
T1	1.589	1.808	9.219	1.093	23.703	21.063	7.840
T2	4.013	5.829	29.729	1.502	29.868	28.063	5.483
T3	3.711	6.114	31.182	1.664	35.183	30.913	5.015
T4	3.149	5.449	27.794	1.764	34.123	32.320	5.713
T5	3.064	5.325	27.159	1.749	34.525	30.775	6.645
SEm±	0.2634	0.4687	2.3904	0.1560	1.3165	1.0159	0.3066
CD (5%)	0.8118	1.4444	7.3662	NS	4.0569	3.1307	0.9448

superior to T4, T5 and T1. Though the treatments T3, T4 and T5 were on par, they were significantly superior to T1.

6.2.2. Fruit yield per plant and per hectare

With regard to the fruit yield per plant, the treatments T2, T3, T4 and T5 which were on par, were significantly superior to T1. Similar trend was observed for fruit yield per hectare also.

6.2.3. Mean length of fruit

T3 which recorded the maximum length was on par with T4 and T5 and all these were signficantly superior to T2 and T1. T2 in turn was superior to T1.

6.2.4. Mean girth of fruit

T3, T4 and T5 were on par and were significantly superior to T2 and T1 with respect to the mean girth of fruit. T2 in turn was significantly superior to T1 which recorded the least fruit girth values.

6.2.5. Mean weight of fruit

There was no significant difference among the treatments with respect to mean fruit weight. T4 recorded the maximum fruit weight followed by T5, T3, T2 and T1.

6.2.6. Percentage dry matter of fruit

T1 recorded the maximum dry matter content and was significantly superior to all the other treatments. T5 was on par with T4 and significantly superior to T2 and T3. T4 was on par with T2 and T3.

6.3. Moisture studies

6.3.1. Consumptive use

Seasonal consumptive use from 27 days after sowing to the end of crop growth and the average consumptive use per day are given in Table 17(a). Seasonal consumptive use was maximum for T3 (218.72 ha mm) followed by T4 (137.66 ha mm), T5 (123.90 ha mm) and T1 (35.87 ha mm). The average daily consumptive use also exhibited the same pattern. In treatment T2 since daily irrigation was practiced, consumptive use determination from soil moisture data was not feasible and hence not calculated.

The variation in consumptive use at intervals of 15 days is given in Table 17(b) and graphically represented in Fig.12. At all the growth stages, T3 registered the maximum consumptive use followed by T4 and T5. In all the treatments consumptive use was maximum at 57 days after sowing. Thereafter it declined. The decline was comparatively rapid in T4 and T5 than in T3. After 72 days of sowing the decline was gradual.

6.3.2. Crop coefficient

The data on the average crop coefficients are given in Table 17(a) and for the different growth stages in Table 17(b).

Table 17(a). Consumptive use and crop coefficients of oriental pickling melon as affected by levels of irrigation

Treatment	Seasonal consumptive use (litres per basin)	Seasonal consumptive use (ha-mm)	Per day consumptive use (litres per basin)	Crop coefficient
T1	211.013	35.87	2.814	0.07
T2	-	-	-	-
T3	1286.57	218.72	17.154	0.429
T4	809.77	137.66	10.797	0.269
T5	728.85	123.90	9.718	0.243

Table 17(b) Cummulative consumptive use and crop coefficient values of oriental pickling melon at intervals of 15 days

Particulars	Treatment	Period (days after sowing)				
		27-42	42-57	57-72	72-87	87-102
Consumptive use (litres)	T3	211.81	313.75	286.86	261.44	212.19
Consumptive use (ha-mm)	T3	36.09	53.34	48.77	44.44	36.07
Crop coefficient	T3	0.320	0.489	0.413	0.510	0.429
Consumptive use (litres)	T4	139.0	241.94	176.56	151.36	100.92
Consumptive use (ha-mm)	T4	23.63	41.12	30.02	25.73	17.16
Crop coefficient	T4	0.211	0.378	0.254	0.295	0.204
Consumptive use (litres)	T5	131.12	192.88	151.52	148.90	104.42
Consumptive use (ha-mm)	T5	22.29	32.79	25.76	25.31	17.75
Crop coefficient	T5	0.198	0.301	0.218	0.291	0.211

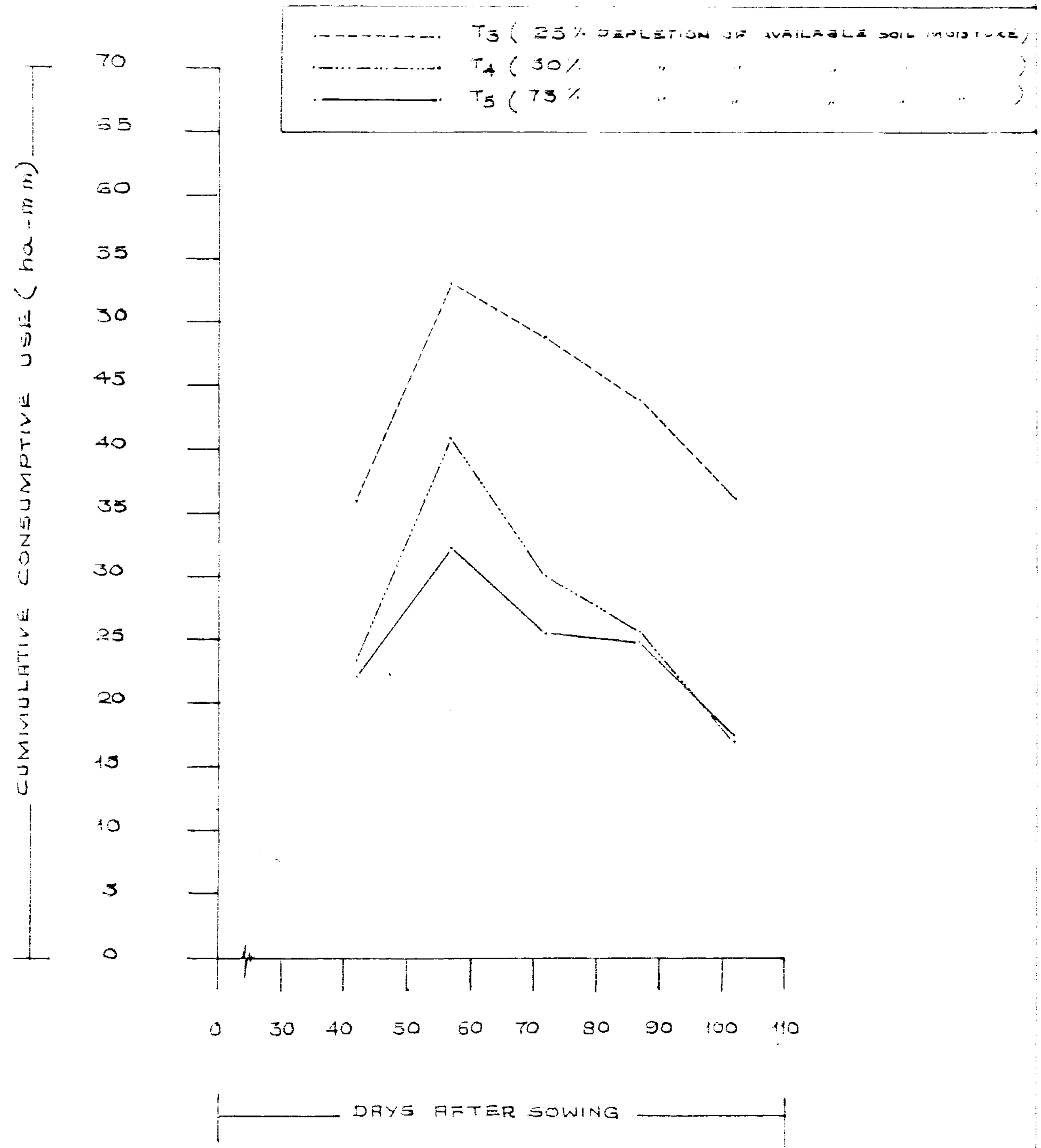

FIG: 12. CUMMULATIVE CONSUMPTIVE USE OF ORIENTAL PICKLING MELON AT INTERVALS OF 15 DAYS

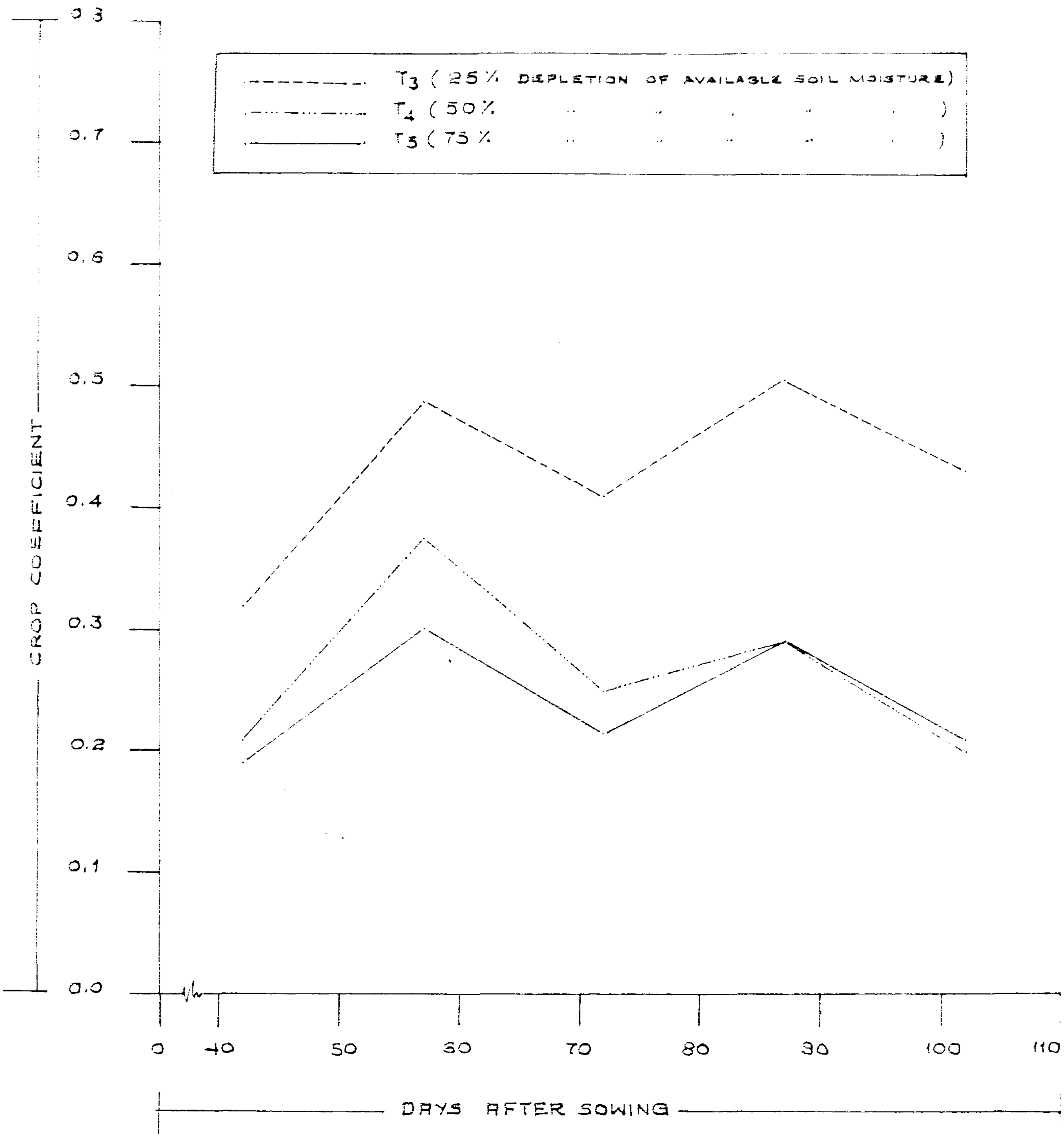

FIG: 13. CROP COEFFICIENTS FOR ORIENTAL PICKLING MELON AT INTERVALS OF 15 DAYS.

T3 recorded the highest value of crop coefficient followed by T4, T5 and T1. The variation in crop coefficients during the crop growth period at intervals of 15 days is also graphically represented in Fig.15. The maximum values at all the levels of irrigation was found to occur at 57 days after sowing and thereafter it declined. However a second peak in crop coefficient values was observed at 87 days after sowing, after which it again declined. Both the peaks were highest for T3.

6.3.3. Field water use efficiency

Data on field water use efficiency are given in Table 18(a) and the analysis of variance in Appendix IV. The graphical representation of the same is given in Fig.14.

Though there were no significant differences, the field water use efficiency was maximum for T1 (220.088 kg $hamm^{-1}$) followed by T3 (182.638 kg ha mm^{-1}), T2 (156.083 kg ha mm^{-1}), T5 (142.588 kg ha mm^{-1}) and T4 (138.078 kg ha mm^{-1}).

6.3.4. Crop water use efficiency

Data on crop water use efficiency are given in Table 18(b) and Fig.14.

Table 18(a). Field water use efficiency of oriental pickling melon as affected by levels of irrigation

Treatment	Yield (kg ha^{-1})	Total water applied (ha-mm)	Field water use efficiency (kg ha mm^{-1})
T1	9219	41.89	220.088
T2	29729	190.47	156.083
T3	31182	170.73	182.638
T4	27794	201.29	138.078
T5	27159	190.47	142.588
SEm±	-	-	33.9673
CD (5%)	-	-	NS

Table 18(b) Crop water use efficiency of oriental pickling melon as affected by levels of irrigation

Treatment	Yield (kg ha^{-1})	Total consummptive use (ha-mm)	Crop water use efficiency (ka ha mm^{-1})
T1	9219	35.87	257.01
T2	29729	-	-
T3	31182	218.72	142.57
T4	27794	137.66	201.90
T5	27159	123.90	219.200

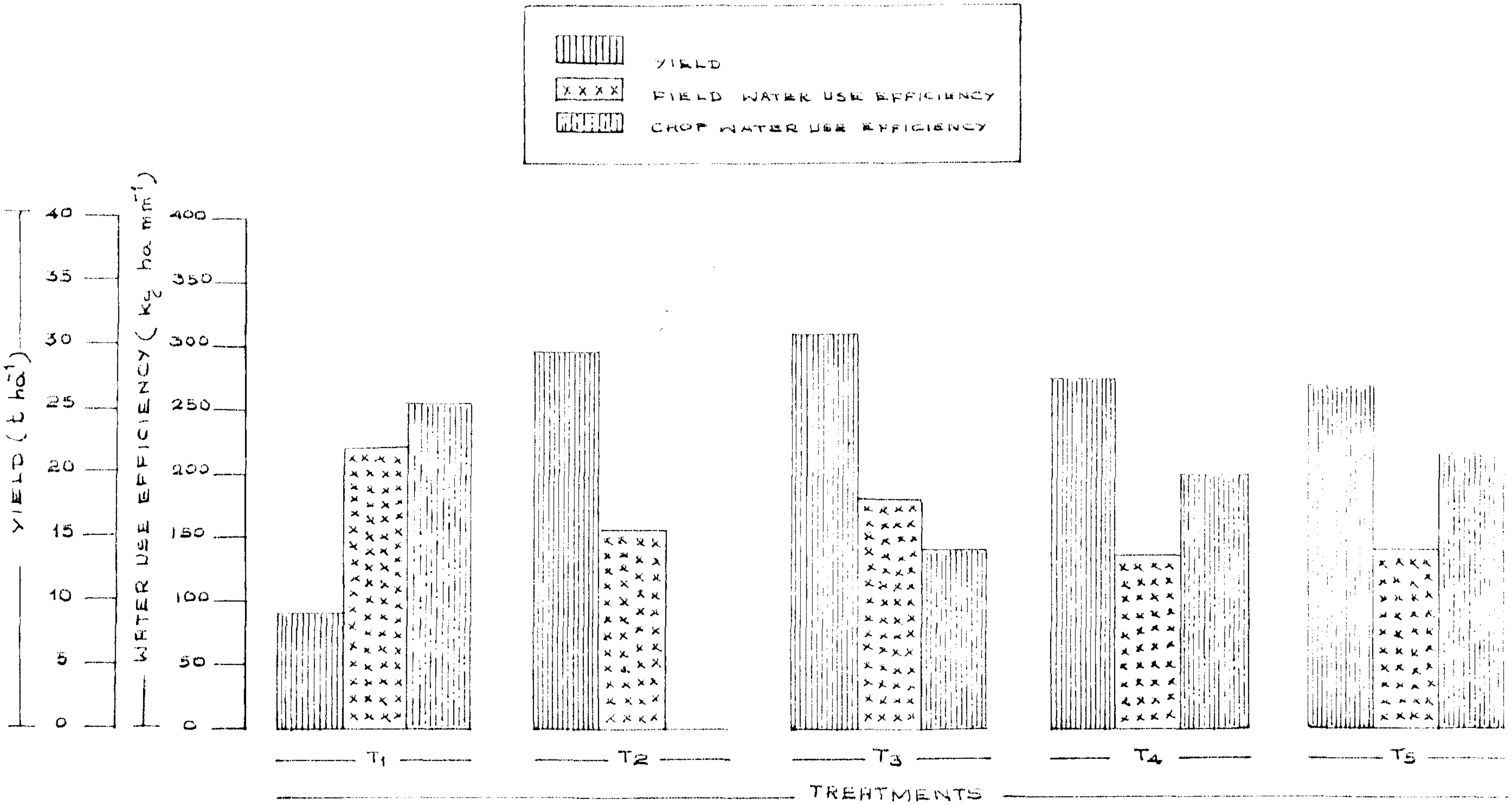

FIG: 14. YIELD AND WATER USE EFFICIENCY OF ORIENTAL PICKLING MELON AT DIFFERENT MOISTURE REGIMES

Crop water use efficiency was maximum for T1 (257.01 kg ha mm^{-1}) followed by T5 (219.200 kg ha mm^{-1}), T4 (201.90 kg ha mm^{-1}) and T3 (142.57 kg ha mm^{-1}).

6.3.5. Soil moisture extraction pattern

The overall moisture extraction pattern is given in Fig.15. It was observed that the moisture extraction in general was high from the top 15 cm layer in all the treatments. The moisture extracted from the surface layer (0-15 cm) was highest for T3 (45.5%) followed by T4 (41%), T5 (36.4%) and T1 (30.9%). Moisture extraction declined with increasing soil depth. While this decline was rapid in T3 and T4, it was very gradual in T5 and T1. The highest moisture extraction from the lowermost layer (45-60 cm) was noted in the case of T1. Also, the extraction of moisture from the deeper layers was higher in T1 and T5 compared to T3 and T4.

6.4. Rooting pattern

The data on root observations are given in Table 19. The maximum lateral spread of roots was found to occur in T1 and the least in T3. With regards to the vertical depth, the maximum was found to occur in T1. The drier regimes exhibited more vertical penetration of roots. The number of roots per tap root was almost the same in all the treatments except in T4 which showed a slightly higher root number.

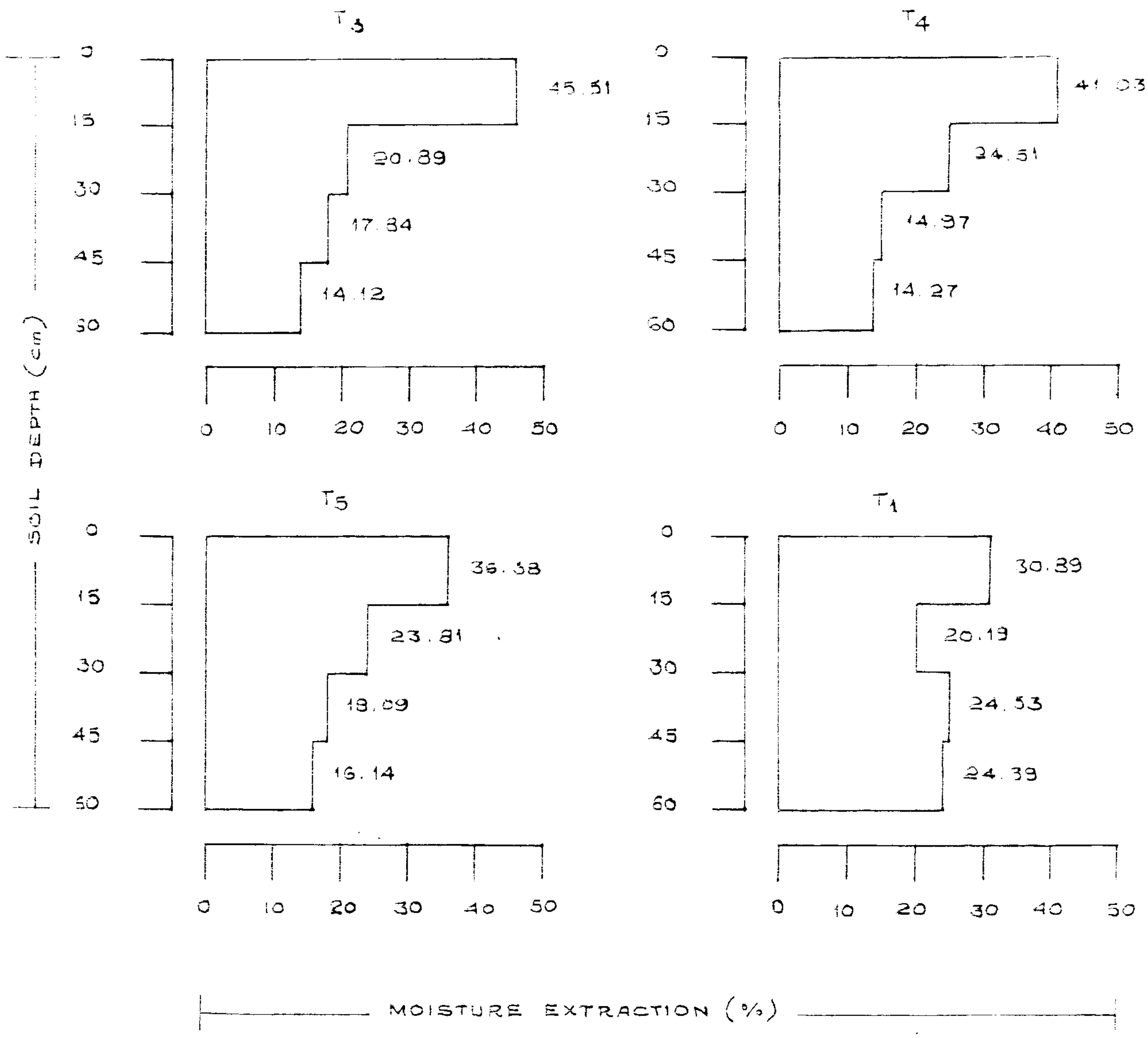

FIG: 15. OVERALL SOIL MOISTURE EXTRACTION PATTERN OF ORIENTAL PICKLING MELON AT DIFFERENT MOISTURE REGIMES

Table 19. Rooting pattern of oriental pickling melon as influenced by the treatments (at harvest)

Treatment	Lateral distance (cm)	Vertical distance (cm)	Number of roots per tap root	Total dry weight of roots (g)	Root/shoot ratio
T1	152.00	71.71	9.75	12.313	0.151
T2	133.75	43.0	9.88	15.875	0.126
T3	117.00	57.0	9.33	12.750	0.116
T4	132.00	63.3	11.80	17.250	0.093
T5	128.50	68.2	9.75	17.625	0.133

The total weight of roots was found to be less in T3. Root shoot ratio was almost the same in all the treatments. T1 showed a slightly higher ratio (0.151).

6.5. Evaporimetry

The correlation coefficient between the pan and can evaporation values and the relative merits of the two types of evaporimeters is as given under pumpkin.

The average pan and can evaporimeter values and the ratios of pan/can at intervals of 15 days for the crop growth period, for the moisture regimes T2, T4, T4 and T5 are given in Table 20. The cummulative pan evaporation values per irrigation interval for T2, T3, T4 and T5 was found to range from 5-8 mm, 16-23 mm, 27-37 mm and 36-59 mm, while the can evaporation values ranged from 7-11 mm, 19-32 mm, 32-53 mm and 47-80 mm respectively for the crop growing season. The ratio of pan/can evaporation values increased with increasing age of the crop, but showed a decline in the final stages of crop growth.

Table 20. Average pan and can evaporation values and pan/can ratio's for the different intervals in oriental pickling melon

Treatment	Interval (days after sowing)	Average pan evaporation for an irrigation interval (mm)	Average can evaporation for an irrigation interval (mm)	Pan/Can
T2	27-42	7.47	10.55	0.71
	42-57	7.78	11.02	0.71
	57-72	8.44	11.39	0.74
	72-87	6.70	7.42	0.90
	87-102	5.52	7.05	0.78
T3	27-42	22.42	31.66	0.71
	42-57	18.15	23.87	0.76
	57-72	16.89	22.79	0.74
	72-87	17.42	19.28	0.90
	87-102	17.95	22.90	0.78
T4	27-42	37.37	52.77	0.71
	42-57	27.23	35.80	0.76
	57-72	29.55	39.88	0.74
	72-87	29.03	32.13	0.90
	87-102	35.90	45.80	0.78
T5	27-42	56.05	79.15	0.71
	42-57	36.30	47.73	0.76
	57-72	59.10	79.75	0.74
	72-87	43.56	48.20	0.90
	87-102	47.87	61.06	0.78

DISCUSSION

The results of the studies in oriental pickling melon are briefly discussed below.

7.1. Growth characters

With respect to the vine length, the irrigated plants in general recorded higher values than the unirrigated plants (Table 13). However, significant differences were not observed among the different levels of irrigation. Also the effect of irrigation was less pronounced during the later stages of growth. These findings are in conformity with the observations of Ortega and Kretchman (1982) who had also found that cucumber plants subjected to stress showed a reduction in vine length. During the later stages of growth the irrigation effects were not pronounced because of the rains received at this stage.

For the calculation of leaf area, out of the three models tried, the first model was found to have a high predictability. However it would be suitable only for leaf diameter values between 6 and 18 cm. The predictability of the second equation was found to be very low and would be suitable only for leaf diameter values in the range of 12-15 cm. Though the third model ($A = 0.76\ x^2$) was found to have a slightly lower predictability than the first model, it would be suitable for a wider range of leaf diameter values (Fig.11). Also the equation is simple and calculations are easy.

With respect to the number of leaves at the different growth stages, though the treatments had not much influence the leaf area index exhibited significant variations (Table 15). The leaf area index values were higher for the irrigated plants than the unirrigated control. However, the different irrigation levels did not show much significant differences. Low leaf area index values in the unirrigated plots may be due to the development of low leaf water potential, which might have led to a reduction in the leaf area. Cummins and Kretchman (1974) had also observed that leaf area in cucumbers was greatly reduced under water stress. The lack of significant differences among the different irrigation levels may be because the stress caused by any of the moisture depletion levels was not severe enough to bring about a reduction in the leaf size. The dry matter production at harvest was not much influenced by the different treatments. This may be due to the rains received during the later stages of crop growth. When water becomes available after a short period of stress, growth is very rapid for a short time, so that no net reduction is caused by stress (Kramer, 1983).

7.2. Yield and yield attributes

The number of fruits per plant, the length of fruit, girth of fruit and the dry matter content of the fruits were favourably influenced by irrigation (Table 16). However, the mean weight of fruit did not differ significantly among the treatments. The number of fruits increased with increase in the frequency of irrigation. Favourable influences of moist regime on the number of marketable fruits were also reported by Haynes and Herring (1980) in squash and by Thomas (1984) in bittergourd. The mean girth and length of fruits were slightly less in the frequently irrigated plots and this may be as a result of the higher number of fruits in these treatments. The total yield was not significantly affected by the levels of irrigation. However, there was a decreasing trend with a reduction in frequency of irrigation.

The results on yield indicated that the plant was not subjected to severe water stress by any of the irrigation levels, since water deficit if any, developed during the period of fruit enlargement would have caused a marked reduction in size of the fruits (Kaufman, 1972). Similar observations was also made by Loomis and Crandall (1977) in cucumbers.

The drier regimes showed a comparatively higher percentage of fruit dry matter. Krynska *et al.* (1976) had also reported that irrigation lowered fruit dry matter, Vitamin C and sugar content in both fresh and processed cucumbers. The unirrigated plots gave the lowest fruit yields. The favourable influence of irrigation on the yield of cucurbitaceous crops has been reported by several workers (Mac Gillivray, 1951; Flocker *et al.* 1965; Varga, 1974; Ortega and Kretchman, 1982).

7.3. Moisture studies

The seasonal consumptive use was found to be the highest for T3 and the least for T1 (Table 17(a). There was a gradual decrease in the consumptive use with the decrease in the wetness of soil. The average daily consumptive use also exhibited a similar pattern. These observations are in conformity with the findings of Tomitaka (1974) and Thomas (1984) who had recorded a steady decline in consumptive use with the decrease in the soil moisture level.

The consumptive use calculated at the various growth stages (Table 17(b) revealed that the peak consumptive use was reached at 57 days after sowing, after which there was a steady decline. The peak consumptive use stage coincides with the flowering and the full canopy development in cucumber. These factors, together with the meteorological parameters like high wind speed, low humidity (Fig.1) might have contributed to the high consumptive use during that period. The decline in consumptive use after 57 days may be attributed to the attainment of fruit maturity stage and the normalisation of the meteorological parameters. Several workers have also reported that consumptive use increases during flowering and early fruiting and then levels off during late harvest (Cselotel and Varga, 1973; Loomis and Crandall, 1977).

With respect to crop coefficients (Table 17(a)) T3 was observed to have the highest value and there was a steady decline in the crop coefficients with decrease in the degree of wetness. The increase in crop coefficient values with increase in wetness has to be expected as there was a similar increase in the consumptive use with increase in the frequency of irrigation. However, even during the peak consumptive use period, the crop coefficient values reached upto only 0.51. The low values of crop coefficients may be because of the limiting water supply. Crop coefficients increase till 57 days after sowing in all treatments, then showed a decline by 72 days after sowing, again increased and reached peak values at 87 days and than declined. The crop coefficients of T3 were always higher than in T4 and T5. The crop coefficient values of T4 and T5 were almost the same during the later stages of crop growth.

The variation in crop coefficient values with the different growth stages is due to the corresponding changes in consumptive use. The first peak of the crop coefficient at around 57 days coincides with the full canopy development of the crop, which might have led to a high consumptive use. The second peak may be attributed to the flowering that occurred after the first harvest of fruits and the reduction in the evaporative demand of the atmosphere. The subsequent decline in the crop coefficient values would probably be due to the reduction in crop canopy, as the crop was at its senescence stage.

Significant differences were not observed with respect to the field water use efficiency (Table 18(a). However, field water use efficiency increased with decrease in the quantity of water applied. The absence of any significant difference in field water use efficiency among the irrigation levels may be because the quantity of water added was just sufficient to bring the rootzone to field capacity level. Moreover, since pot watering was adopted conveyance loss of water was also reduced.

Crop water use efficiency (Fig.14) also exhibited the same pattern. The crop water use efficiency decreased with the increase in the soil wetness. This may be because of the higher consumptive use from the more frequently irrigated plots which was not accompanied by a corresponding increase in the yield.

Maximum depletion of soil water was observed from the top 0-15 cm soil layer irrespective of the treatment and then decreased with an increase in soil depth (Fig.15). The decline in soil moisture extraction with increase in depth was rapid in the wet regimes compared to the dry regimes. This may be because, when the surface soil is wet there is chance of higher evapotranspiration losses. Also the roots of the crop will be mostly confined to the top surface layer, when the surface soil is wet. Similar results were obtained by Loomis and Crandall (1977) and by Thomas (1984). With decreasing soil wetness soil moisture extraction from the lower layers increased. In the case of the unirrigated control the moisture extraction was more or less uniform from the surface layer to the lowermost soil layer. This may be due to the uniform root distribution of the unirrigated crop throughout the soil profile.

7.4. Rooting pattern

Both the lateral and vertical spread of the roots was found to be higher in the case of the drier regimes. Water has been found to influence the direction, vertical and lateral spread and the root-shoot ratio (Peters and Runkles, 1967). Salim *et al.* (1965) had also found that the drier treatments produced more branching in the upper soil layer in oats and barley. Portas (1973) also observed that frequent irrigations resulted in shallow root development in case of vegetables like tomatoes, onions, cauliflowers and lettuces. Only a slight variation in root-shoot ratios was observed between the treatments. The ratios were found to be slightly more in the dry regimes than in the wet regimes. This is in line with the findings of Kramer (1983) who had also observed an increase in the root shoot ratios with increase in water stress.

7.5. Evaporimetry

The relation between can and pan evaporation and the influence of meteorological parameters on both can and pan evaporimeters have been discussed under pumpkin.

The increase in ratio's with increasing age of the crop is mainly due to season and advancing age of the crop. The decline in the ratio at the final stages is due to the reduction in crop canopy since the crop was at its senescence stage. Scheduling irrigation at 75 per cent depletion of available soil moisture was found to be optimum for crop growth and yield. For this moisture regime, irrigation may be given when the cummulative can evaporation values reaches about 80 mm for the period from 27-42 days after sowing. For the interval between 42-57 days after sowing irrigation should be given when the cummulative can evaporation values reaches about 50 mm. For the next 15 day stage irrigation should be given when the cummulative can evaporation values reach about 80 mm, followed by 50 mm for the subsequent 15 days period. During the final stages of crop growth irrigation need be given only at 60 mm can evaporation values.

The conclusions drawn from the above results and discussion are briefly given below.

1. Irrigation to oriental pickling melon raised in summer rice fallows may be given at 75 per cent depletion of available soil water in 60 cm of the soil profile. This involves irrigation at 5-7 days interval.

2. With can evaporimeters irrigation may be given when the cummulative can evaporation values reach 80 mm during the vegetative stages of growth (27-42 days after sowing). During the flowering and fruit formation stages irrigation may be given at 50 mm can evaporation values followed by 60 mm during the later stages of crop growth.

ASHGOURD

(*Benincasa hispida* (Thumb) Cogn.)

RESULTS

The experiment with ashgourd was terminated at 90 days after sowing as the treatment effects could not be studied due to the frequent rains, that occurred after this stage.

8.1. Growth characters

8.1.1. Length of main vine

The data on length of main vine are given in Table 21 and their analysis of variance in Appendix VI.

There was no significant difference among the treatments with respect to the length of main vine at both the stages of observation. T5 recorded the highest vine length followed by T4, T3, T2 and T1 at 45 days after sowing. More or less the some trend was maintained at 75 days after sowing also.

8.1.2. Number of leaves per plant

The data relating to the number of leaves taken at 45 and 75 days after sowing are given in Table 21 and their analysis of variance in Appendix VI.

At 45 days after sowing, the different levels of irrigations, T2, T3, T4 and T5 were on par and were significantly superior to T1. At 75 days after sowing, there was no significant difference among the treatments.

8.1.3. <u>Leaf area</u>

Correlation coefficients were worked out between actual leaf area and maximum width of the leaves. A significant correlation of 0.9 was obtained between actual leaf area and maximum width of the leaf. Regression equations were then fitted to find out the relationship between the actual leaf area (A) and maximum width of the leaf (x). The regression equations developed and their predictability are given below.

Equation	Predictability
1. $A = 25.45\,x - 230.29$	81%
2. $A = 10.56\,x$	53%
3. $A = 0.67\,x^2$	78%

Data on the predicted leaf area from the three models corresponding to diameter values upto 28 cm are given in Table 22 and the graphical representation of these along with the scatter diagram showing actual measured leaf area values are given in Fig.16.

Table 21. Length of vine and number of leaves in ashgourd as affected by the levels of irrigation

Treatment	Length of main vine (m)		Number of leaves per plant	
	45 days after sowing	75 days after sowing	45 days after sowing	75 days after sowing
T1	3.61	5.21	38.00	31.31
T2	3.82	5.97	66.98	48.25
T3	4.03	5.65	74.17	54.58
T4	4.26	5.99	71.06	51.21
T5	4.37	6.15	69.42	48.08
SEm±	0.2859	0.2242	5.1832	5.0839
CD (5%)	NS	NS	15.9725	NS

Table 23. Leaf area index and dry matter production in ashgourd as affected by the levels of irrigation

Treatment	Dry matter production (g/plant)	Leaf area index	
		45 days after sowing	75 days after sowing
T1	242.488	0.514	0.324
T2	371.100	1.443	0.819
T3	447.110	1.499	0.831
T4	399.238	1.539	0.786
T5	443.813	1.444	0.722
SEm±	72.1245	0.0912	0.1072
CD (5%)	NS	0.3305	0.2812

Table 22. Predicted leaf area in ashgourd

Leaf diameter (cm)	Predicted leaf area (cm^2)		
	$A = 25.45x - 230.29$	$A = 0.67x^2$	$A = 10.56x$
0	0	0	0
11	-	0.67	10.56
2	-	2.68	21.12
3	-	6.03	31.68
4	-	10.72	42.24
5	-	16.75	52.80
6	-	24.12	63.36
7	-	32.83	73.92
8	-	42.88	84.48
9	-	54.27	95.04
10	24.21	67.00	105.60
11	49.66	81.07	116.16
12	75.11	96.48	126.72
13	100.56	113.23	137.28
14	126.01	131.32	147.84
15	151.46	150.75	158.40
16	176.91	171.52	168.96
17	202.36	193.63	179.52
18	227.81	217.08	190.08
19	253.26	241.87	200.64
20	278.71	268.00	211.20
21	304.16	295.00	221.76
22	329.16	324.28	232.32
23	355.06	354.43	242.88
24	380.51	385.92	253.44
25	405.96	418.75	264.00
26	431.41	452.92	274.56
27	456.86	488.43	285.12
28	482.31	525.28	295.68

A = predicted leaf area (cm^2)

x = Measured maximum leaf diameter (cm)

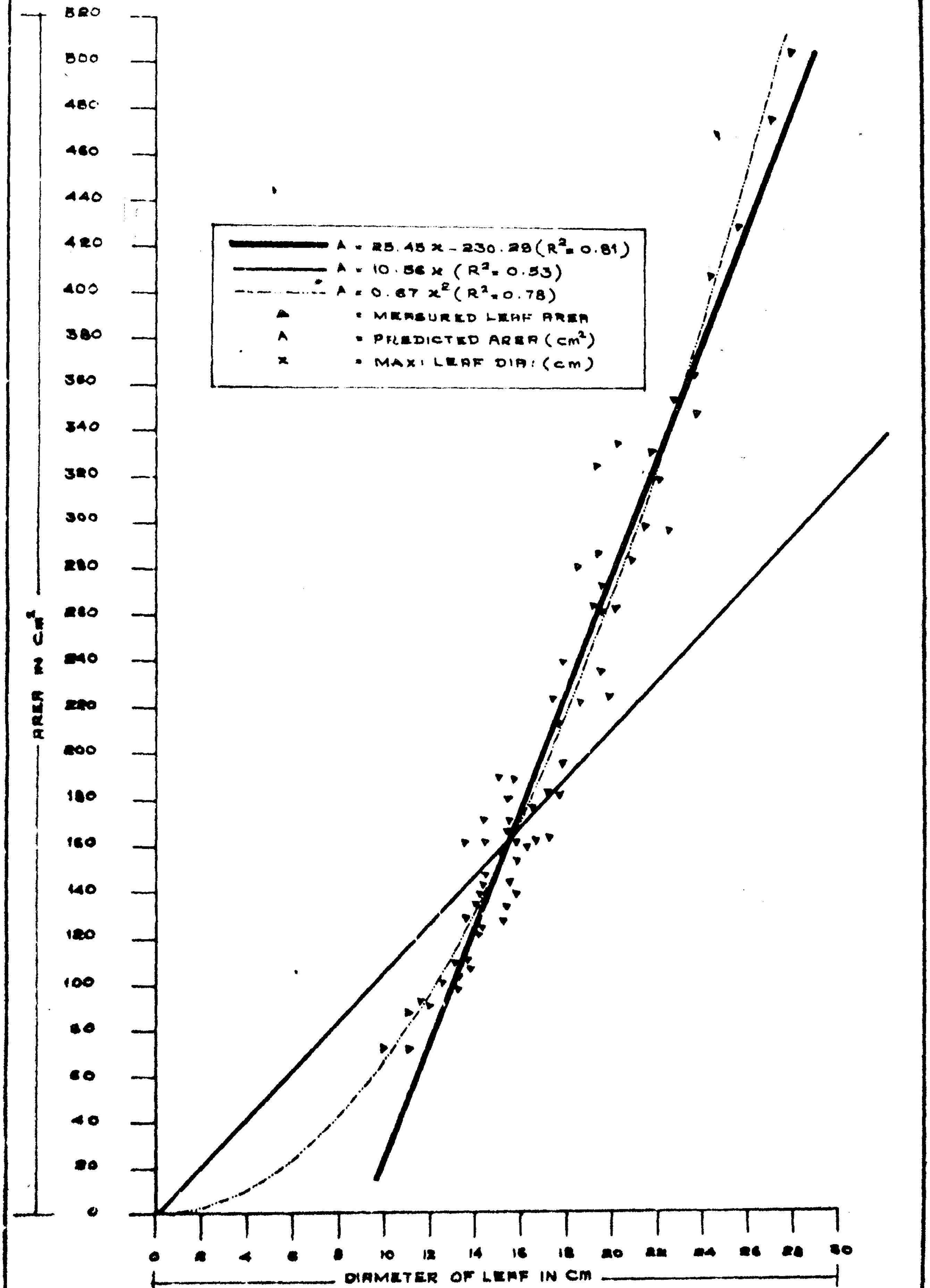

FIG: 16. RELATION BETWEEN ACTUAL AND PREDICTED LEAF AREA IN ASHGOURD

8.1.4. Leaf area index

The data on leaf area index are given in Table 23 and their analysis of variance in Appendix VI. At both the stages of observation T2, T3, T4 and T5 were on par and were significantly superior to T1.

8.1.5. Dry matter production

The data on dry matter content of the vegetative parts recorded at the time of harvest are given in Table 23 and the analysis of variance in Appendix VI.

There was no significant difference among the treatments with respect to the dry matter production. T3 showed the maximum dry matter production (447.11 g/plant) and T1 the least (242.488 g/plant).

8.2. Yield and yield attributes

The data relating to yield and yield attributes are given in Table 24 and the analysis of variance in Appendix VII.

8.2.1. Number of fruits per plant

T2 which produced the highest number of fruits per plant (1.396) was on par with T3, T4 and T5 and all these were significantly superior to T1.

Table 24. Yield and yield attributes of ashgourd as affected by levels of irrigation

Treatment	Number of fruits per plant	Fruit yield		Mean fruit weight (kg)	Mean length of fruit (cm)	Mean girth of fruit (cm)	Per cent dry matter of fruit
		Per plant (kg)	Per hectare (t)				
T1	0.438	1.448	7.384	3.310	28.725	48.178	6.298
T2	1.396	4.489	22.897	3.305	28.900	47.250	6.018
T3	1.104	4.302	21.942	3.808	37.250	55.193	6.070
T4	1.063	3.896	19.869	3.740	41.775	63.405	6.190
T5	1.292	4.252	21.685	3.843	37.225	61.128	6.030
SEm±	0.1335	0.5319	2.7126	0.2937	1.6445	3.5138	0.3799
CD (5%)	0.4085	1.6390	8.3591	NS	5.0677	10.8279	NS

8.2.2. Fruit yield per plant and per hectare

The different levels of irrigation T2, T3, T4 and T5 were on par and were significantly superior to that of the unirrigated control (T1). With respect to both yield per plant and yield per hectare, T2 produced the maximum yield (22.897 t ha^{-1}) with T1 producing the lowest yield of 7.384 t ha^{-1}.

8.2.3. Mean length of fruit

The treatment T4 which recorded the maximum length of fruit (41.775 cm) was on par with T3 and T5 and was significantly superior to T2 and T1. T2 was on par with T1.

8.2.4. Mean girth of fruit

The treatments T4, T5 and T3 were on par with respect to mean girth of fruit. T4 and T5 were significantly superior to T2 and T1. T3 was on par with T2 and T1.

8.2.5. Mean weight of fruit

There was no significant difference among the treatments with respect to mean fruit weight. However T5 recorded the maximum fruit weight followed by T3, T4, T2 and T1.

8.2.6. Percentage dry matter of fruit

There was no significant difference among the treatments with respect to the percentage dry matter content of fruits. However, T1 recorded the highest value of 6.298 per cent and T2 the least (6.018 per cent).

8.3. Moisture studies

8.3.1. Consumptive use

The data on seasonal consumptive use from 27 days after sowing to 90 days after sowing are given in Table 25(a). In treatment T2 since daily irrigation was practiced, consumptive use determination from soil moisture data was not feasible and these were hence not calculated. The consumptive use calculated at intervals of 15 days for the treatments T3, T4 and T5 are given in Table 25(b) and graphically represented in Fig.17.

The seasonal consumptive use was maximum for T3 (133.000 ha mm) followed by T4 (103.04 ha mm), T5 (91.56 ha mm) and T1 (24.91 ha mm). With respect to the average per day consumptive use also, the same trend was observed. The consumptive use calculated at 15 days intervals showed that the peak consumptive use occurred at 72 days after sowing for the treatments T3, T4 and T5. Thereafter a decline in the consumptive use was noticed.

Table 25(a). Consumptive use and crop coefficients of ashgourd as affected by levels of irrigation

Treatment	Seasonal consumptive use (litres per basin)	Seasonal consumptive use (ha-mm)	Per day consumptive use (litres per basin)	Crop Coeffi-cient
T1	146.528	24.91	2.442	0.07
T2	-	-	-	-
T3	782.36	133.00	13.039	0.371
T4	606.11	103.04	10.102	0.288
T5	538.59	91.56	8.977	0.256

Table 25(b). Cummulative consumptive use and crop coefficient values of ashgourd at intervals of 15 days

Particulars	Treatments	Period (days after sowing)			
		27-42	42-57	57-72	72-87
Consumptive use (litres)		124.80	150.60	262.24	244.72
Consumptive use (ha-mm)	T3	21.20	25.60	44.58	41.60
Crop coefficient		0.228	0.244	0.476	0.633
Consumptive use (litres)		150.32	159.22	162.92	133.66
Consumptive use (ha-mm)	T4	25.56	27.07	27.69	22.72
Crop coefficient		0.275	0.258	0.296	0.346
Consumptive use (litres)		121.80	140.94	167.72	108.13
Consumptive use (ha-mm)	T5	20.70	23.96	28.51	18.38
Crop coefficient		0.223	0.228	0.305	0.279

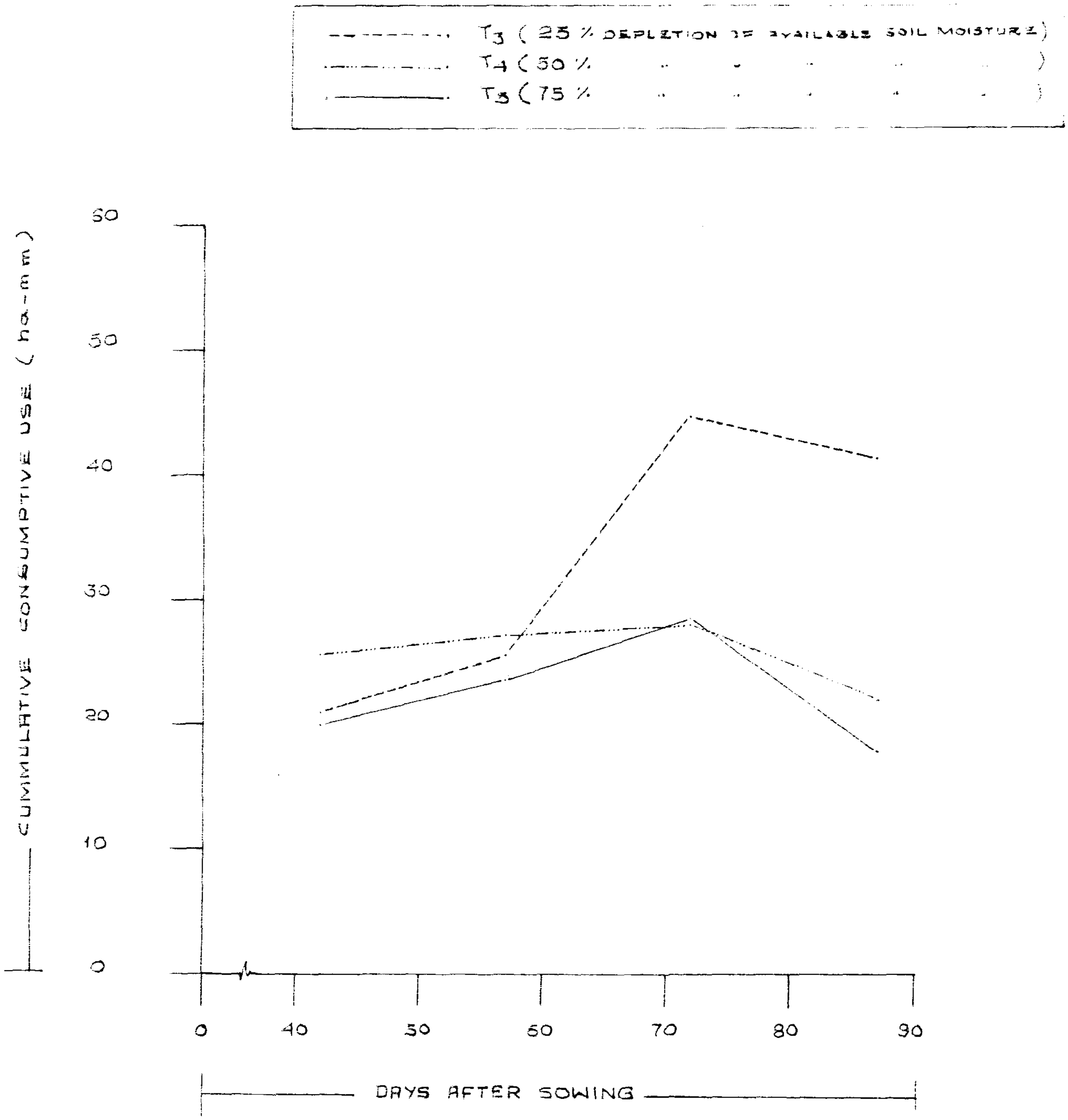

FIG: 17. CUMMULATIVE CONSUMPTIVE USE OF ASHGOURD AT INTERVALS OF 15 DAYS

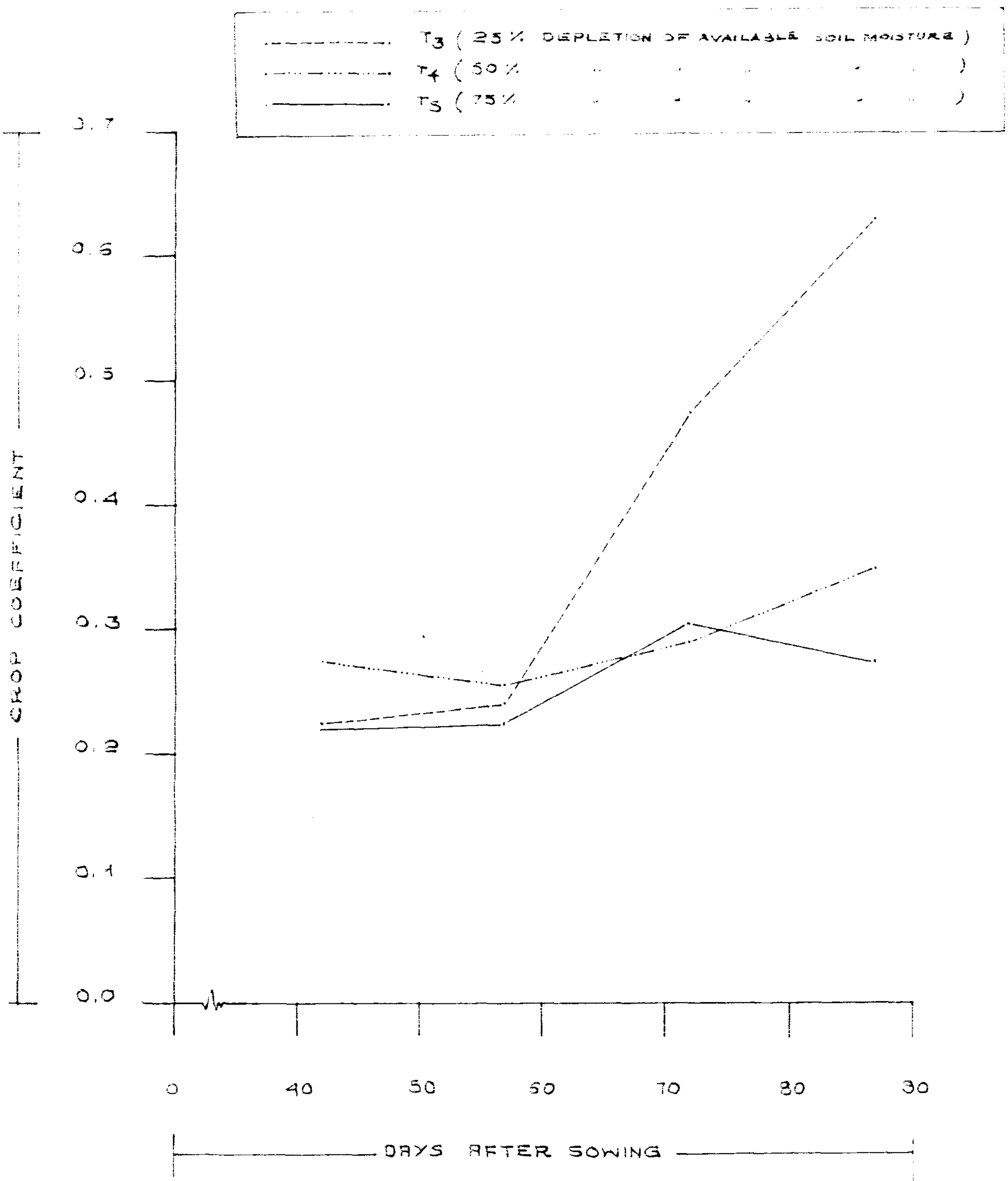

FIG. 18. CROP COEFFICIENTS FOR ASHGOURD AT INTERVALS OF 15 DAYS

This decline was found to be more rapid in the case of T4 and T5. In the case of T3 only a slight decline was observed.

8.3.2. Crop coefficient

The data on crop coefficients are presented in Table 25(a). The crop coefficient values were highest for T3 (0.371), followed by T4 (0.288), T5 (0.256) and T1 (0.07). Crop coefficient values calculated at the different growth stages (Table 25(b) and Fig.18), showed that it is low in the early stages of crop growth, after which a rapid increase was noticed. It is difficult to find out peak time of crop coefficient as the experiment was terminated at 90 days after sowing.

8.3.3. Field water use efficiency

The data on field water use efficiency are given in Table 26(a) and depicted in Fig.19. The analysis of variance is presented in Appendix VI.

There was no significant difference in field water use efficiency among the treatments. However, the maximum field water use efficiency was noticed for T3 followed by T1, T2, T5 and T4.

8.3.4. Crop water use efficiency

The data on crop water use efficiency are given in Table 26(b) and graphically represented in Fig.19.

Table 26(a). Field water use efficiency of ashgourd as affected by levels of irrigation

Treatment	Yield (kg ha^{-1})	Total water applied (ha-mm)	Field water use efficiency (kg-ha mm^{-1})
T1	7384	45.35	162.813
T2	22897	153.64	149.028
T3	21942	127.47	172.133
T4	19869	144.51	137.493
T5	21685	148.71	145.825
SEm±	—	—	22.3807
CD (5%)	—	—	NS

Table 26(b). Crop water use efficiency of ashgourd as affected by levels of irrigation

Treatment	Yield (kg ha^{-1})	Total consumptive use (ha-mm)	Crop water use efficiency (kg-ha mm^{-1})
T1	7384	24.91	296.43
T2	22897	—	—
T3	21942	133.00	164.98
T4	19869	103.04	192.83
T5	21685	91.56	236.84

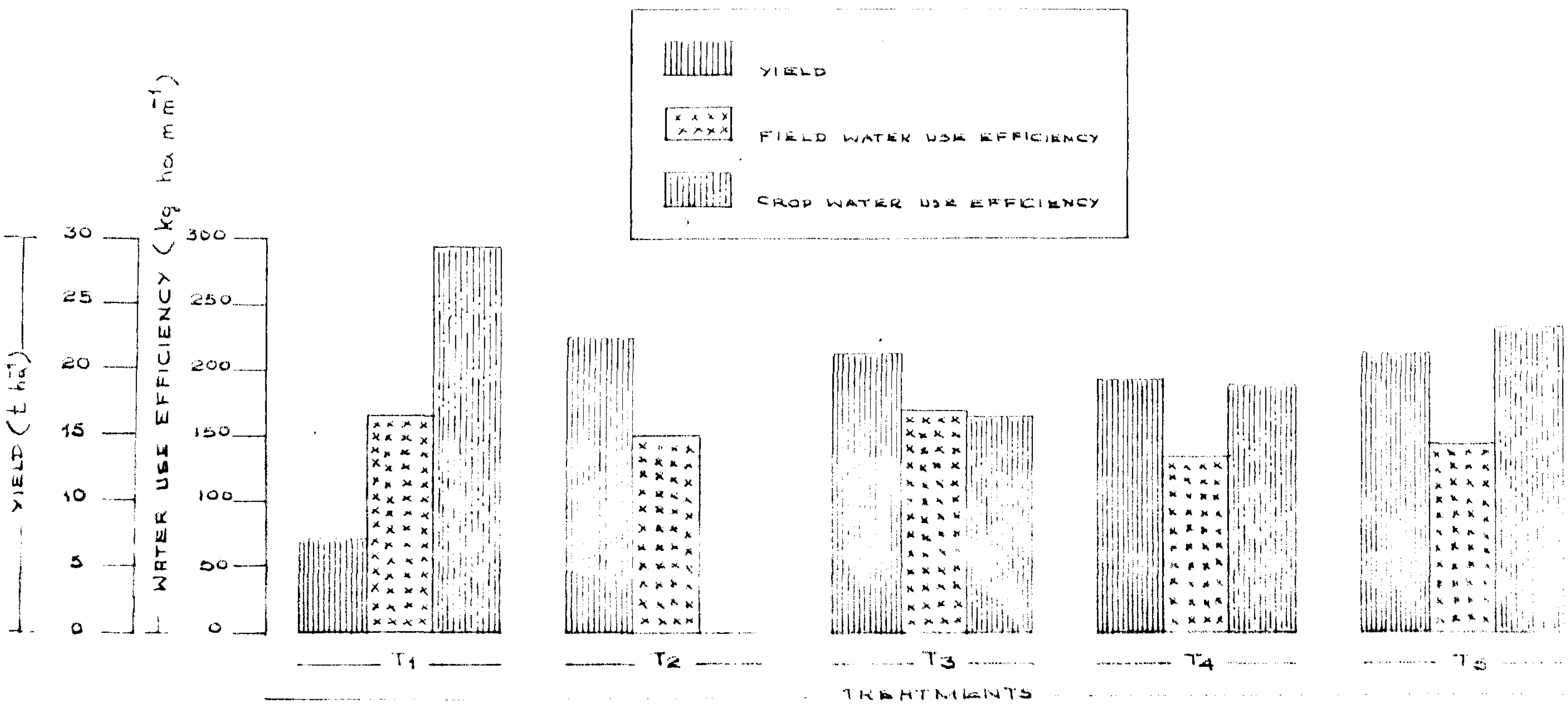

FIG. 19. YIELD AND WATER USE EFFICIENCY OF ASHGOURD AT DIFFERENT MOISTURE REGIMES

Crop water use efficiency was maximum for T1 (296.43 kg ha mm^{-1}) followed by T5 (236.84 kg ha mm^{-1}), T4 (192.83 kg ha mm^{-1}) and T3 (164.98 kg ha mm^{-1}).

8.3.5. Soil moisture extraction pattern

The overall soil moisture extraction pattern (Fig.20) showed that from the top 0-15 cm depth, the highest extraction was observed for all the treatments. A rapid decrease in soil moisture extraction, with increase in depth was noticed for the treatments T3, T4 and T5. But for T1, the soil moisture extraction was more or less uniform from all the different depths.

8.4. Rooting pattern

The data relating to root observations are presented in Table 27. The lateral spread of the roots was maximum for the unirrigated control (T1) followed by T5, T4, T2 and T3. The vertical depth was also maximum in case of T1 followed by T2, T3, T5 and T4. The number of primary roots per tap root was maximum for T2 followed by T4, T5, T1 and T3. The dry weight of the roots was lowest in the control plot (T1). T5 produced the maximum dry weight of the roots with T2, T3 and T4 having almost the same dry weight. The root shoot ratio was highest for T1 (0.098) followed by T5 (0.081), T2 (0.079), T4 (0.076) and T3 (0.067).

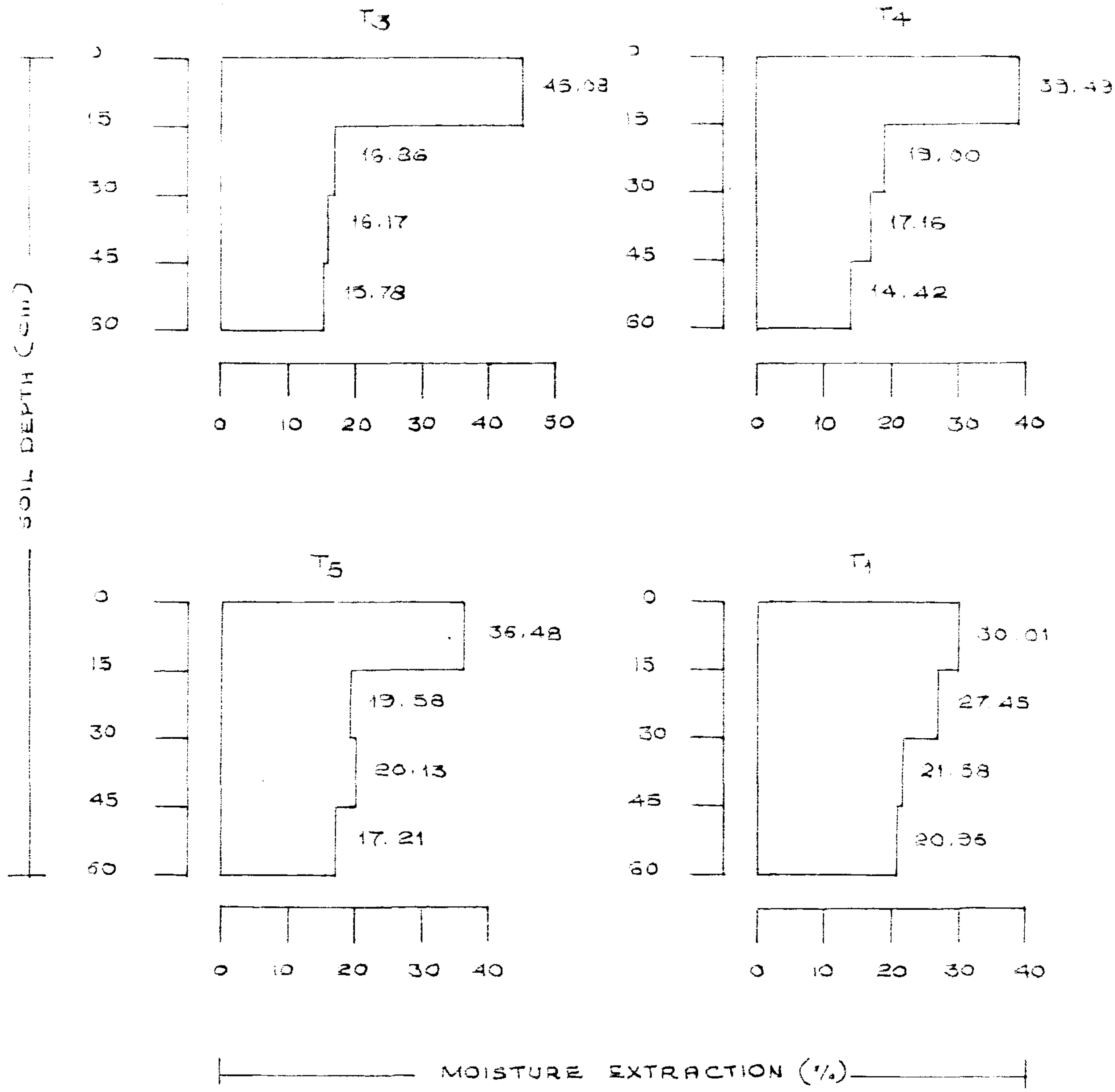

FIG. 20. OVERALL SOIL MOISTURE EXTRACTION PATTERN OF ASHGOURD AT DIFFERENT MOISTURE REGIMES

Table 27. Rooting pattern of ashgourd as affected by the treatments (at harvest)

Treatment	Lateral distance (cm)	Vertical distance (cm)	Number of roots per tap root	Total dry weight of roots (g)	Root/Shoot ratio
T1	287.50	71.25	12.50	23.75	0.098
T2	182.25	67.00	20.50	29.25	0.079
T3	175.75	63.00	12.25	30.13	0.067
T4	189.00	59.33	15.75	30.50	0.076
T5	264.00	62.00	13.33	35.75	0.081

8.5. Evaporimetry

The correlation coefficient between the pan and can evaporation values and the relative merits of the two types of evaporimeters is as given under pumpkin.

The average pan and can evaporation values and the ratios of pan/can at intervals of 15 days for the crop growth period, for the moisture regimes T2, T3, T4 and T5 are given in Table 28. The cummulative pan evaporation values per irrigation interval for T2, T3, T4 and T5 was found to range from 5 to 8 mm, 16-31 mm, 21-47 mm and 33-53 mm, while the can evaporation values ranged from 7-11 mm, 20-39 mm, 29-59 mm and 43-71 mm respectively for the crop growing season. The ratio of pan/can evaporation values increased with increasing age of the crop, but showed a decline in the final stages of crop growth.

Table 28. Average pan and can evaporation values and pan/can ratio's for the different intervals in ashgourd

Treatment	Interval (days after sowing)	Average pan evaporation for an irrigation interval (mm)	Average can evaporation for an irrigation interval (mm)	Pan/Can
T2	27-42	7.15	9.09	0.79
	42-57	8.08	10.94	0.74
	57-72	6.69	7.15	0.94
	72-87	5.48	7.30	0.75
T3	27-42	30.97	39.40	0.79
	42-57	26.28	35.55	0.74
	57-72	18.72	20.02	0.94
	72-87	16.45	21.90	0.75
T4	27-42	46.45	59.10	0.79
	42-57	35-05	47-40	0.74
	57-72	46.80	50.05	0.94
	72-87	21.90	29.20	0.75
T5	27-42	46.45	59.10	0.79
	42-57	52.55	71.10	0.74
	57-72	46.80	50.05	0.94
	72-87	32-85	43-80	0.75

DISCUSSION

The results of the studies in ashgourd are briefly discussed below.

9.1. Growth characters

The different levels of irrigation did not exert a significant influence on the growth parameters like length of vine, number of leaves, dry matter content and leaf area index (Table 21 and 23). However the vegetative growth was in general poor in the unirrigated control, especially during the early stages of growth.

Among the three models tried for the calculation of leaf area, the first model was found to have a high predictability. However it would be suitable only for leaf diameter values beyond 13 cm. The second model which has a very low predictability would be suitable only for leaf diameter values between 15 and 18 cm. Though the third model has a slightly lower predictability than the first model, it would be suitable for a wider range of leaf diameter values (Fig.16). Moreover the equation is simple and the calculations are easy.

The effect of the treatments, in general were not much pronounced during the later stages of crop growth due to the frequent light showers received during this time.

The poor vegetative growth of the plant in the unirrigated control may be due to the stress following water deficit. Water deficit is likely to affect the two vital processes of growth viz. cell division and cell enlargement, resulting in poor growth (Begg and Turnor, 1976). However, when water becomes available after a short period of stress, growth is very rapid, for a short time, so that no net reduction is caused by stress (Kramer, 1983). This may be the reason for the lack of response towards the treatments, during the later stages of growth when rains were received.

All the treatments had received uniform irrigation upto 27 days after sowing, thereby the seedling and establishment phases of crop growth were not subjected to any stress. Hence stress if any, might have occurred only at the vegetative growth stages when the treatments were given. According to Vamadevan (1980) any water shortage during germination and early seedling stages will have deleterious effects on plants while water shortage during the vegetative growth stages usually has little effects on subsequent production, until it is so severe so as to drastically reduce the leaf area. It can thus be assumed that between the levels of irrigation, the plants were not subjected to severe water stress. The rains received during the crop growing season would have nullified any significant differences in the rate of growth between the levels of irrigations.

9.2. Yield and yield attributes

The number of fruits per plant, the mean length and girth of fruit were improved substantially with irrigation (Table 24). However, the mean fruit weight did not vary significantly among the treatments. The number of fruits showed a slight increase with more frequent irrigations. The same was observed in pumpkin and oriental pickling melon. Favourable influence of moist regime on the number of marketable fruits was reported by Haynes and Herring (1980) in squash and by Thomas (1984) in bittergourd. The mean girth and length of fruits were found to be slightly less in the frequently irrigated plots and this may be due to the higher number of fruits in these treatments. The dry matter content of the fruits also did not differ markedly and all the treatments were on par (Table 24). Neil and Zunino (1972) had also reported that irrigation did not affect the dry matter content in doublon melons.

The total yield did not vary significantly among the different irrigation levels. This may be due to the reason that, the levels of irrigation at 25, 50 and 75 per cent depletion of available soil moisture and the daily irrigated plots were not subjected to severe water stress, since water deficit if any, developed during the period of fruit enlargement would have caused a marked reduction in the size of the fruits (Kaufman, 1972). Loomis and Crandall (1977) had also observed that removal of 48 to 64 per cent of available soil moisture had minimal effect on yield. The unirrigated plot gave the lowest fruit yield. This has to be expected as the unirrigated crop had a very poor vegetative growth and with respect to yield attributes also, it was inferior to all the other treatments (Mac Gillivray, 1951; Flocker et al. 1965; Varga, 1974 and Ortega and Kretchman, 1982).

9.3. Moisture studies

Consumptive use was always higher in the case of the wet regimes compared to the dry regimes (Table 25(a)). A similar trend was observed in the case of pumpkin and cucumber. Tomitaka (1974) and Thomas (1984) also observed that the consumptive use rate declined with a decrease in soil moisture level. Consumptive use showed only a gradual increase from 42 to 57 days after sowing after which there was a sharp increase and reached the peak value at 72 days after sowing (Fig.17). This may be due to the full canopy development of the crop and the high evaporative demand of the atmosphere as evidenced by the pan evaporation data (Fig. 1(a)). The full canopy development coincides with the flowering stage of the crop. Flowering in ashgourd starts about 58 days after sowing (George, 1981). The later decline may be assumed to be due to the fruit maturity stage and reduction in leaf area index due to senescence of leaves. Several workers have reported that consumptive use increases during flowering and early fruiting and levels off during late harvest (Caelotel and Varga, 1973; Loomis and Crandall, 1977).

The wet regimes showed comparatively higher crop coefficient values than the dry regimes. The unirrigated control showed the lowest values of crop coefficient. Frequent irrigations that keep the soil surface moist will decrease the effective diffusive resistance to evapotranspiration. Hence crop coefficients will be larger under these conditions compared with in frequent irrigations where the soil surface may remain dry for extensive periods of time (Jensen, 1968).

There was no significant difference in field water use efficiency, but it showed an increase with a decrease in the quantity of water applied. The unirrigated plots showed the highest field water use efficiency. The absence of any significant difference may be because the quantity of water added was just sufficient to bring the root zone to field capacity level. Moreover since pot watering was adopted loss of water as conveyance losses was practically absent.

Crop water use efficiency was highest for the unirrigated control plots. In general the drier regimes showed a higher crop water use efficiency. This may be due to the reduction in consumptive use, in the dry regimes following water stress. The depletion of soil moisture was almost similar to that observed for pumpkin and cucumber. Extraction was high from the surface layers and decreased with increase in soil depth. The high moisture loss from the surface layer may be because of the high evaporation losses taking place from the surface layer in addition to transpiration. With decreasing soil wetness, moisture extraction from the lower layers increased. Similar results were reported by Loomis and Crandall (1977) and by Thomas (1984). In the ease of the unirrigated control the moisture extraction from the different soil layers upto 60 cm depth was more or less uniform. This may be attributed to the better root distribution of the crop both vertically and laterally (Table 27) in the dry regimes.

9.4. Rooting pattern

The drier treatments showed a comparatively greater lateral spread of roots. The vertical spread of the roots did not vary markedly. The total dry weight of roots of the unirrigated control was the least, however the root-shoot ratio was the highest. The treatments T2, T3, T4 and T5 showed more or less the same root-shoot ratios. These findings are in conformity with those of Kramer (1983) who had reported that the root-shoot ratios increase with water stress though the dry weight usually decreases.

9.5. Evaporimetry

The relation between can and pan evaporation and the influence of meteorological parameters on both can and pan evaporimeters have been discussed under pumpkin.

The increase in the ratios with increasing age of the crop is due to season and advancing age of the crop. The decline in the ratio at the final stages may be due to a reduction in crop canopy.

Scheduling irrigation at 75 per cent depletion of available soil moisture was found to be optimum for crop growth and yield. For this moisture regime irrigation may be given when the cummulative can evaporation values reach about 60 mm for the period between 27-42 days after sowing. For the interval between 42-57 days after sowing irrigation should be given when the can evaporation reaches about 70 mm. For the next 15 days period, irrigation should be given at 50 mm can evaporation values, followed by 45 mm for the subsequent 15 days.

The conclusions drawn from the above results and discussions are briefly given below.

1. Irrigation to ashgourd raised in summer rice fallows may be given at 75 per cent depletion of available soil moisture in 60 cm of the soil profile. This involves irrigation at 5-7 days interval.

2. With can evaporimeters irrigation may be given when the cummulative can evaporation values reach about 60-70 mm during the vegetative growth stages (27-57 days after sowing). During the flowering, fruit formation and maturity stages irrigation may be given at cummulative can evaporation values of about 45-50 mm.

Summary

SUMMARY

An experiment was conducted at the Agricultural Research Station, Mannuthy, to study the response of cucurbitaceous vegetables namely pumpkin, oriental pickling melon and ashgourd to different moisture regimes, in summer rice fallows. The experiment was laid out in randomised block design with four replications. The treatments consisted of five moisture regimes viz., unirrigated control, conventional method of irrigation @ 13 litres per day, irrigation at 25 per cent, 50 per cent and 75 per cent depletion of available soil moisture. The results of the experiment are summarised below.

1. Irrigation significantly influenced the vine length at all the stages of growth. The unirrigated control recorded the lowest vine length.

2. Irrigation was found to favourably influence leaf production. Treatments which received frequent irrigations showed greater production of leaves in the early stages of growth. Leaf production was found to be the least in the unirrigated plots.

3. A high positive and significant correlation was obtained between leaf area and maximum width of the leaf, for all the three crops studied. Among the models

tried for the calculation of leaf area from leaf diameter measurements the equation $A = 0.72\ x^2$ ($R^2 = 0.94$) was found to be the best suited for pumpkin. In the case of oriental pickling melon the model $A = 0.76\ x^2$ ($R^2 = 0.85$) and for ashgourd $A = 0.67\ x^2$ ($R^2 = 0.78$) were found to be the best fit.

4. With respect to leaf area index, frequent irrigations showed higher leaf area index values during the initial stages of growth. At the later stages there was no significant differences among the treatments. The unirrigated plots recorded the least values of leaf area index.

5. The dry matter production per plant did not vary significantly between the different levels of irrigation. The unirrigated plots showed the lowest dry matter production.

6. The mean number of fruits per plant increased with increase in the frequency of irrigation.

7. There were no significant differences among the different levels of irrigation with respect to fruit yield per plant and per hectare. The unirrigated plots produced the lowest fruit yield.

8. The mean length, girth and weight of fruits were found to be higher in the less frequently irrigated plots; however all recorded the lowest values in the unirrigated plots.

9. The dry matter content of the fruits was found to be highest in the unirrigated plots. Treatments which received irrigation at less frequent intervals showed a higher dry matter content.

10. Seasonal consumptive use was found to be maximum for T3 (25% depletion of available soil moisture) followed by T4 (50% depletion of available soil moisture), T5 (75% depletion of available soil moisture) and T1 (unirrigated control). Frequent irrigations showed higher values of consumptive use. In case of pumpkin and oriental pickling melon, the peak values of consumptive use were found to occur at 42-57 days after sowing in all the treatments. For ashgourd the peak was found to occur at 57-72 days after sowing.

11. The highest values of crop coefficient in pumpkin and oriental pickling melon, were found to occur at 42-57 days after sowing in all the treatments. At 87 days after sowing, a second peak in crop coefficient values was observed. In case of ashgourd crop coefficient values showed a progressive increase upto 87 days after sowing.

12. There was no significant difference among the treatments with respect to field water use efficiency in the case of oriental pickling melon and ashgourd. The pumpkin, the unirrigated control recorded a significantly higher field water use efficiency.

13. Crop water use efficiency was maximum for the unirrigated control. In general, the drier regimes showed a higher crop water use efficiency.

14. The soil moisture extraction pattern showed that the highest extraction of moisture was from the surface layer (0-15 cm) in all the treatments. The loss of moisture from the surface was higher in the case of the wet regimes and a rapid decrease in moisture extraction with depth was noticed. In comparison with wet regimes, dry regimes extracted more moisture from the deeper layers. However, in the unirrigated control, moisture extraction was more or less uniform from all the different depths.

15. The drier regimes showed greater lateral spread of roots. The depth of penetration of roots was more or less same in all the treatments in the case of pumpkin and ashgourd, while in melon the drier regimes showed a greater vertical spread of roots. Though the total dry weight of roots was lowest in the unirrigated control plots, the root-shoot ratio was found to be the highest.

16. A high positive and significant correlation of 0.94 was obtained between the values of evaporation from a USWB class A pan and can evaporimeter. The can evaporimeter values were always found to be slightly higher than the pan evaporimeter values.

17. A high positive significant correlation was obtained between wind velocity and pan/can evaporation values; however the effect of other meteorological parameters viz., temperature, humidity and sunshine hours were not much pronounced.

18. From the comparative study of the two types of evaporimeters it was found that, there was no significant difference between the two types of evaporimeters. Hence can evaporimeters can be used for scheduling of irrigations.

19. From this study it can be concluded that irrigation to pumpkin, oriental pickling melon and ashgourd, raised in summer rice fallows need be given at 75 per cent depletion of available soil moisture in 60 cm of the soil profile. This involves irrigation at intervals of 5-7 days. With can evaporimeters, irrigation may be given when the cumulative can evaporation values reach about 60-70 mm during the vegetative stages of growth and about 45-55 mm during the flowering, fruit formation and fruit maturity stages.

References

REFERENCES

Arnon, I. 1975. Physiological principles of dryland crop production. In. Physiological aspects of dryland farming. (ed. Gupta, U.S.) Oxford and IBH publishing Co., New Delhi. pp. 3-145.

Begg, J.E. 1980. Morphological adaptations of leaves to water stress. In. Adaptation of plants to water and high temperature stress. Ist Ed. (ed. Turner, N.C. and Kramer, P.J.) John Wiley and Sons. New York. pp. 33-42.

Begg, J.E. and Turner, N.C. 1976. Crop water deficits. Advan. Agron. 28: 161-207.

*Belik, V.F. 1961. The growth and development of cucumbers and cell sap concentration of the leaves at different soil moisture levels. Fiziol. Rast. 8: 497-500.

*Belik, V.F. and Veselovskii, M.Y . 1975. The characteristics of growth and development of irrigated watermelons. Nauchnye Trudy NII Ovoshch Kha-Va. 5: 254-257

Blake, G.R. 1965. Particle density. In. Methods of soil analysis. Ist Ed. (ed. Black, C.A.) Part I. American Society of Agronomy, Madison, U.S.A. pp. 371-373.

Blake, G.R. 1965. Bulk density. Core method. In. Methods of soil analysis. Ist Ed. (ed. Black, C.A.) Part I. American Society of Agronomy, Madison, U.S.A. pp. 375-376.

Bohm, W. 1979. Root parameters and their measurement. General aspects. In. Methods of studying root systems. Ecological Series 33, New York. pp. 5-19.

*Borna, Z. 1969. The effect of fertilization and sprinkler irrigation on cucumber and celery yields. Roczniki Wyzszej Szkoly Rolniczejw Ponznaniu No.44: 15-26.

*Bradley, G.A. and Rhodes, B.B. 1969. Cultural studies on summer squash. Arkans. Fm. Res. 18(3): 9.

*Caro, A. and Linsalata, D. 1977. Melon yields as a function of seasonal volume of irrigation water. La Ricerce Scientifica No.99: 129-138.

Chauhan, D.V.S. 1983. Cucurbitaceous crops. In. Vegetable production in India. Ist Ed. Ram Prasad and Sons. Agra. pp. 149-170.

Chernovel, A.E. 1980. Cucumber yield in relation to the time of irrigation. Nauch - Teckhn. Byul. Ukr. NII. Ovoschevodi i Bakhchevod. No.10: 8-10.

Choudhury, B. 1983. Cucurbits. In. Vegetables. Ist Ed. National Book Trust, India. New Delhi. pp.151-161.

*Cselotel, L. and Varga, G. 1973. Relationship between development and water utilisation in cucumbers. Agrartudomanyi Egyetem Kozlemenyei. pp. 137-149.

*Cummins, T.L. and Kretchman, D.W. 1974. Moisture stress relations to growth and development of the pickling cucumber. Out door vegetable crops research, Research Summary. Ohio Agricultural Research and Development Centre. No.81: 23-24.

Dastane, N.G. 1967. A practical manual for water use research. Ist Ed. Navabharat Prakashans. Poona-4. pp.102.

*Dastane, N.G. 1974. Effective rainfall in irrigated agriculture. Irrigation and drainage paper. No.25. FAO of the U.N., Rome. pp.62.

Dastane, N.G., Singh, M., Hukkeri, S.B. and Vamadevan, V.K. 1970. Review of work done on water requirements of crops in India. Ist Ed. Navabharat Prakashans, Poona-4. pp.106.

*Dimitrov, Z. 1973. Seasonal irrigation pattern of watermelons. Gradinarstov. 15(11): 31-34.

*Dimitrov, Z. 1974. Green house cucumber irrigation. B'lgarski Plodove, Zelenchutsi i Konservi No.1: 120-122.

*Downes , J.D. 1966. Conventional irrigation versus frequent light sprinkling. Hort. Rep. Mich. St. Univ. No.30:7.

Doorenbos, J. and Kassam, A.H. 1979. Crop and water: Watermelon. In. Yield response to water. FAO Irrigation and drainage paper No.33:161-163.

*Dunkel, K.H. 1966. The effect of varying water supply on yield and tomatoes and cucumbers under glass. Acta. Hort., int. Soc. hort. sci. No.4: 42-49.

*Elkner, K. and Radzikowska, D. 1976. Influence of irrigation, mineral nutrition and variety on the pickling quality of cucumber. Zezyty Problemowe Postepow Nauk Rolniczych. No.181: 55-70.

*Escobar, D.E. and Gausman, H.W. 1974. Water stress reduces light reflectance of squash leaves. J. Rio Grande Valley Hort. Soc. 28: 57-63.

Flocker, W.J., Lingle, J.C., Davis, R.M. and Miller, R.J. 1965. Influence of irrigation and nitrogen fertilization on yield, quality and size of cantaloups. Proc. Amer. Soc. Hort. Sci. 86: 424-432.

*Frohlich, H. and Henkel, A. 1961. The use of supplementary irrigation for outdoor cucumbers. Arch. Gartend. No.9: 538-551.

George, T.E. 1981. Biometrical studies in ashgourd (Beninacasa hispida (Thumb.) Cogn.). M.Sc.(Hort.) thesis. College of Horticulture, Vellanikkara, Mannuthy, Trichur.

*Goto, Y., Ichikawa, H., Araki, Y. and Shibata, H. 1981. Studies on the variation of soil water suction and the beginning of irrigation and the irrigation requirement of some vegetables under green house conditions. I. An experiment with cucumber under forcing conditions. Bulletin of the Vegetable and Ornamental Crop Research Station. No.9: 133-141.

*Hammett, H.L., Albritton, R.C., Brock, W.A., Crockett, S.P. and Wagoner, B.E. 1974. Production of cucumbers for pickles. Miss. Agr. and For. Sta. Bul. 801.

*Haynes, R. and Herring, S. 1980. Effect of trickle irrigation on yield and quality of summer squash. Arkansas Farm Research. 29(5):6

*Henriksen, K. 1980. Irrigation of ridge cucumbers. Tidsskrift for Planteaul. 84(6): 479-490.

Indian Council of Agricultural Research. 1981. Annual Report 1980-81. Co-ordinated project for research on water management (ICAR), Chalakudy centre.

Indian Council of Agricultural Research. 1982. Annual Report 1981-82. Co-ordinated project for research on water management (ICAR), Chalakudy centre.

Jackson, M.L. 1958. Soil Chemical analysis. Prentice-Hall. Inc. Englewood Cliffs. N.J. USA. reprint (1973) by Prentice-Hall of India (Pvt) Ltd., New Delhi. pp.498.

*Jagoda, J. and Kaniszewski, S.L. 1975. The effectiveness of irrigation and mineral fertilization during cultivation of two cucumber cultivars. Biuletyn Warzywnicky. 18: 47-61.

Jassal, N.S., Randhawa, K.S. and Nandpuri, K.S. 1970. A study on the effect of irrigation and certain doses of N, P and K on the weight of fruit and yield of muskmelon.(Cucumis melo. L.). Punjab Hort. J. 10(3): 143-149.

Jensen, M.E. 1968. Water consumption by agricultural plants. In. Water deficits and plant growth. Vol. II. (ed. Kozlowskii, T.T.) Academic Press, New York. pp.1-19.

Katyal, S.L. 1980. Cucurbits and vine crops. In. Vegetable growing in India. Ist Ed. Oxford and IBH publishing Co., New Delhi. pp.79-81.

Kaufman, M.R. 1972. Plant responses and control of water balance - water deficits and reproductive growth. In. Water deficits and plant growth. Vol. III. (ed. Kozlowskii, T.T.) Academic Press, New York. pp. 91-124.

*Konishi, K. 1974. The amount and nature of water consumption in muskmelon plants. Scientific Reports of the Faculty of Agriculture, Okayama University. No.43: 27-37.

Kramer, P.J. 1983. Water deficits and plant growth. In. Water relations of plants. Academic Press, New York. pp.342-389.

*Krynska, W., Kawecki, Z. and Piotrowski, L. 1976. The effect of fertilisation, irrigation and cultivars on the quality of fresh, sour and pickled cucumbers. Zeszyty Naukowe Akademi Rolniczo - Techniczyej w Olsztynie. Rolnictwo. No.15: 109-123.

Kvet, J. and Marshall, J.K. 1971. Assessment of leaf area and other assimilating plant surfaces. In. Plant photosynthetic production, Manual of methods. (ed. Sestak, Z., Catsky, T. and Jarvis, P.G.) Dr. W. Junk, N.V. Publishers, The Hague. pp.517-546.

Loomis, E.L. and Crandall, P.C. 1977. Water consumption of cucumbers during vegetative and reproductive stages of growth. J. Amer. Soc. Hort. Sci. 102(2): 124-127.

Mac Gillivray, J.H. 1951. Effect of irrigation on the production of cantaloups. Proc. Amer. Soc. Hort. Sci. No.57: 266-272.

*Mannimi, P. and Roncozzi, M. 1983. The yield response of cucumbers to different intervals, volumes and systems of irrigation in the unheated glass house. Colture Protette. 12(4): 29-36.

Michael, A.M. 1978. Soil - plant - water relationships. In. Irrigation. Theory and Praftice. Vikas publishing House Pvt. Ltd. New Delhi. pp.448-563.

Michael, A.M., Hukkeri, S.B. and Singh, N.P. 1977. Estimating water requirement of crops. In. Water requirement and irrigation management of crops in India. Water Technology Centre. IARI. Monograph No.4. pp.91-160.

*Molnar, B. 1965. Irrigation of melons. Novenytermeles. No.14: 203-214.

*Motoki, M. and Kurokawa, H. 1977. The effect of irrigating at different moisture levels on melons growing on coarse volcanic ash soil in Komogadake. Bulletin of Hokkaido Prefectural Agricultural Experiment Stations. No.37:-50-67.

*Neil, P. and Zunino, J.P. 1972. Water requirements of melon and methods of irrigation. Pepinieristes, Horticulteurs, Meraichers. No.123-43.54.

Ortega, D.G. and Kretchman, D.W. 1982. Water stress effects on pickling cucumbers. J. Amer. Hort. Sci. 107(3): 409-412.

Pai, A.A. and Hukkeri, S.B.(ed) 1979. Manual on irrigation water management. Ministry of Agriculture and Irrigation. Department of Agriculture, Krishi Bhavan, New Delhi. pp. 3-26.

*Pavlov, F.I. 1976. Irrigation regime for cucumbers under heated plastic green houses. Poklady Mosk. S-Kl. Akad. K.A. Timiryazeva. No.216: 126-132.

Peters, D.B. and Runkles, J.R. 1967. Shoot and root growth as affected by water availability. In. Irrigation of agricultural lands. (ed. Hagan, R.M., Haise, H.R. and Edminster, T.W.) American Society of Agronomy, Madison, USA. pp. 373-386.

Pew, W.D. and Gardner, B.R. 1983. Effects of irrigation practices on vine growth, yield and quality of muskmelons. J. Amer. Soc. Hort. Sci. 108(1): 134-137.

Piper, C.S. 1950. Soil and plant analysis. University of Adelaide. Australia, pp. 368.

Portas, C.A.M. 1973. Development of root systems during the growth of some vegetable crops. Plant and Soil. 39(3): 507-518.

Rao, A.S., Varadan, K.M. and Vamadevan, V.K. 1983. Interim Report - Studies on Scheduling of irrigation using Can evaporation under different crops. CWRDM, Calicut. pp.14.

Reddy, G.H. and Reddy, R.S. 1982. Can evaporation for scheduling of irrigation to crops. 'Wamana'.

Reddy, R.N.S., Reddy, K.C. and Reddy, S.G.H. 1973. Note on evapotranspiration in Soybean and its relationship with evaporation from different evaporimeters. Indian J. Agron. 18(2): 233-236.

Reddy, M.G., Rao, Y.Y., Rao, K.S. and Ramaseshaiah, K. 1983. A preliminary study on scheduling irrigation with can evaporimeters. Agric. Water. Manage. Elsevier Science Publishers. B.V. Amsterdam. 6(4): 403-407.

Richards, L.A. 1947. Pressure membrane apparatus. Construction and use. Agr. Engg. 28: 451-454.

Rudich, J., Elassar, G. and Shefi, Y. 1978. Optimal growth stages for the application of drip irrigation to muskmelon and watermelon. J. Hort. Sci. 53(1): 11-15.

Salim, M.H., Todd, G.W. and Schlehuber, A.M. 1965. Root development of wheat, oats and barley under conditions of soil moisture stress. Agron. J. 57(5): 603-607.

Sharma, H.C. and Dastane, N.G. 1969. Assessing evapotranspiration with Can evaporimeters. Annals of Arid Zone. 8(1): 23-26.

Sharma, H.C., Dastane, N.G. and Singh, N.P. 1975. Studies on Can evaporimeters in relation to evapotranspiration from field crops. Indian J. Agron. 20(2): 147-152.

Singh, S.D. and Singh, P. 1978. Values of drip irrigation compared with conventional irrigation for vegetable production in a hot arid climate. Agron. J. 70(6): 945-947.

Singh, N.P. and Sinha, S.K. 1977. Water use efficiency in crop production. In. Water requirement and irrigation management of crops in India. Water Technology Centre, IARI, New Delhi. pp.286-335.

Snedecor, G.W. and Cochran, W.G. 1967. Statistical Methods. 6th Ed. Oxford and IBH Publishing Co., Calcutta-16. pp. 593.

Stanhill, G. and Vaadia, Y. 1967. Factors affecting plant responses to soil water. In. Irrigation of agricultural lands. (ed. Hagan, M.R., Haise, H.R. and Edminster, T.W.) American Society of Agronomy, Madison, USA. pp. 446-456.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. Current Sci. 25(8): 259-260.

Tarr, C.S., Futton, J.M. and Nuttal, V.M. 1983. The influence of soil moisture stress and plant populations on the yield of pickling cucumber. Scientia Horticulturae. 21(3): 217-224.

Thomas, C.G. 1984. Water management practices for bittergourd (Momordica charantia. L.) under different fertility levels. M.Sc.(Ag.) thesis. College of Agriculture, Vellayani, Trivandrum.

*Tomitaka, Y. 1974. Studies on the amount of evapotranspiration from crop plants. III. The effect of moisture regimes on evaporation from cucumber plants. J. Agrl. Sci. Japan. 19(1): 19-24.

Vamadevan, V.K. 1980. Scientific water management practices for important crops of Kerala. In. Proceedings - Seminar on water management practices in Kerala. Calicut 11-12, Oct. CWRDM. pp.13-29.

*Varga, D. 1973. The problem of cucumber irrigation in Hungary. Zanradnictvi. pp.199-211.

*Varga, G. 1971. The combined effect of temperature and water supply on yield. Agrartudomanyi Egyetem Kozlemenyei. No.2: 345-347.

Vittum, M.T. and Flocker, W.J. 1967. Vegetable crops. In. Irrigation of agricultural lands. (ed. Hagan, R.M., Haise, H.R. and Edminster, T.W.) American Society of Agronomy, Wisconsin, USA. pp.674-685.

Watson, D.J. 1947. Comparative physiological studies on the growth of field crops. II: The effect of varying nutrient supply of net assimilation rate and leaf area. Ann. Bot. N.S. II: 375-407.

Whitaker, W.T. and Davis, G.N. 1962. Cucurbits. Botany, cultivation and utilisation. Interscience publishers, Inc. New York. pp.145-150.

Yawalkar, K.S. 1980. Cucurbitaceous or vine crops. In. Vegetable crops of India. 2nd Ed. Agri-Horticultural Publishing House, Nagpur. pp.120-180.

*Zabara, Yu.M. 1978. The effect of irrigation on root distribution in cucumbers grown on derno-podzolic soil. Referativnyi Zhurnal. 8(55):429.

* Originals not seen.

Appendices

APPENDIX I

Weather data during the crop period - 1983-'84 (weekly average)

Period	Meteorology week	Evaporation (mm)	Wind speed km hr^{-1}	Rainfall (mm)*	Sunshine (hrs)	Temperature (°C)		Relative humidity (%)	
						Maximum	Minimum	8 AM	2 PM
XII	51	5.53	11.74	1.9	4.12	28.96	23.89	73.86	67.29
	52	2.70	2.97	21.6	5.25	30.50	23.01	95.13	70.75
I	1	5.27	9.53	-	9.11	30.81	23.57	77.14	58.29
	2	6.73	12.94	-	7.50	30.13	23.40	72.29	54.71
	3	4.97	6.81	-	8.14	32.19	23.43	86.86	57.57
	4	6.81	7.44	-	9.60	32.70	20.70	74.00	39.57
	5	8.23	11.87	-	8.27	32.63	22.44	73.86	43.00
II	6	7.49	13.39	-	5.26	32.46	24.91	77.43	54.86
	7	6.94	9.41	6.2	8.07	34.23	24.39	85.43	57.29
	8	5.77	4.74	30.9	9.33	34.93	23.46	92.43	48.43
	9	10.00	13.11	-	6.31	33.89	25.15	65.38	45.50
III	10	3.84	6.34	8.2	4.93	31.29	23.76	92.14	74.29
	11	6.19	4.24	2.0	10.10	35.34	23.47	92.86	48.71
	12	6.98	3.80	-	10.06	36.84	23.61	92.57	50.86
	13	5.89	4.33	-	9.19	35.63	25.00	91.43	55.29
IV	14	4.23	3.37	14.2	2.69	33.70	22.91	93.86	68.00
	15	5.94	5.03	6.8	9.20	35.71	22.77	83.43	51.57

* Weekly total

APPENDIX II

Abstract of analysis of variance Biometric observations and water use efficiency of pumpkin

Source	df	Mean squares					
		Length of main vine			Number of leaves		
		45 days after sowing	57 days after sowing	Harvest	45 days after sowing	75 days after sowing	Harvest
Blocks	3	0.1268	0.0793	0.4747	34.3266	31.2967	284.4797
Treatment	4	1.0527**	1.2438**	1.9620**	333.8726**	132.0489	1818.959**
Error	12	0.0729	0.1308	0.2090	35.6061	151.8474	278.469

** Significant at 1 per cent level.

APPENDIX II Contd.

Source	df	Mean squares				
		Leaf area index			Dry matter production at harvest	Field water use efficiency
		45 days after sowing	75 days after sowing	Harvest		
Blocks	3	0.0153*	0.0020	0.0087	1920.9950	374.4741
Treatment	4	0.1538**	0.0603*	0.1418**	10493.0655*	2593.9979**
Error	12	0.0042	0.0149	0.0158	2619.3177	416.7307

* Significant at 5 per cent level.

** Significant at 1 per cent level.

APPENDIX III

Abstract of analysis of variance yield and yield attributes in pumpkin

Source	df	Mean squares						
		Number of fruits per plant	Length of fruit	Girth of fruit	Mean weight of fruit	Per cent dry matter of fruit	Yield per plant	Yield per hectare
Block	3	0.0393	0.2460	46.8863	0.1183	1.0943	0.6037	13.6219
Treatment	4	0.6295**	30.0100**	272.4580**	2.0368**	2.7545*	9.7242**	253.2134**
Error	12	0.0531	0.7914	28.6847	0.2373	0.7494	0.6093	15.7541

* Significant at 5 per cent level.

** Significant at 1 per cent level.

APPENDIX IV

Abstract of analysis of variance Biometric observations and water use efficiency of oriental pickling melon

Source	df	Mean squares					
		Length of main vine			Number of leaves		
		45 days after sowing	75 days after sowing	Harvest	45 days after sowing	75 days after sowing	Harvest
Block	3	0.8308	0.1693	0.1327	181.3240	1906.8633	1553.7750
Treatment	4	0.6710**	0.9200**	0.7806**	1762.2370**	298.9935	400.0105*
Error	12	0.0873	0.0725	0.1099	135.6737	254.3298	119.8191

* Significant at 5 per cent level.

** Significant at 1 per cent level.

APPENDIX IV contd.

Source	df	Mean squares				
		Leaf area index			Dry matter production at harvest	Field water use efficiency
		45 days after sowing	75 days after sowing	Harvest		
Block	3	0.0179	0.0655	0.0127	1788.0373	3199.4164
Treatment	4	0.1859**	0.0148	0.0140**	5731.8483*	4610.4864
Error	12	0.0144	0.0154	0.0009	1112.8839	4615.1059

* Significant at 5 per cent level.

** Significant at 1 per cent level.

APPENDIX V

Abstract of analysis of variance yield and yield attributes in oriental pickling melon

Source	df	Mean squares						
		Number of fruits per plant	Length of fruit	Girth of fruit	Mean weight of fruit	Per cent dry matter of fruit	Yield per plant	Yield per hectare
Block	3	1.5013*	30.1561*	9.0559	0.0837	0.2913	2.0993	54.5947
Treatment	4	3.4938**	93.0530**	81.0159**	0.3098	5.0258**	12.3823**	322.0599**
Error	12	0.2776	6.9329	4.1286	0.0974	0.3760	0.8788	22.8563

* Significant at 5 per cent level.

** Significant at 1 per cent level.

APPENDIX VI

Abstract of analysis of variance Biometric observations and water use efficiency in ashgourd

Source	df	Mean squares							
		Length of vine		Number of leaves		Leaf area index		Dry matter production at harvest	Field water use efficiency
		45 days after sowing	75 days after sowing	45 days after sowing	75 days after sowing	45 days after sowing	75 days after sowing		
Block	3	0.1657	0.1857	172.8287	100.1393	0.0993	0.0621	5984.0300	1401.327
Treatment	4	0.3915	0.5590	867.4203**	323.5647	0.7553**	0.1802**	27931.9575	769.071
Error	12	0.3272	0.2013	107.4634	103.3859	0.0460	0.0333	20807.7815	2003.5744

** Significant at 1 per cent level.

APPENDIX VII

Abstract of analysis of variance yield and yield attributes in ashgourd

Source	df	Mean squares						
		Number of fruits per plant	Length of fruit	Girth of fruit	Mean weight of fruit	Per cent dry matter of fruit	Yield per plant	Yield per hectare
Block	3	0.0763	19.7555	11.1003	1.0173	1.4023	1.1107	28.8930
Treatment	4	0.5560**	132.2463**	214.8315	0.2925	0.5973	6.3990**	166.4467**
Error	12	0.0713	10.8176	49.3860	0.3446	0.5775	1.1316	29.4327

** Significant at 1 per cent level.

SCHEDULING OF IRRIGATION FOR CUCURBITACEOUS VEGETABLES

By

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ABSTRACT OF A THESIS

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ABSTRACT

An experiment was conducted at the Agricultural Research Station, Mannuthy during the summer season of 1983-84 to study the response of cucurbitaceous vegetables viz., pumpkin, oriental pickling melon and ashgourd to different moisture regimes. The experiment was laid out in randomised block design with four replications. The treatments consisted of five moisture regimes viz., unirrigated control, conventional method of irrigation @ 13 litres/day, irrigation at 25 per cent, 50 per cent and 75 per cent depletion of available soil moisture.

The study revealed that irrigation favourably influenced the crop growth and yield. However, there were no significant differences in total yield per plant and per hectare between the different levels of irrigation, for the three crops studied.

Treatments which received frequent irrigations showed higher values of consumptive use throughout the crop growth period. Crop coefficients were also higher in the frequently irrigated plots. Field water use efficiency did not vary significantly between the treatments. The drier regimes showed a higher crop water use efficiency than the wet regimes.

Moisture extraction was found to be high from the surface layer (0-15 cm) in all the treatments. Loss of moisture from the surface was greater in the case of the wet regimes. Moisture extraction decreased with depth. The dry regimes extracted more moisture from the deeper layers than the wet regimes.

The drier regimes indicated greater lateral spread of roots. The depth of penetration of roots did not vary markedly between the different treatments in pumpkin and ashgourd while in melon, the drier regimes showed a greater vertical spread of roots. The unirrigated plots showed the highest value of root-shoot ratio though the dry weight of roots was the least.

Among the different irrigation levels tried, 75 per cent depletion of available soil moisture was found to be the optimum permissible level of depletion for pumpkin, oriental pickling melon and ashgourd. This involves irrigation at 5-7 days interval. Can evaporimeters were found to be useful in scheduling irrigations. With can evaporimeters, irrigation to pumpkin, oriental pickling melon and ashgourd may be given at cummulative can evaporation values of about 60-70 mm during the vegetative stages of growth followed by 45-55 mm during the flowering, fruit formation and fruit maturity stages.