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ESTIMATION OF CONSUMPTIVE USE OF WATER FOR WHEAT UNDER OPTIMUM MANAGEMENT CONDITIONS

BY
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JOINT CONTRIBUTION OF COLORAD STATE UNIVERSITY
AND THE
DIRECTORATE OF MONA RECLAMATION EXPERIMENTAL PROJECT
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BHALWAL

MAY 1975

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FORWORD

One of the objectives of Mona Reclamation Experimental Project is to develop new techniques for on-farm water management. Accordingly, various studies have been initiated at Mona to fulfill this objective. The present report on "Estimation of Consumptive Use of Water for Wheat Under Optimum Management Conditions" is a part of this program. The study has been undertaken in collaboration with Colorado State University advisors and funded by USAID Pakistan.

In order to plan an irrigation system and to make efficient use of available irrigation water on the farm, an accurate estimate of consumptive use requirement of crops is essential. The result of this study will be of immense importance for the planners of future irrigation projects and water users. I am confident that the findings of this report will also help the Government in fixing more realistic targets of wheat production in Pakistan keeping in view the available irrigation supplies during rabi season.

(Mohammad Ashraf)
Project Director

ACKNOWLEDGEMENTS

This study, "Estimation of Consumptive Use of Water for Wheat Under Optimum Management Conditions" was undertaken at Mona Reclamation Experimental Project, Bhalwal, in collaboration with Colorado State University in Pakistan under USAID contract No. AID/ta-c-1100, water management research program. The experiment was conducted under the general direction of Mr. Badar-ud-Din, Chief Engineer, Central Monitoring Organization, WAPDA and under the administrative control and supervision of Mr. Mohammad Ashraf, Project Director, Mona Reclamation Experimental Project, to whom the authors extend their heartiest gratitude.

We are grateful to Dr. Wayne Clyma, Agricultural Engineer of the Colorado State University advisory group, for making useful suggestions during the course of finalization of this report. Our sincere thanks are also due to Mr. Afzal Haider Taqvi, Junior Research Assistant, for his help in collection and processing of the data. We are also greatly indebted to the staff of the Mona Soil and Water Laboratory for carrying out moisture estimation on the soil samples collected from the experimental plots.

SUMMARY

Conservation of existing irrigation supplies in Pakistan is becoming increasingly important as the demand for irrigation water continues to increase and new sources of supply become harder to find. Presently, much water is wasted by overirrigation to crops. A large portion of this water can be saved by applying the exact amount of irrigation water required to meet the consumptive use requirements of crops. Wheat is one of the most important food crops in Pakistan and occupies by far the largest area under cultivation. This study was, therefore, undertaken to estimate the consumptive use requirement of wheat under optimum management conditions. This is an interim report based on one season data collected during rabi 1973-74. The study is still in progress. The final report will be issued at the conclusion of the experiment. The findings of this report should, therefore, be used with caution.

For the purpose a one-acre field of medium-to fine-textured, non-saline, non-alkali soil was selected. The following treatments were tested.

Treatment	Levels	Description
Soil moisture stress	3	Irrigation was applied at moisture stress of 1, 2 and 4 bar tensions for top 0-6 inches (treatment M_1, M_2, and M_3 respectively).
Fertility (N,P,K)	2	High: 150-75-30 (F_1) Low: 50- 0-30 (F_2)
Replications	4	
Total No. of plots 3x2x4 = 24		

Moisture and fertilizer treatments were applied in 3x2 factorial design with 4 replications. One acre field was divided into 24 plots of equal size. Individual plot size was 51' x 28', i.e., 1/30th of an acre. Wheat variety Chenab-70 was sown on 17 November 1973. Fertilizer doses were applied in two parts. Entire doses of phosphorus and potash were applied to the respective plots just before sowing. Half the quantity of N in case of high dose was also applied before sowing. The remaining half of the N in the high dose and all the N in the low dose were applied at the time of first irrigation.

The irrigation to wheat crop was given at 3 levels of moisture stress i.e., at 1, 2 and 4 bar tensions. The 3 moisture stress levels corresponded to 13.3, 11.0 and 8.6 precent, by weight of moisture remaining in the top 6" of soil, respectively. The field capacity and wilting point of the soil were 18.6 and 6.9 percent, respectively. The plots were irrigated as soon as the desired stress was reached in the top 0-6 inches soil in the respective plots. Pure tubewell water was used for irrigation. The TDS, SAR and RSC of the water applied was 576 ppm, 2.8 and zero respectively. The depth of irrigation to be applied to each plot was calculated from the pre-irrigation

soil moisture content which was determined by moisture sampling down to 5 feet depth. Each irrigation restored the moisture level of the soil down to 5 feet depth to field capacity. A cutthroat flume of 4"x3' size was used to measure the quantity of irrigation water applied. The moisture samples were taken from 0-6, 6-12, 12-24, 24-36, 36-48 and 48-60 inches depths. The first soil sampling for moisture estimation was done at the time of planting of wheat and the subsequent sampling was carried out as close before and after every irrigation as possible. Final moisture sampling was done at the time of wheat harvest. The samples were dried in an electric oven at 105°C to constant weight and the moisture contents calculated on dry-weight basis.

The consumptive use of water for wheat was worked out by two independent methods. Firstly, by gravimetric measurement of soil moisture depletion, wherein the consumptive use was estimated by adding the water loss between soil samplings i.e., after and before each irrigation, plus pan evaporation for 3 days after each irrigation, plus rainfall, plus evapotranspiration for the days not otherwise accounted for. These days included the periods from the time of last sampling before each irrigation up to the actual time of irrigation, and also from the end of the 3rd day after each irrigation up to the actual time of soil sampling after each irrigation. The estimation of evapotranspiration for these periods was made by extrapolating the moisture depletion graph. Dividing the total water used between two irrigations by the number of days between these irrigations, the consumptive use per day was also calculated. Secondly, the estimation of consumptive use was also made by adding the total quantity of irrigation water applied during the growth period of wheat, plus or minus the difference in soil moisture at sowing and harvest time. The potential evapotranspiration was calculated by the Jensen-Haise method. The crop was harvested on 30 April 1974 and yield estimation was made by harvesting an area of 45' x 24' from each plot. The following tentative conclusions were drawn:

1. The consumptive use of water for wheat came to 18.10, 18.37 and 13.92 inches when the crop was irrigated at 1, 2 and 4 bar tensions, respectively.

2. There were no significant differences in wheat yields among the treatments. Therefore, an appreciable amount of water can be saved by using no more than 14 inches of water from irrigation, rainfall and moisture available in the soil without loss in production.

3. Growing season for the crop coefficients, relating actual to potential evapotranspiration, averaged 0.76 for the 1 and 2 bars stress and 0.59 and 4 bars stress.

4. During the active growing period of wheat the experimentally obtained value of evapotranspiration agreed reasonably well with the potential evapotranspiration calculated by the Jensen-Haise method. At early and late stages of growth, the actual evapotranspiration was lower than the potential as expected.

ESTIMATION OF CONSUMPTIVE USE OF WATER FOR WHEAT UNDER OPTIMUM MANAGEMENT CONDITIONS

G. Haider [1], M.A.R. Farooqi [2] and C. J. deMooy [3]

CHAPTER I

INTRODUCTION

Pakistan is predominately an agricultural country. Inspite of favorable conditions of soils, irrigation water and climate, agriculture in the country suffers from under production both in terms of yield per acre and production per farm worker. The country is heavily dependent on agriculture for food and fibre requirements of the ever increasing population. In order to cope with these requirements, it is essential to increase food and fibre production not only to attain self sufficiency but also to the extent of exportable surplus for earning foreign exchange.

Agriculture in the country mainly depends on irrigation. Unfortunately, present irrigation supplies in the country are inadequate. In major part of the canal irrigated areas, one cusec of water is provided for 350 acres whereas the same quantity is hardly sufficient to meet the water requirements of crops including leaching requirements, for 100 to 150 acres. Inadequate irrigation supply is one of the major constraints in agricultural production. the irrigation supplies can be improved in two ways:

1. Exploiting new resources i.e., construciion of more dams and tubewells.

2. Conserving the existing irrigation supplies by making the most efficient use of the available water through reduction of undue wasteages such as seepage, over spilling, leakage, overirrigation of crops, etc.

The former method of improving irrigation supplies is very expensive and time consuming. It will take decades before such programs are executed. The latter method, however, affords an opportunity of adopting quick measures to increase the irrigation supplies by reducing the loss of existing irrigation supplies. The International Commission on Irrigation and Drainage has also stressed the need of conservation of the existing supplies on a world wide scale when they pointed out:

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2/ Junior Research Officer, Mona Reclamation Experimental Project, WAPDA, Bhalwal.

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"Conservation of water supplies is becoming increasingly important as the demand continues to increase and new sources of supply become harder to find. The time is rapidly approaching when the only additional natural water supplies available will be those salvaged from loss through transpiration, evaporation, consumptive waste, inefficient storage and transportation practices. Principles of conservation require that full use be made of our natural water supplies, and the greatest results probably can be accomplished on most irrigation projects by a reduction in amount of water lost through seepage during transportation to the farmers fields".

Irrigation experts are of the opinion that by checking the conveyance and field application losses, water savings of the order of that provided by Tarbela Dam can be effected. Another major source of saving irrigation water is to irrigate the crops when required and to apply water just sufficient to meet the actual water requirement of the crops. By overirrigation water is not only wasted but crop yields are also adversely affected. Similarly, by underirrigation the yield of crops is drastically reduced. In order to conserve the irrigation supplies and to increase crop yields, it is essential to know the actual consumptive use water requirements of crops grown in the country. The knowledge of consumptive use of major crops will not only enable the cultivators to make the most efficient and economical use of the available irrigation supplies but will also help the planners to fix more realistic and reliable targets of crop acreages and production.

Wheat is one of the most important food crops in Pakistan. It occupies by far the largest area under crops. The Government of Pakistan is doing everything within her means to increase wheat production to attain self sufficiency in food. Little field work has been done to determine the consumptive use of wheat in Pakistan. Although, estimation of water requirements of wheat have been made by certain workers, their estimations are either based on hypothetical calculations made by using climatological data or on lysimeter studies. Reliable information about actual water requirements of crops based on carefully conducted field studies is lacking. Consequently, this study was carried out to estimate the consumptive use water requirement of wheat under optimum conditions of management, mineral nutrition, and water supply on demand indicated by soil moisture tension.

Mona Reclamation Experimental Project was conceived as a pilot project, to develop new criteria for the optimum use of land and water resources and to formulate new concepts, for obtaining the rapid development of agriculture in the Indus Plains. In order to achieve these objectives, an area comprising of 1,10,000 acres was selected in the North Central Portion of Chaj Doab (Figure 1.). The project came into operation during November 1965. One of the major objectives of this project was to develop new criteria for the optimum use of water resources. The present study was undertaken in Mona Reclamation Experimental Project, in collaboration with Colorado State University, USAID. The data presented in this report was collected during rabi 1973-74.

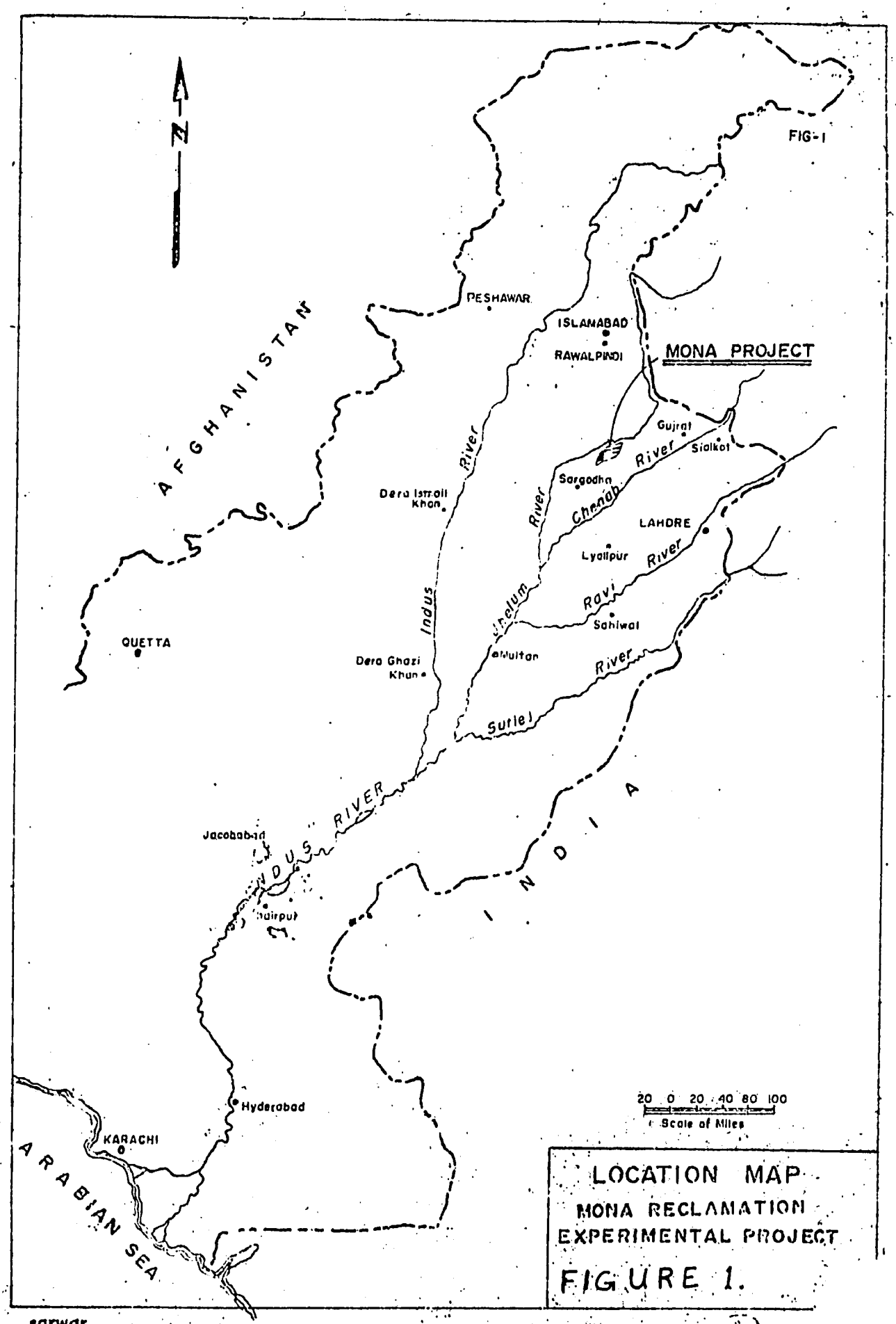
FIG-1
N
AFGHANISTAN
PESHAWAR
ISLAMABAD
RAWALPINDI
MONA PROJECT
Gujrat
Sialkot
Sargodha
Dera Ismail Khan
Indus River
Jhelum River
Chenab River
LAHORE
Lyallpur
Ravi River
Sahiwal
QUETTA
Dera Ghazi Khan
Multan
Sutlej River
INDUS RIVER
Jacobabad
Khairpur
INDIA
Hyderabad
KARACHI
ARABIAN SEA
20 0 20 40 80 100
Scale of Miles
LOCATION MAP
MONA RECLAMATION
EXPERIMENTAL PROJECT
FIGURE 1.
sarwar

CHAPTER II

REVIEW OF LITERATURE

Considerable work has been done on consumptive use of crops by various workers in different countries. In Pakistan as well some work has been done on estimation of consumptive use of water of crops by certain workers but their findings are either based on estimation made in lysimeters, or from calculations using empirical coefficients developed from climatological data. Little work has been done in the country on estimation of consumptive use of crops in the field, based on soil moisture depletion method. The findings of various workers are however, reported as follows:

By computations

Blaney and Criddle (1957) calculated the evapotranspiration amounts for wheat to be 16 inches. Similarly, Asghar and Ahmad (1962) and Revelle et al (1964) reported that evapotranspiration amounts in case of wheat was 14 and 13 inches, respectively. M/s Hunting Technical Services Ltd., (1966) calculated consumptive use of water for wheat in Hyderabad area to be 16.3 inches. These findings were based on hypothetical calculations using climatological data.

Dastane, (1966) worked out corelations between values of actual consumptive use and those computed by using various empirical equations in optimum moisture regions. In case of wheat the corelation values for Penman, Thornthwaite and U. S. Open Pan Evaporation Methods were 0.982, 0.939 and 0.998 respectively. He reported that total evapotranspiration in case of wheat was 13.0 inches.

M/s Harza Engineering Company, Int. (1968) determined the consumptive use of water of various crops using the evaporation index method. The findings were based on studies carried out in USA. The computation from USA to determine crop use coefficients were modified to make them applicable to conditions in Pakistan. Based on hypothetical calculations they reported that consumptive use of water for wheat was 15.87 inches. The Ministry of Agriculture (1971) computed the consumptive use of different crops using climatological data. It was found that the consumptive use coefficient (K) for wheat was 0.61 for Ludhiana and Poona districts of India.

Clyma (1973) advocated the Jensen-Haise method for estimating evapotranspiration for crops. He estimated mean annual potential evapotranspiration for Sargodha to be near 6 feet per year. With wheat during rabi and cotton during kharif, evapotranspiration ranged from 3.6 feet in a wet year to 4.0 feet in a dry year. He calculated net evapotranspiration amounts of wheat grown in Sargodha under wet and dry seasons as 6.8 and 16.3 inches respectively.

Lysimeter studies

In a lysimeter study Asghar et al (1962) found that wheat crop used

19.87 inches of water during its growing season, when the water table was kept at 10.5 feet. In a similar lysimeter study Hussain (1970) calculated the water requirements of crops in West Pakistan. He found that the consumptive use of wheat was 13.27 inches. He further reported that the consumptive use for wheat (indigenous) and wheat (Mexipak) was 13.34 and 20.54 inches respectively. Using climatological data, the author worked out the crop coefficients (K) for wheat to 0.50.

Ali, et al (1973) calculated the consumptive use of common crops in lysimeters keeping the goundwater table at various depths. They used climatological data and worked out empirical consumptive use coefficients. They found that the consumptive use of wheat (Mexipak) grown with the groundwater at a depth of 5, 7 and 9 feet was 21.50, 19.0 and 19.2 inches, respectively

Field studies

Khan, et al (1968) while comparing the effect of varying quantities of water on yield of wheat (Mexipak) found that the water requirement of wheat was 20.6 inches. They observed that this delta of water was optimum for obtaining maximum yields. These findings were, however, not based on actual consumptive use estimations. Hussain and Asghar (1969) reported that water requirements of wheat grown at various places in West Pakistan varied from 13.50 inches to 23.88 inches.

Assifi (1970) estimated that consumptive use of wheat grown in Helmand Valley Shamalan was 20.10 inches. He tabulated the monthwise consumptive use of water and concluded that the minimum requirement was in the month of January and maximum in May.

Unpublished data from Punjab Agricultural Research Institute, Lyallpur and Directorate Mona Reclamation Experimental Project, Bhalwal indicated that wheat should be irrigated at 25% of the available moisture left in the soil and at 65% of the field capacity respectively.

CHAPTER III

PROCEDURE

Selection of site:

One acre field of medium to fine textured, non-saline, non-alkali soil was selected in Mona Project area during kharif, 1973. The field was lying fallow at the time of selection. It was properly leveled. In the process of leveling the top 6 inches of soil from one-fourth of the area (replication 4) was removed and spread over the remainder of the field. The soil texture in replication 4 plots was relatively coarse compared with the other replications. Chemical and physical characteristics of the soil are given in Table 1. To ensure that the crop would not use groundwater the site was selected so that the water table was at least 15 feet below the surface.

Treatments:

Moisture and fertilizer treatments were applied in 3 x 2 factorial design with 4 replications. The following treatments were applied:

Treatment	Number	Description
Soil Moisture stress	3	Irrigation was applied at moisture stress level of 1, 2 and 4 bar tensions at a depth of top 0-6 inches (treatments M_1, M_2 and M_3, respectively.
Fertility (N, P_2O_5, K_2O)	2	High: 150-75-30 (treatment F_1) Low:: 50- 0-30 (treatment F_2)
Replications	4	R_1, R_2, R_3, R_4

Total number of plots 3x2x4 = 24

Field Layout:

The field was divided into 24 plots of equal size. Individual plot bunds and field watercourses were so constructed that all the plots had direct access to water. The plot size was 51' x 28' i.e., 1/30th of an acre. The layout plan is presented in Appendix I. A fine seed bed was prepared before sowing of wheat.

Fertilizer application:

Two rates of fertilizer viz., high and low, were applied. The high rate NPK consisted of 150-75-30 whereas the low rate represented the fertilizer application on the average farm 50 lbs of N per acre. A blanket application of 30 lbs. of K_2O was applied over the entire area to eliminate any chances of K deficiency. The fertilizer doses were applied in two parts. All phosphorus and potash were applied to the respective plots just before sowing. Half the nitrogen at the high rate also was applied before sowing.

Table 1. Initial Physico-Chemical Condition of the Soil

A. PHYSICAL ANALYSIS

Sampling depth (inches)	Mechanical Analysis				Field Capacity (%)	Bulk Density (g/cm^3)	Wilting Point (%)
	Clay (%)	Silt (%)	Sand (%)	Textural Class			
0-6	24.58	34.62	40.37	Loam	18.6	1.52	6.9
6-12	32.42	36.17	31.50	Clay loam			
12-24	35.21	35.21	29.58	Clay loam			
24-36	35.83	35.12	28.62	Clay loam			
36-48	36.25	35.87	27.96	Clay loam			
48-60	36.58	34.85	28.83	Clay loam			

Infiltration rate

Inches of water percolated after (hours)					
1	2	3	4	5	6
0.97	1.30	1.52	1.68	1.78	1.87

B. CHEMICAL ANALYSIS

Sampling depth (inches)	Salinity			Fertility		
	ECe x 10^3	SAR	pH	N (%)	P_2O_5 (ppm)	K (lbs/acre)
0-6	1.6	2.8	8.0	0.10	2.5	390
6-12	1.5	3.1	8.1			
12-24	1.3	3.6	7.9			
24-36	1.4	3.3	7.8			
36-48	1.3	3.4	7.8			
48-60-	1.5	3.4	7.8			

The remainder and all the nitrogen at the low rate were applied at the time of first irrigation. The nitrogen was applied in the form of urea and diammonium phosphate, phosphorus in the form of diammonium phosphate and potash in the form of potassium sulphate. The calculated quantities of fertilizer were broadcast in the respective plots and mixed with the soil by ploughing.

Sowing of wheat.

Wheat variety Chenab-73 was sown in rows 9" apart with the help of a rabi drill on 17 November, 1973. The seed rate used was one maund per acre. Germination of wheat started after about one week and was completed within two weeks. Germination was very good. Wheat was also sown in all the fields surrounding the experimental area to avoid oasis effect. The details of various cultural operations carried out are presented in Appendix V.

Irrigation:

The soil moisture tension curve was determined in the laboratories of the Central Monitoring Organization, Lahore, on samples from surface and sub-surface soil using porous plate and pressure membrane before the experiment was laid out (Appendix III). The irrigation was given at 3 levels of moisture stress i.e , at 1, 2 and 4 bar tensions; each aimed at optimum production of wheat. The three moisture stress levels amounted to 13.3, 11.0 and 8.6 precent by weight of moisture, respectively in the top 6" of soil. This corresponds to 54.7, 35.0 and 14.5 percent of the available moisture remaining in the top 6" soil or to 71.5, 59.9 and 46.2 percent of field capacity, respectively. The field capacity of the soil was 18.6 and wilting point 6.9 percent. These plots were irrigated as soon as the desired stress was reached in the top 0-6 inches soil. Pure tubewell water, the chemical composition of which is given below, was used for irrigation.

pH	Conductivity micromhos/cm	TDS ppm	SAR	RSC me/l
7.5	900	576	2.8	0

The schedule of irrigation is presented in Appendix IV.

The depth of irrigation to be applied to each plot was calculated from the pre-irrigation soil moisture content. To find out the moisture status of the soil, moisture samples were taken at sowing and before and after each irrigation down to a depth of 5 feet i.e., from 0-6, 6-12, 12-24, 24-36, 36-48 and 48-60 inches depth. The quantity of each irrigation applied was calculated on the basis of moisture deficit of the soil as indicated by pre-irrigation moisture sampling. Each irrigation restored the moisture level of the soil down to 5 feet depth to field capacity. This was done to prevent loss of water through leaching. For the purpose of applying the measured quantity of irrigation water, a cutthroat flume of 4" x 3' size was installed near the point where the water entered the field. The time required to obtain the desired depth of irrigation for each plot

was calculated from the following formula:

$$t = \frac{d \times a}{q}$$

where t is time in hours, d is depth of water to be applied in inches, a is area in acres and q is discharge of the outlet in cusecs. A flow of 1 cusec per hour is practically equal to 1 acre inch of water.

Installation of tensiometer and gypsum blocks:

Tensiometers and gypsum blocks were installed in 2 replications to indicate crop needs for irrigation water. The tensiometers and gypsum blocks were placed at depths of 9" and 18". They were used only to assist in determining the correct timing of irrigation. The quantity of irrigation water needed was calculated from the field capacity of the surface 5 feet of soil minus the water content of soil measured gravimetrically on samples taken before each irrigation.

Moisture sampling:

The first soil sampling for moisture estimation was done at the time of planting of wheat and the subsequent moisture samplings were carried out as close before and after every irrigation as possible. Moisture samples were also collected in between irrigations to check depletion of moisture in the soil. After each substantial rain, moisture samples were also taken. Final moisture sampling was done at the time of harvest. Soil samples for moisture estimation were taken at an interval of one foot to a depth of 5 feet with the exception of surface layer which was divided into 0-6 and 6-12 inches depths. Each sample was composited from 2 randomly located spots in each plot. The samples were dried in the oven at 105°C to a constant weight and moisture was calculated on dry weight basis.

Rainfall:

Rainfall data was collected from the rain gauge station at Miani Rest House which was about two miles from the experimental site. The record of rainfall is given in Appendix V.

Lodging of wheat:

Due to a wind storm on 16 March 1974, heavy lodging of wheat occurred. Other windstorms on 25 March 1974 and 29 March 1974 followed by rains caused most of crop to lodge. The intensity of lodging of crop at harvest is given in Appendix VI.

Consumptive use computations:

Wheat was sown on 17 November 1973 and harvested on 30 April 1974. Four irrigations were given to 1 and 2 bar tension plots and two irrigations to 4 bar tension plots. The consumptive use of water for wheat was worked out by two independent methods. Firstly, by gravimeteric measurement of soil moisture depletion wherein consumptive use was calculated by adding the water loss between soil samplings i.e., after and before irrigations, plus pan evaporation for three days after each irrigation, plus rainfall (assuming all rainfall was effective), plus actual evapotranspiration estimated from

soil moisture depletion graph for the days not otherwise accounted for (Figures 5 to 7). These days included water loss from the time of last sampling before each irrigation up to the actual time of irrigation, and water lost from the end of the 3rd day after each irrigation (pan evaporation accounted for the first 3 days after each irrigation) up to the actual time of soil sampling after each irrigation. The estimates were made by extrapolation of the graph of soil moisture depletion. Dividing the total water used between two irrigations by the number of days between these irrigations, the consumptive use per day was also calculated.

Secondly, the estimation of the consumptive use was also made by adding the total quantity of irrigation water applied during the growth period of wheat plus or minus the difference in soil moisture at sowing and harvest time. Potential evapotranspiration for wheat was also calculated by using Jensen-Haise equation (10 and 11).

Yield estimation:

Yield estimation was made through crop cutting method. For this purpose an area of 45' x 24' was harvested from each plot and yield per acre was calculated. The crop from the harvested area was separately thrashed, winnowed and weighed for yield estimation. The details of wheat yield are given in Appendix VII.

CHAPTER IV

RESULTS AND DISCUSSION

Consumptive use:

The consumptive use of water was determined by two independent methods. Firstly, by measurements of soil moisture depletion in the field and secondly by adding the total quantity of water, i.e. irrigation plus rainfall, applied together with the difference in soil moisture present at sowing and harvest time. The results presented in Tables 2 to 4 are derived by the former method. The data show that the consumptive use of water for wheat (Chenab-70) was 18.10, 18.37 and 13.92 inches when the crop was irrigated at 1, 2 and 4 bar tensions, respectively. Measurements of consumptive use based on the total amount of irrigation applied resulted 19.52, 18.73 and 16.07 inches for 1, 2 and 4 bar tension treatments, respectively (Table 5). The consumptive use values derived from gravimetric estimations agree closely with those obtained from the total amount of irrigation water applied. The latter values for the 1 and 4 bar tension levels were somewhat higher indicating possible seepage losses.

It is obvious from Tables 2-4 that there was no significant difference in consumptive use of water for 1 and 2 bar tension treatments, as measured by soil moisture depletion method. At the 4 bar tension level, the consumptive use was significantly lower compared with 1 and 2 bar tensions. The low consumptive use in 4 bar tension plots was probably due to the moisture stress imposed. As a result the vegetative growth of crops in these plots was comparatively less than 1 and 2 bar tension plots.

The experimentally obtained evapotranspiration rates at different stages of wheat growth and the potential evapotranspiration rates as computed by the Jensen-Haise equation (10 and 11) are presented in Figures 2 and 3. The data indicate that the experimentally obtained values of evaporation rates agree fairly well with the potential evapotranspiration rates during the active growth period of the crop i.e., between January 15 to March 30. At the early and late stages of growth, the experimentally obtained values were low compared with the calculated values of evapotranspiration. This is to be expected because during the early stages the plants are small and the crop cover is incomplete as such the soil moisture is not used to its full potential. Similarly, at the late growth stage i.e., near maturity the plants dry up and hence transpire less water. The main source of water loss during these stages is through evaporation. In 4 bar tension plots, the experimentally obtained rates of evapotranspiration were low throughout the growth period compared with the calculated rates (Figure 4). This may be due to moisture stress imposed in this treatment. From figures 2, 3 and 4 it is seen that during March evapotranspiration rates were the highest. During this period, the weather starts getting hot, the canopy cover is complete and this combination of factors raises the water requirements of the plants. The actual and potential evapotranspiration rates for the 1, 2 and 4 bar stress levels are given in Appendices VIII and IX.

The distribution of moisture in the soil up to 5 feet depth, during the growing season of wheat, is shown in figures 5 to 7. It is seen from

Table 2. Computation of consumptive use of water for wheat 1973-74 (Moisture level M_1^+)

Irrigations	Rauni		10-1-74		12-2-74		9-3-74		5-4-74	
Soil depth at sowing inches	17-11-73	B.N.I* 3-1-74	A.I** 16-1-74	B.N.I. 8-2-74	A.I 21-2-74	B.N.I. 5-3-74	A.I 18-3-74	B.N.I. 29-3-74	A.I. 13-4-74	At Harvest 30-4-74
0-6	1.10	1.19	1.75	1.10	1.37	0.96	1.31	1.03	1.40	0.54
6-12	1.31	1.32	1.56	1.37	1.40	1.22	1.33	0.98	1.42	0.81
12-24	3.07	3.03	3.20	3.00	3.22	2.94	2.92	2.53	2.90	2.28
24-36	3.03	2.94	3.16	2.66	2.86	3.11	2.98	2.75	2.71	2.55
36-48	3.09	2.70	3.15	2.88	3.50	3.24	3.13	2.94	2.92	2.77
48=60	2.94	3.05	3.16	3.00	3.48	3.31	3.26	3.11	3.07	2.92
Inches of water in 0-60" of soil	14.54	14.23	15.98	14.01	15.83	14.78	14.93	13.34	14.42	11.87
Water used between samplings		0.31		1.97		1.05		1.59	2.55	
Pan evapo.		0.00		0.31		0.34		0.61	0.59	
Rainfall	0.05+0.20+0.30 = 0.55		0.40+0.05 = 0.45		0.85+0.05 = 0.90		0.05,(0.60+0.30) = 0.05		(0.15+0.08) 0.00	
Estimation from graph		0.23		0.31+0.10 = 0.41		0.63+0.28 = 0.91		2.47+0.85+0.30 = 3.62	1.56+0.10 = 1.66	
Water used between irrigations		1.09		3.14		3.20		5.87	4.80	Total = 18.10
No. of days between irrigations		54		33		25		27	27	
Consumptive use/day (inches/day)		0.020		0.095		0.128		0.217	0.178	

Consumptive use of water by the crop over the whole period = 18.10".

+M! = Irrigation given at 1 bar tension

∓ Compensation made in estimation

* B.N.I. = Before next irrigation

** A.I. = After irrigation

Table 3. Computation of Consumptive use of water for wheat 1973-74 (Moisture Level M_2^+)

Irrigations	Rauni	10-1-74		12-2-74		9-3-74		5-4-74	
Soil depth inches	At sowing 17-11-73	B.N.I* 3-1-74	A.I. ** 16-1-74	B.N.I 8-2-74	A.I. 21-2-74	B.N.I. 5-3-74	A.I. 18-3-74	B.N.I. 30-3-74	A.I. At harvest 13-4-74	30-4-74
0-6	1.11	1.22	1.81	1.17	1.10	0.89	1.37	0.95	1.56	0.59
6-12	1.47	1.44	1.61	1.48	1.37	1.19	1.46	0.99	1.54	0.90
12-24	3.11	3.15	3.33	3.28	3.15	2.86	3.11	2.47	3.11	2.32
24-36	3.20	3.01	3.29	2.68	3.31	3.00	3.13	2.71	2.79	2.77
36-48	3.18	2.94	3.22	2.94	3.39	3.09	3.22	2.90	2.88	2.58
48-60	3.22	2.86	3.28	2.98	3.39	3.28	3.31	3.11	3.07	2.98
Inches of water in 0-60" of soil	15.2	14.62	16.54	14.53	15.71	14.31	15.60	13.13	14.95	12.14
Water used between samplings		0.67		2.01		1.40		2.47		2.81
Pan evapo.		0.00		0.31		0.34		0.61		0.59
Rainfall		0.05+0.20+0.30 = 0.55		0.40+0.05 = 0.45		0.85+0.05 = 0.90		0.05+0.60,(0.30)∓ = 0.65		(0.15+0.08)∓ 0.00
Estimation from graph		0.12		0.26+0.15 = 0.41		0.39+0.21 = 0.60		1.30+0.53+0.30 = 2.13		1.15 + 0.20 = 1.35
Water used between irrigations		1.34		3.18		3.24		5.86		Total 4.75=18.37
No. of days between irrigations		54		33		25		27		27
Consumptive use/day (inches/day)		0.025		0.096		0.130		0.217		0.176

Consumptive use of water by the crop over the whole period = 18.37 "

$+M_2$ = Irrigation given at 2 bars tension

∓Compensation made in estimation

* B.N.I. = Before next irrigation

** A.I. = After irrigation

Table 4. Computation of consumptive use of water for wheat 1973-74 (Moisture Level M_3^+)

Irrigations	Rauni		10-1-74		14-3-74	
Soil depth inches	At sowing 17-11-73	B.N.I * 3-1-74	A.I. ** 16-1-74	B.N.I. 11-3-74	A.I. 30-3-74	At harvest 2-5-74 30-4-74
0-6	1.11	1.20	1.68	0.77	1.10	0.51
6-12	1.34	1.36	1.59	0.99	1.13	0.70
12-24	2.83	2.88	3.16	2.43	2.64	1.93
24-36	3.05	2.77	3.20	2.71	2.64	2.25
36-48	3.07	2.94	3.07	2.92	2.79	2.38
48-60	3.05	2.85	3.13	3.05	2.88	2.70
Inches of water in 0-60" soil depth	14.45	14.00	15.83	12.87	13.18	10.47
Water used between samplings	0.45		2.96		2.71	
Pan evapo.	0.00		0.31		0.68	
Rainfall	0.05+0.20+0.30 = 0.55		0.40+0.05+0.85≠ 0.05+0.65 = 2.0		(0.05+0.60)≠ 0.30+0.15+0.08= 0.53	
Estimation from graph	0.30		0.17+0.26+0.10 = 0.53		2.80+0.10 = 2.90	
Water used between irrigations	1.30		5.80		6.82	
No. of days between irrigations	54		63		49	
Consumptive use/day (inches/day)	0.024		0.092		0.139	

Consumptive use of water by the crop over the whole period = 13.92"

+M_3 = Irrigation given at 4 bars tension

≠Compensation made in estimation

* B.N.I. = Before next irrigation

** A.I. - After Irrigation

Table 5. Consumptive use of water of wheat from Measurement of irrigation water applied (inches)

Source	Moisture stress level (bars) 1	2	4
Amount of irrigation applied	13.77	12.50	9.01
Rainfall	3.08	3.08	3.08
Differential at sowing and harvest	2.67	3.15	3.98
Total	19.52	18.73	16.07

these figures that moisture in the soil increased after each irrigation and then started decreasing as the soil moisture depleted due to evapotranspiration. A similar trend was observed after each rain. In the 1 and 2 bar tension plots the total moisture in the soil up to 5 feet depth varied between 12 and 18 inches (figures 5 and 6), whereas in the 4 bar plots total moisture in the soil varied between 10 and 17 inches (figure 7).

For 3-4 days after irrigation, the actual evaporation from the field surface approaches the rate of evaporation from an open pan. The soil is too wet for moisture sampling to be carried out and daily open pan evaporation measurements were used to estimate evapotranspiration for the period from irrigation up to three days after irrigation. When soil sampling was delayed beyond 3 days after an irrigation for any reason, the rate of evapotranspiration for the period from the end of 3rd day after irrigation up to the actual sampling date was estimated from the soil moisture depletion graphs (figures 5 to 7). Extrapolation of the curves presenting measured evapotranspiration was used also to cover the period between soil sampling and the next irrigation.

Crop coefficients (Kc) were calculated from potential and actual evapotranspiration data presented in tables 2, 3 and 4 and figures 2, 3 and 4. The crop coefficients for wheat grown during rabi 1973-74 are presented in Figures 8 and 9. The mean values for 1 and 2 bar tension plots (Figure 8) are higher than at the 4 bar stress level shown in figure 9. The coefficients varied between 0.14 and 0.98 depending on the stage of growth. The average Kc values for the growing season for the 1 and 2 bar treatments came to 0.74 and that for 4 bar tension plots to 0.57. The values are lower than those reported by Dastane (7) but are higher than the one given by Hussain (8). The depression in the curve during the months of January and February is difficult to explain. This may be due to reduction in actual evapotranspiration caused by unusually heavy fog during this period or random variation.

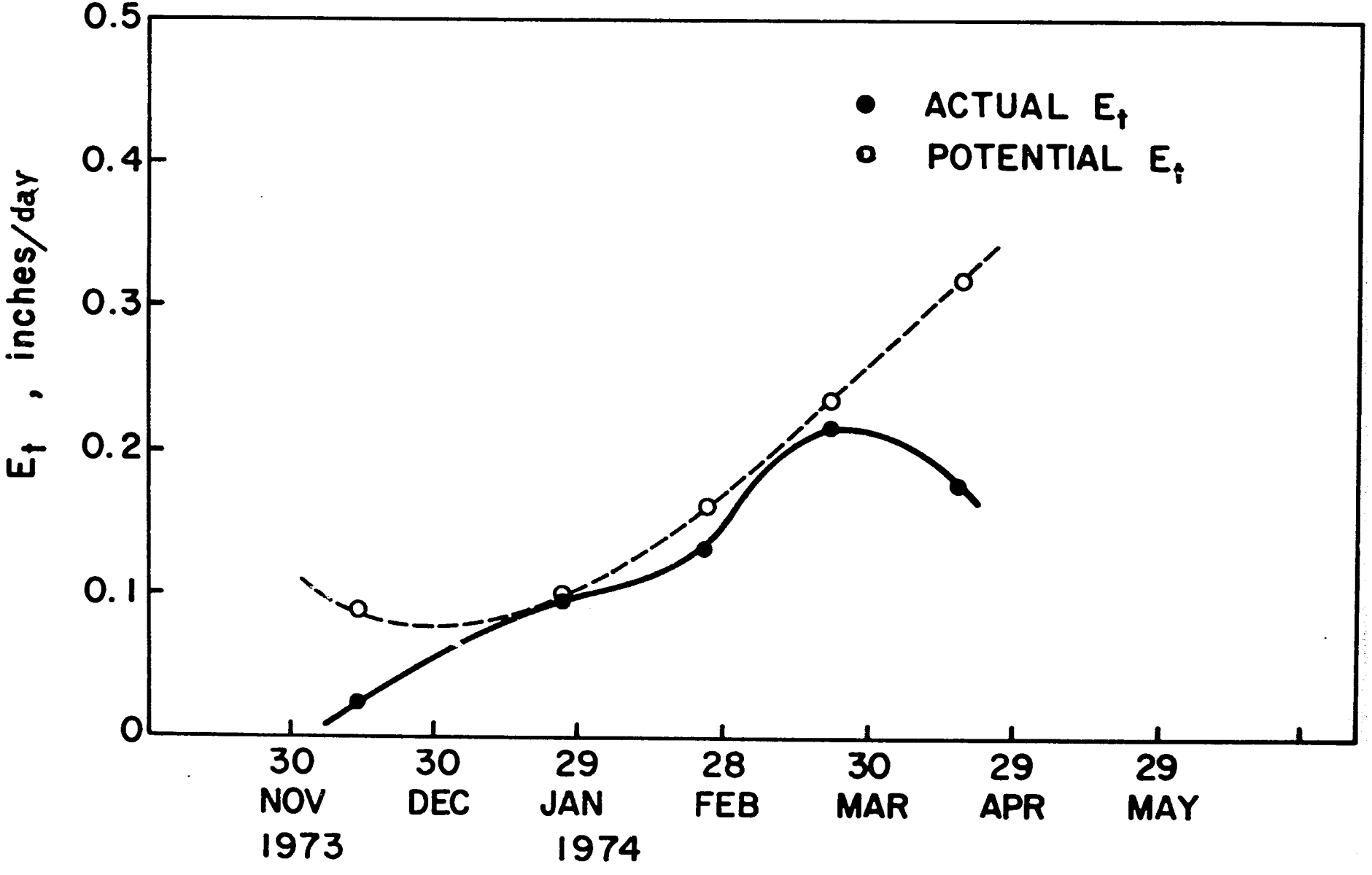

Figure 2. Actual and potential E_t rates for wheat irrigated at 1 bar tension in surface 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

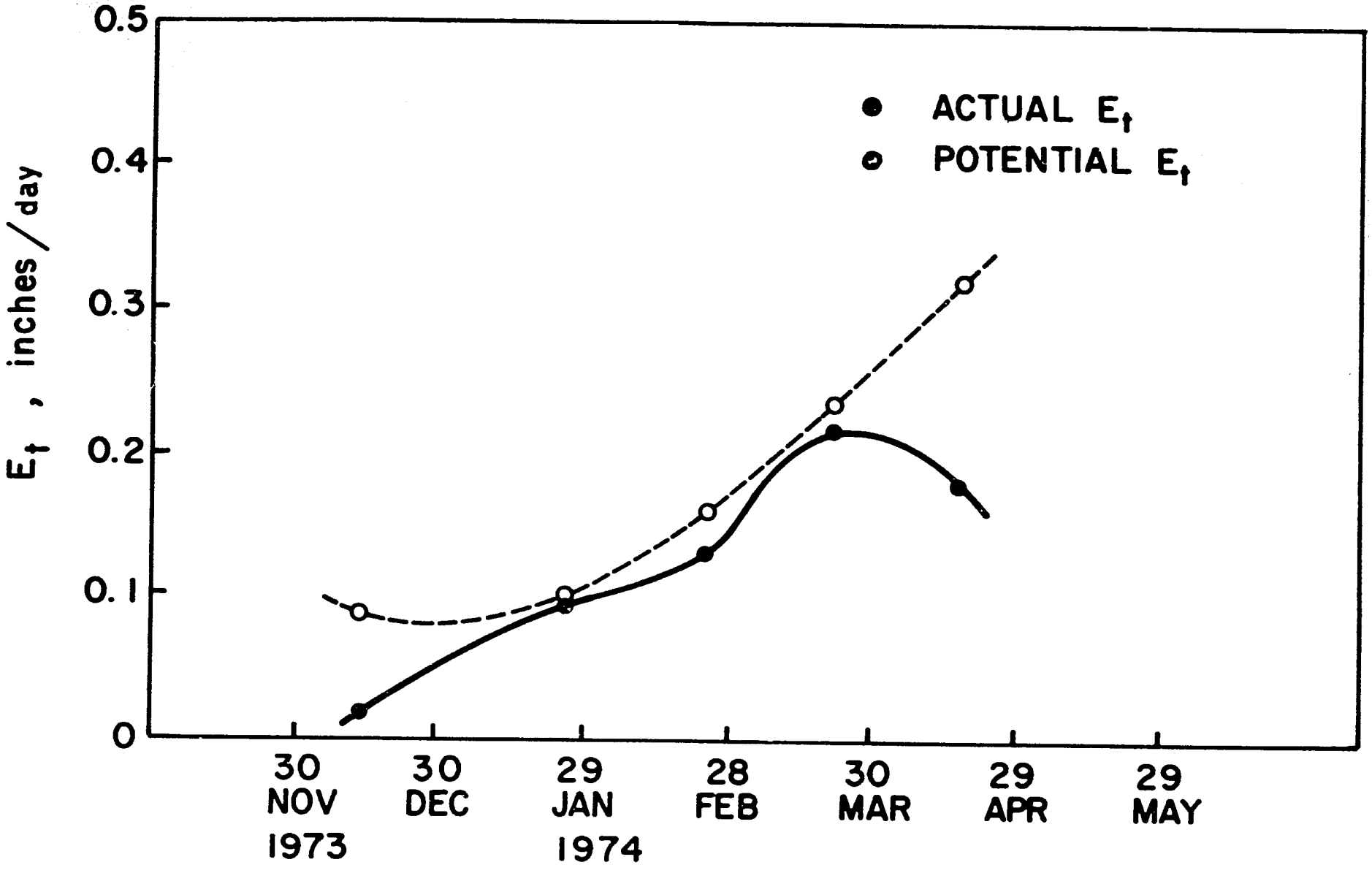

Figure 3. Actual and potential E_t rates for wheat irrigated at 2 bars tension in surface 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

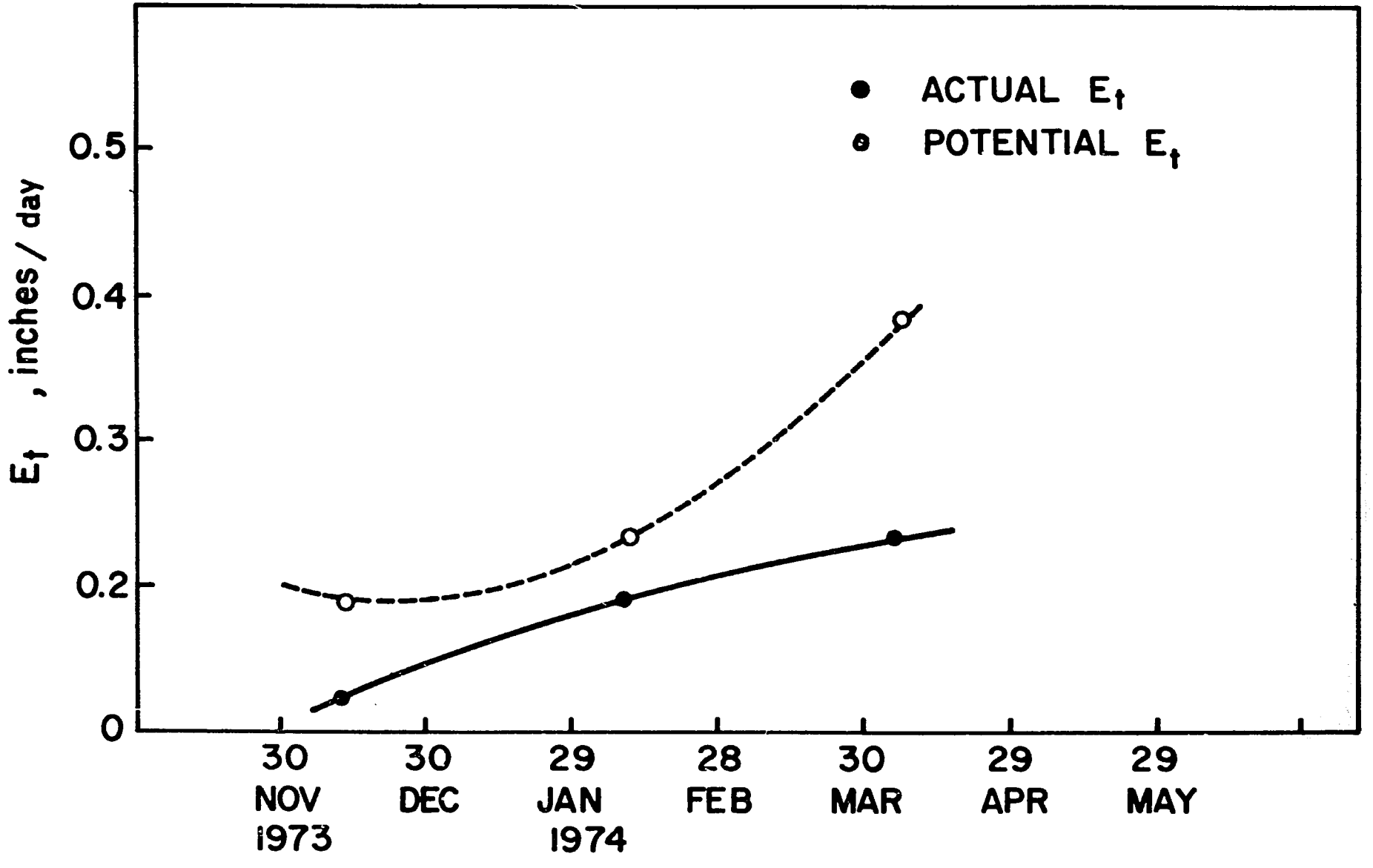

Figure 4. Actual and potential E_t rates for wheat irrigated at 4 bars tension in surface 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

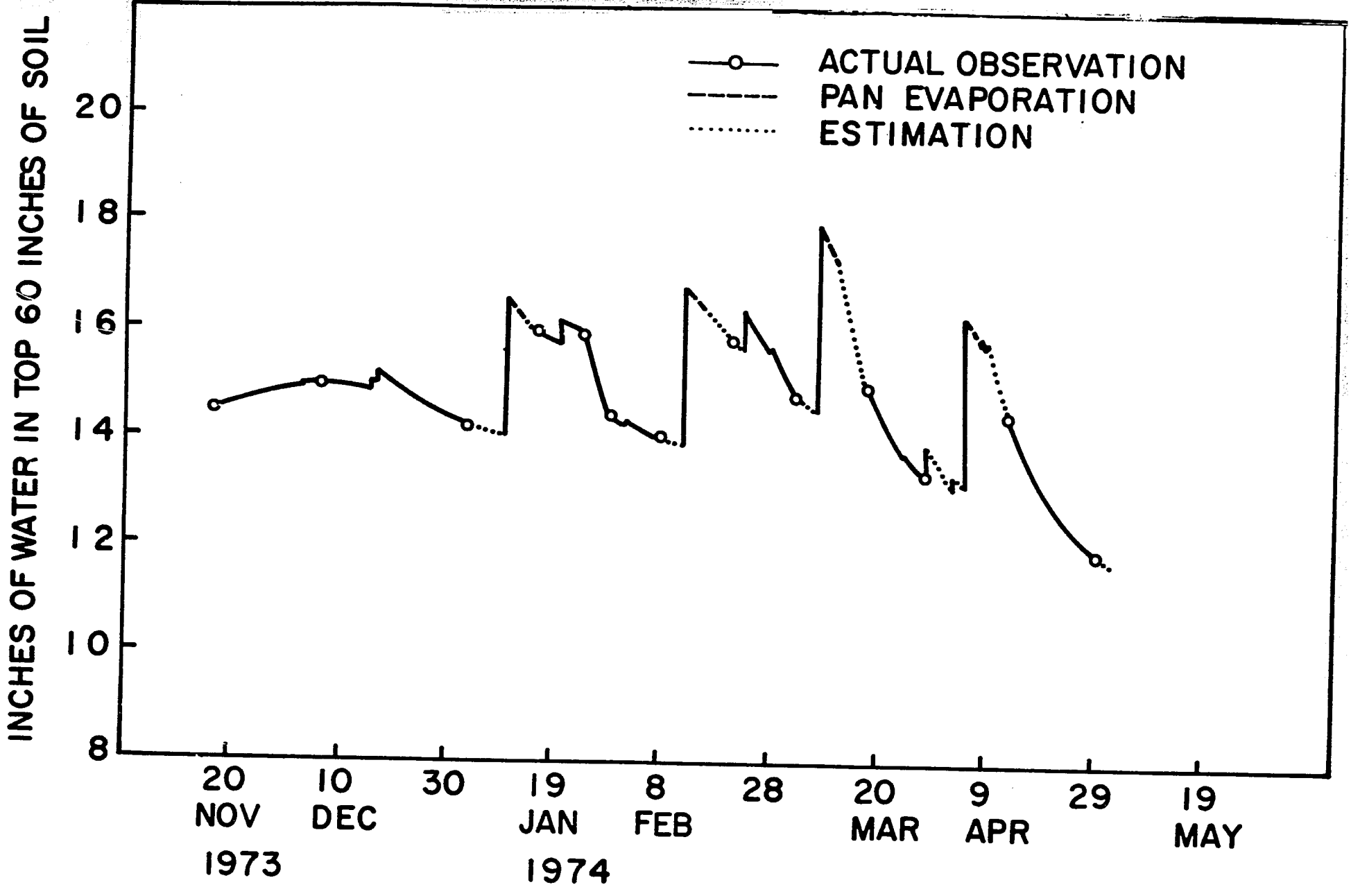

Figure 5. Variation in soil moisture content under wheat irrigated at 1 bar tension in top 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

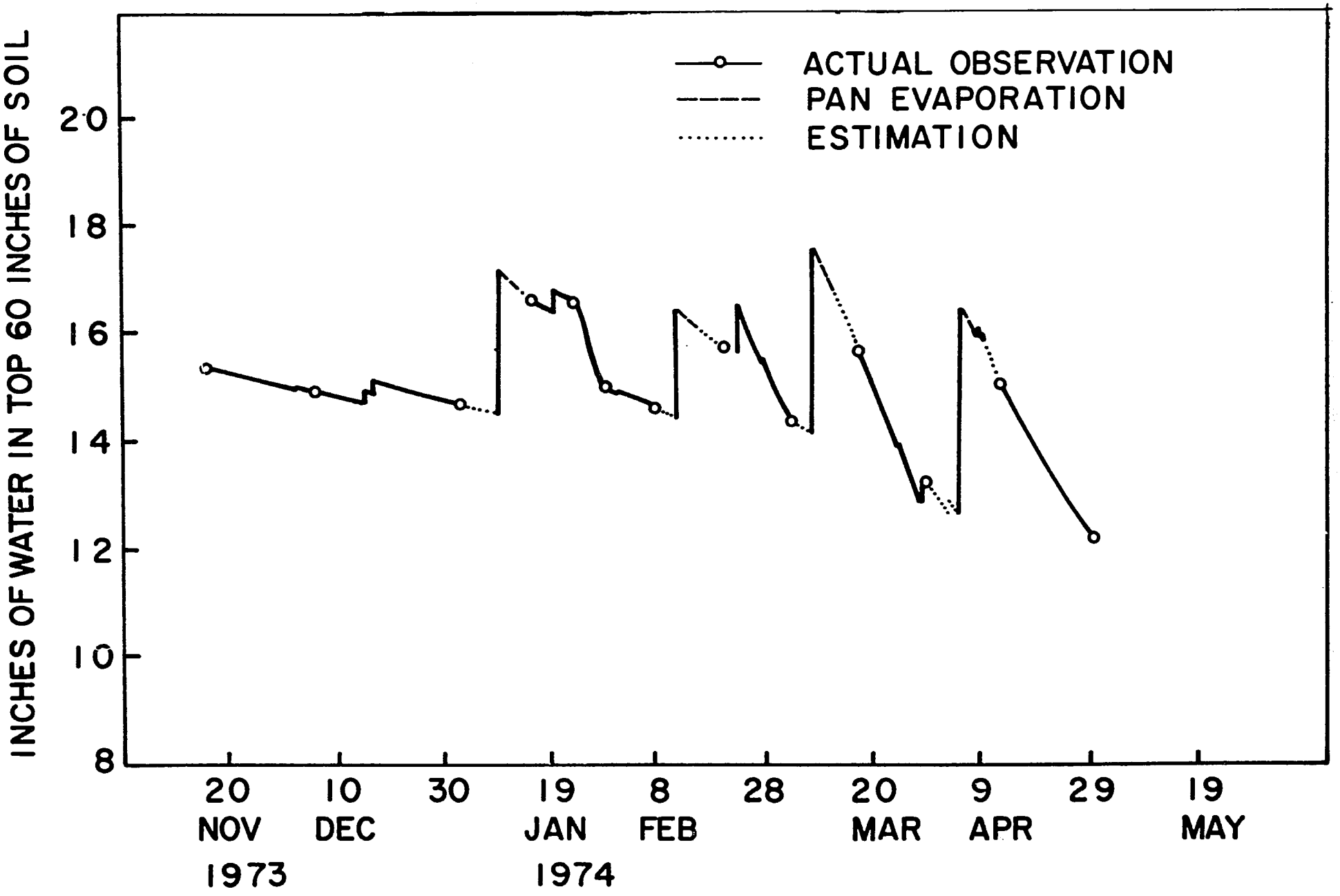

Figure 6. Variation in soil moisture content under wheat irrigated at 2 bars tension in top 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

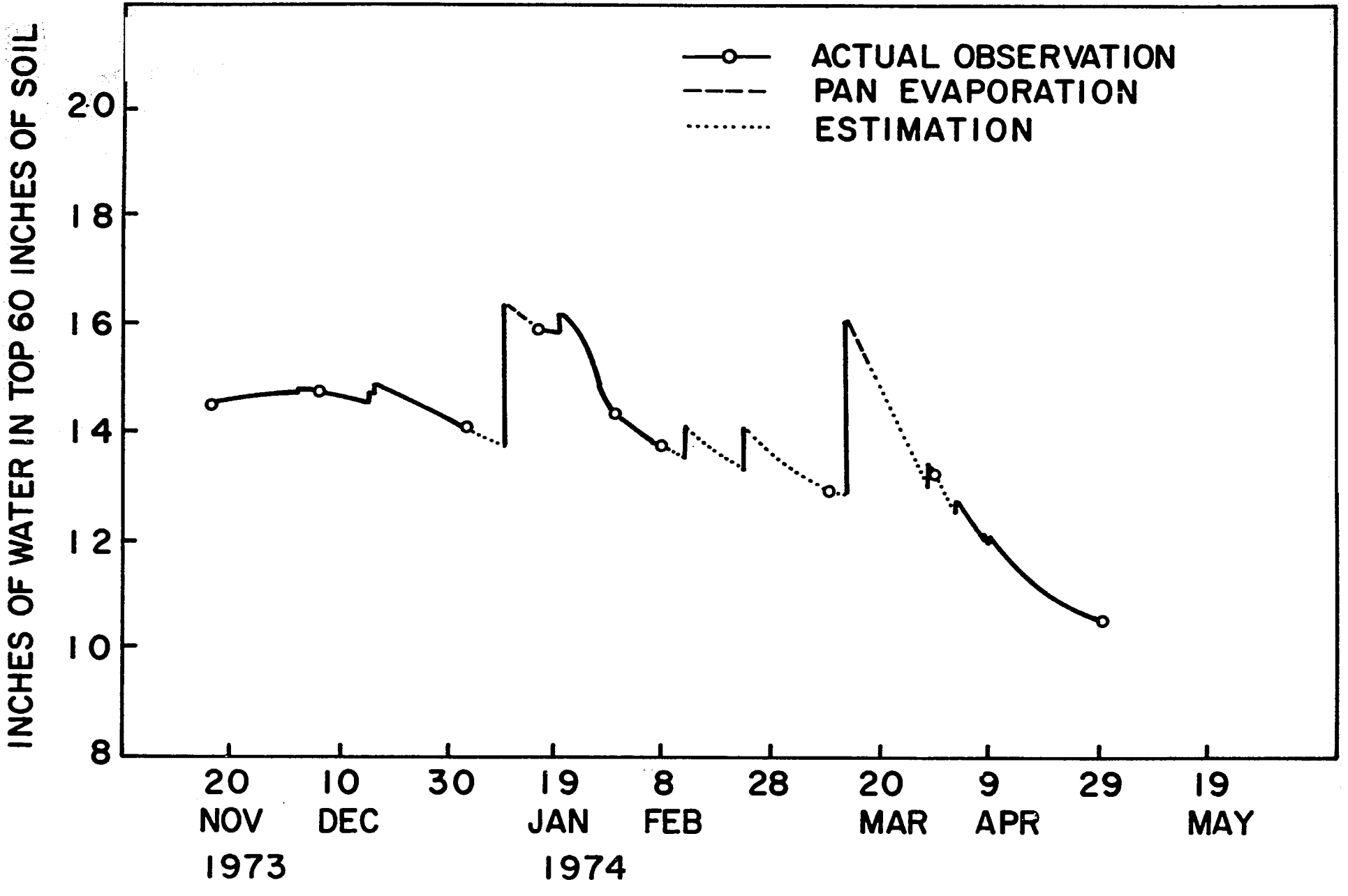

Figure 7 Variation in soil moisture content under wheat irrigated at 4 bars tension in top 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

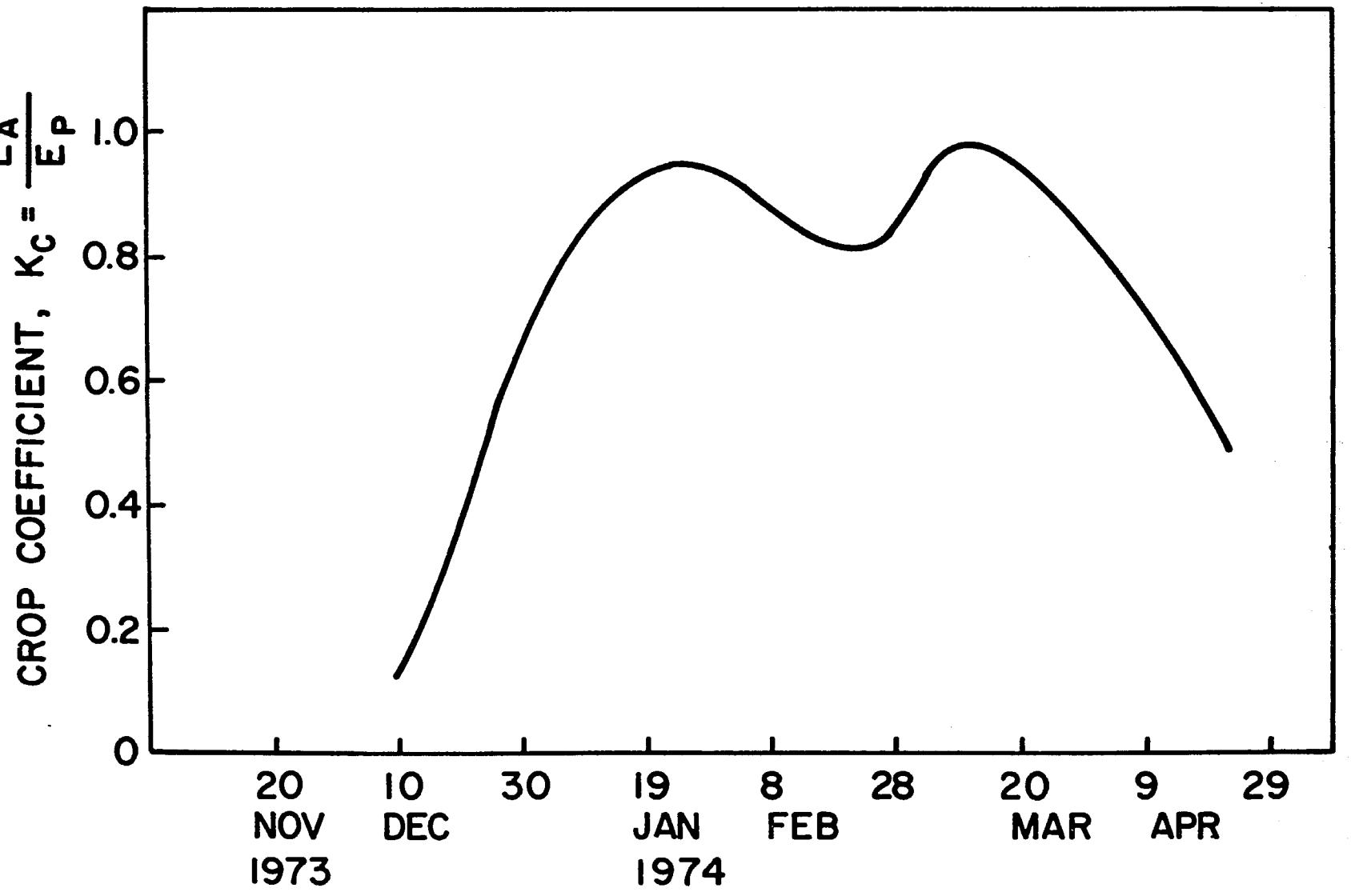

Figure 8. Crop coefficient $K_i = \frac{E_{ta}}{E_{tp}}$ for wheat irrigated at 1 and 2 bars tension in surface 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

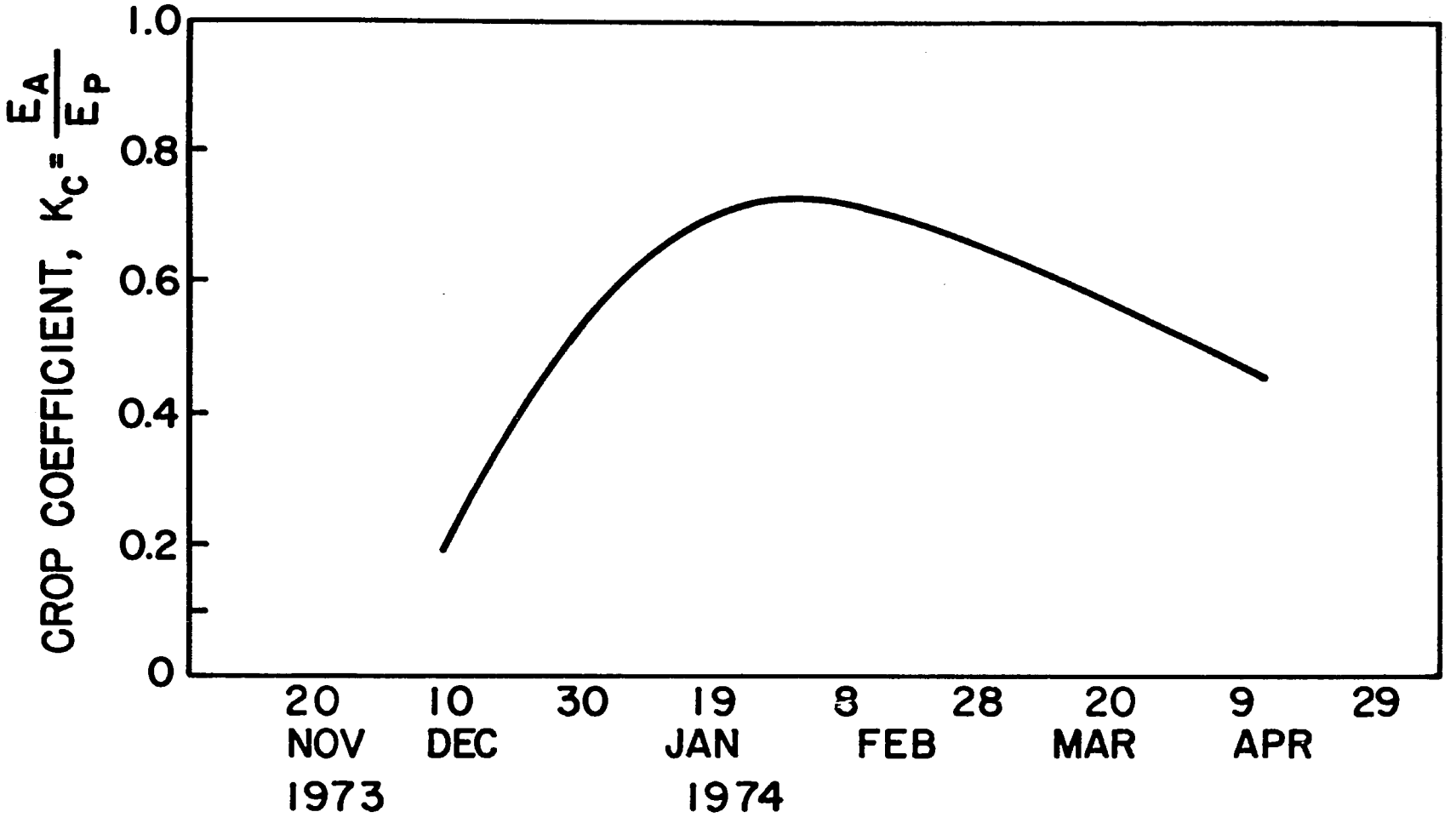

Figure 9. Crop coefficient $K_i = \frac{E_{ta}}{E_{tp}}$ for wheat irrigated at 4 bars tension in surface 12 inches of soil during rabi 1973/74, Mona Reclamation Experiment Project, Bhalwal.

Wheat yield:

Average wheat yield from different treatments varied between 46 to 50 maunds per acre (Table 6). Under optimum growing conditions a yield of 60 to 70 maunds or more can be obtained. Several factors, such as storms, unusually heavy fog and general weather conditions may have contributed to a reduced yield level, especially in F_1, M_1 and M_2 plots. Severe wind and rain storms caused heavy lodging specially in the high fertility plots. Furthermore, unusually thick fog which persisted for a period of about 10 days during the month of February might have adversely affected the wheat yield. Average wheat yield from optimum input demonstration plots in the Mona area was 44.6 maunds per acre during 1973-74 compared with 47.2 maunds per acre during 1972-73.

Although vegetative growth of wheat in F_1 plots appeared comparatively better, statistical analysis showed no significant difference in yield among treatments. This may be due mainly to the severe lodging of wheat in F_1 plots which reduced the margin of yield between F_1 and F_2 plots. In general, lodging especially when occurring at grain development stage, markedly reduces the yield of wheat crop.

The data reported in Appendices VI and VII confirm that where there was severe lodging in F_1 plots, the wheat yield from these plots was less than the corresponding yield of F_2 plots of the same replication e.g., plots No. 2, 5, 6, 7, 10 and 16 versus plots No. 3, 4, 8, 12 and 18. On the contrary, where lodging was minimum, the yield from F_1 plots was considerably higher than that of F_2 plots e.g., plot number 20, 21 and 22 versus plots number 19, 23 and 24. Appendix VI. It is further pointed out that the general yield level of wheat in the plots of replication 4, i.e., (plots number 19 to 24) was low compared with other plots. Due to the fact that the soil in these plots is comparatively lighter in texture. Moreover, during leveling the top 6 inches of soil from these plots was removed and spread over the other plots.

The winter rainfall was well distributed throughout the growing season of wheat (Appendix V), as such the yield difference among treatments remained non-significant.

From the above discussion it follows that the consumptive use of water for wheat was 18.10, 18.37 and 13.92 inches, when the crop was irrigated at 1, 2 and 4 bars of stress, respectively. There were no significant differences in yield among various treatments. Therefore, considerable amounts of water can be saved by accepting a certain degree of moisture stress and irrigating accordingly. The consumptive use of water found at 1 and 2 bar tension agree fairly well with the previous findings of Asghar et al (3), Ali et al (1), Khan et al (12), Hussain and Asghar (9) and Hussain (8), for Mexipak wheat. The consumptive use delta for 4 bars stress level is, appreciably lower than those reported by these authors. This, however, agrees with the findings of Blaney and Criddle (5), and Hussain (8) for indigenous wheat. The results also reveal that wheat when irrigated at 14.5 % of the available moisture left in the top 6" soil or a 46.2% of the field capacity gave as good a yield as when at 35% and 54% of available moisture or at 60 and 70% of field capacity.

Table 6. Wheat yield as affected by different treatments

Sr. No.	Treatment	Yield maunds * per acre
1	M_1F_1	49.19
2	M_1F_2	48.54
3	M_2F_1	49.75
4	M_2F_2	48.86
5	M_3F_1	48.29
6	M_3F_2	46.94

* one maund - 82 pounds

F_1 = 175-75-30 NPK

F_2 = 50-0-30 NPK

M_1 = Irrigation at 1 bar tension

M_2 = Irrigation at 2 bar tension

M_3 = Irrigation at 4 bar tension

CONSLUSIONS

This interim report based on data from one season collected during rabi 1973-74 is still in progress. A final report will be issued at the conclusion of the experiment. From the data reported in this manuscript the following tentative conclusions are drawn:

1. The consumptive use of water for wheat came to 18.10, 18.37 and 13.92 inches when the crop was irrigated at 1, 2 and 4 bars of moisture tension, respectively.

2. There were no significant differences in wheat yield among any treatments. Therefore, water can be saved by applying a certain degree of moisture stress and restriction of the total amount of moisture available to the crop from irrigation, rainfall and soil reserves to about 14 inches.

3. During the active growing period of wheat, the experimentally obtained values of evapotranspiration agreed reasonably well with the potential evapotranspiration rate calculated by the Jensen-Haise equation under 1 and 2 bars stress level. At early and late stages of growth, the experimentally obtained values were lower than the calculated ones as expected. In plots allowed to reach 4 bars stress level, however, the actual evapotranspiration rates remained lower than the calculated ones.

4. When irrigated at 14.5 % of the available moisture left, in the top 6" soil or at 46.2% of the field capacity, the wheat crop gave as good yield as when irrigated at 35% and 54%, available moisture or at 60% and 71% of the field capacity, respectively.

5. Crop coefficient, relating actual to potential evapotranspiration, averaged 0.74 for the 1 and 2 bar stress plots and 0.59 for 4 bar stress plots.

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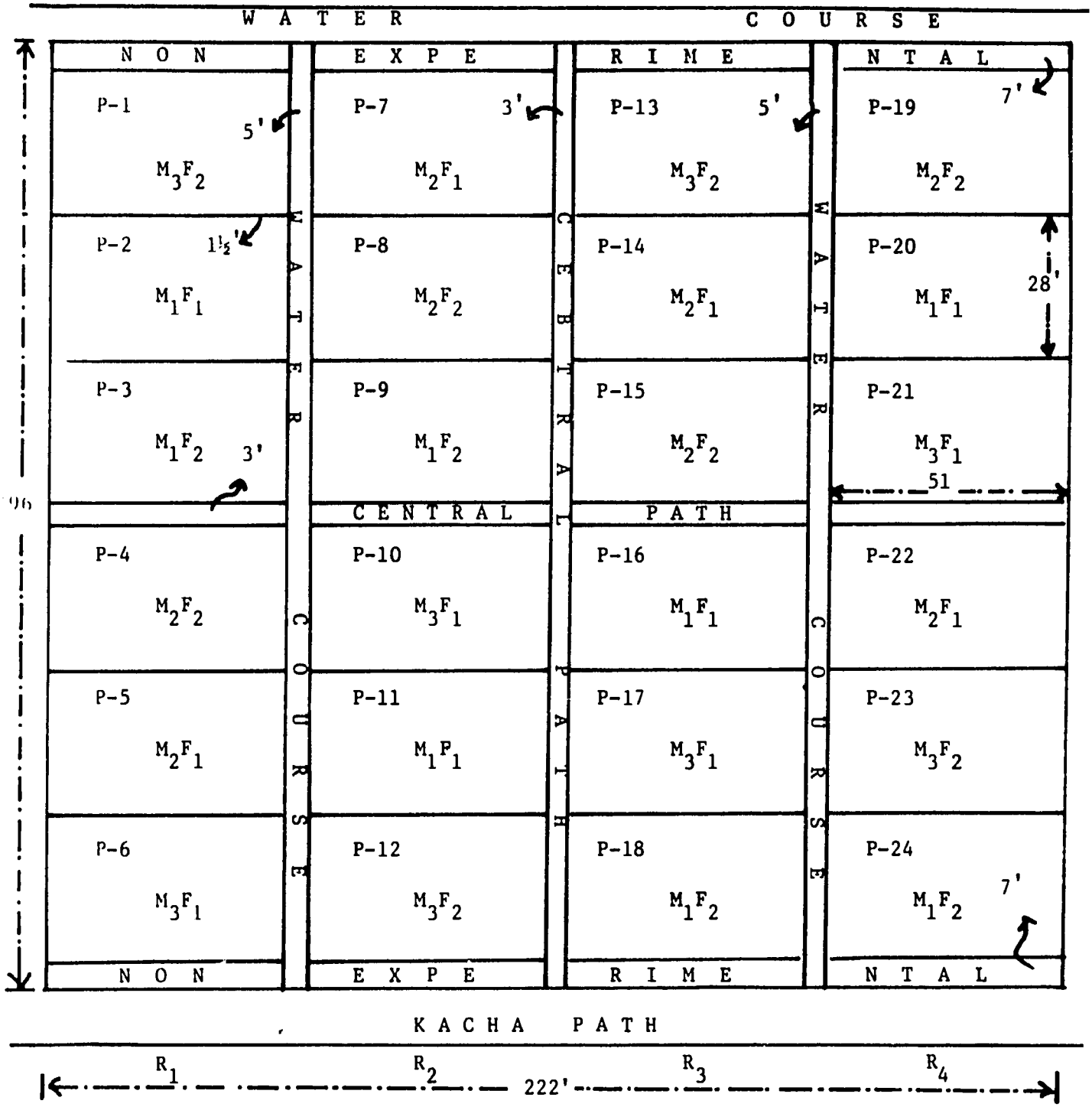
APPENDIX 1. LAYOUT PLAN OF CONSUMPTIVE USE EXPERIMENT



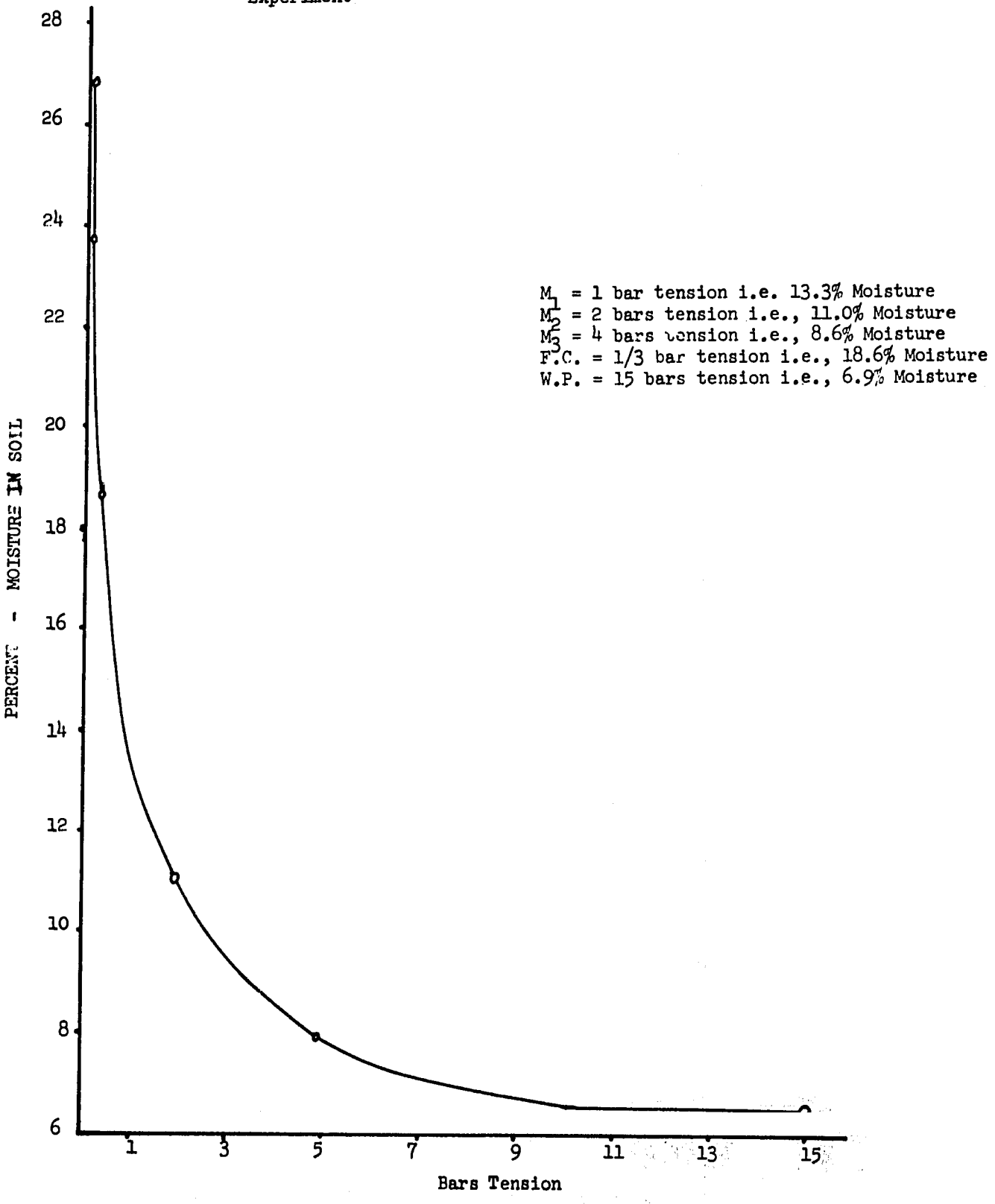
NOTATIONS

P	Plot Number	M_3	4 bar tension
R	Replication	F_1	150-75-30
M_1	1 bar tension	F_2	50-0-30
M_2	2 bar tension	Net Plot Size	51' x 28'

Appendix II. Details of cultural operations for wheat 1973-74

Leveling	Field was not level. Initial leveling was done with the help of tractor and bullocks. Final leveling was done by manual labor. The field was precisely leveled before sowing of wheat.
Seedbed preparation	
No. of ploughings	6 by tractor
No. of plankings	3
Date of sowing	17-11-1973
Fertilizer (lbs. per acre)	
F_1 (NPK)	= 175-75-30
F_2 (NPK)	= 50-0-30
Hoeing	One
Weedings	Three Casual weeding as and when needed was also performed.
Attack of rats	The attack was observed on 27-2-74. At the very first observation, zinc sulphite tablets were kept in plots.

Appendix III. Moisture Characteristic Curve of Soil at Consumptive Use Experiment



APPENDIX IV. IRRIGATION SCHEDULE FOF WHEAT (1973-74)

Plot No.	Treatment	Depth of irrigation applied in inches					Total irrigation inches
		10-1-74	12-2-74	9-3-74	14-3-74	5-4-74	
2	M_1F_1	3.02	2.85	2.97	-	3.56	12.40
3	M_1F_2	3.02	-	3.78	-	4.27	11.07
11	M_1F_1	2.79	2.86	3.11	-	5.17	13.93
9	M_1F_2	2.75	-	4.39	-	5.23	12.37
16	M_1F_1	2.42	3.41	4.81	-	5.40	16.04
18	M_1F_2	3.27	4.68	4.37	-	6.72	19.04
20	M_1F_1	3.42	1.72	1.88	-	3.82	10.84
24	M_1F_2	3.93	3.20	3.10	-	4.24	14.47
Average							13.77+3.08=16.85
5	M_2F_1	3.14	-	5.08	-	5.75	13.97
4	M_2F_2	3.18	-	4.77	-	6.06	14.01
7	M_2F_1	2.92	-	4.86	-	5.53	13.31
8	M_2F_2	2.64	-	3.86	-	5.70	12.00
14	M_2F_1	3.14	-	5.54	-	5.33	14.01
15	M_2F_2	2.56	-	4.70	-	5.03	12.29
22	M_2F_1	3.73	2.57	2.77	-	4.09	13.16
19	M_2F_2	2.42	1.32	1.55	-	2.36	7.65
Average							12.50+3.08*=15.58
6	M_3F_1	2.79	-	-	5.34	-	8.13
1	M_3F_2	3.48	-	-	5.27	-	8.75
10	M_3F_1	2.47	-	-	5.71	-	8.18
12	M_3F_2	3.02	-	-	6.42	-	9.44
17	M_3F_1	3.76	-	-	6.06	-	9.82
13	M_3F_2	2.41	-	-	5.25	-	7.64
21	M_3F_1	3.30	1.86	-	3.82	-	8.98
23	M_3F_2	4.19	3.35	-	3.65	-	11.19
Average							9.01+3.08*=12.09

* Rainfall during growing period = 3.08"

APPENDIX V. RAINFALL DURING GROWING SEASON OF WHEAT 1973-74*

Date	Inches
3.12.1973	0.05
16.12.1973	0.20
17.12.1973	0.30
20. 1.1974	0.40
1. 2.1974	0.05
23. 2.1974	0.85
28. 2.1974	0.05
25. 3.1974	0.05
29. 3.1974	0.60
3. 4.1974	0.30
8. 4.1974	0.15
9. 4.1974	0.08
Total:	3.08

* Recorded at Miani Rest House Rain Gauge Station.

APPENDIX VI. LODGING OF WHEAT 1973-74

Lodging condition	Plot Numbers									
	F_1					F_2				
	R_1	R_2	R_3	R_4	Total	R_1	R_2	R_3	R_4	Total
Severe (> 75%)	2,5 & 6	7&10	16	-	6	-	-	-	-	-
Moderate (25-75%)	-	-	14& 17	-	2	1,3 & 4	8,9 &12	-	-	6
Minimum (< 25%)	-	11	-	20,21 & 22	4	-	-	13 15&18	19,23 &24	6

Notations: F_1 = 175-75-30 pounds NPK

F_2 = 50- 0-30 pounds NPK

R = Replication

APPENDIX VII. WHEAT YIELD AS AFFECTED BY VARIOUS TREATMENTS

Plot No.	Treatment		Yield (maunds* per acre)
2	M_1F_1		46.12
11			54.65
16			44.72
20			51.25
		Total	196.74
		Average	49.19
3	M_1F_2		49.33
9			51.97
18			54.30
24			38.56
		Total	194.16
		Average	48.54
5	M_1F_2		49.14
7			47.03
14			52.16
22			50.65
		Total	198.98
		Average	49.75
4	M_2F_2		49.26
8			52.74
15			49.90
19			43.54
		Total	195.44
		Average	48.86
6	M_3F_1		48.22
10			46.73
17			50.65
21			47.57
		Total	193.17
		Average	48.29
1	M_3F_2		52.48
12			52.96
13			49.64
23			32.88
		Total	187.76
		Average	46.94

Notations:

* one maund = 82 pounds

M_1 = 1 bar tension

M_2 = 2 bar tension

M_3 = 4 bar tension

F_1 = 150-75-30

F_2 = 50- 0-30

APPENDIX VIII. CROP COEFFICIENTS FOR WHEAT IRRIGATED AT 1 & 2 BARS TENSION (MEAN)

Period		Et_A	Et_P	Daily Kc	Monthly (Average) Kc
Dec.	10-12	0.013	0.093	0.14	
	13-15	0.02	0.09	0.22	
	16-18	0.025	0.085	0.29	
	19-21	0.03	0.085	0.35	
	22-24	0.037	0.082	0.45	0.37
	25-27	0.044	0.081	0.54	
	28-30	0.05	0.08	0.63	
Jan.	31- 2	0.055	0.08	0.69	
	3- 5	0.06	0.08	0.75	
	6- 8	0.065	0.082	0.79	
	9-11	0.07	0.084	0.83	
	12-14	0.075	0.036	0.87	
	15-17	0.080	0.088	0.91	0.86
	18-20	0.084	0.09	0.93	
	21-23	0.088	0.095	0.93	
	24-26	0.093	0.10	0.93	
	27-29	0.097	0.102	0.95	
Feb.	30- 1	0.10	0.107	0.93	
	2- 4	0.10	0.11	0.91	
	5- 7	0.104	0.117	0.89	
	8-10	0.107	0.123	0.87	
	11-13	0.11	0.13	0.85	0.85
	14-16	0.113	0.136	0.83	
	17-19	0.117	0.144	0.81	
	20-22	0.122	0.150	0.81	
	23-25	0.128	0.158	0.81	
	26-28	0.140	0.166	0.84	
March	1- 3	0.155	0.174	0.89	
	4- 6	0.170	0.182	0.93	
	7- 9	0.185	0.190	0.97	
	10-12	0.195	0.20	0.98	0.93
	13-15	0.205	0.21	0.98	
	16-18	0.21	0.218	0.96	
	19-21	0.214	0.227	0.94	
	22-24	0.218	0.235	0.93	
	25-27	0.218	0.245	0.89	
	28-30	0.217	0.255	0.85	
April	31- 2	0.215	0.265	0.81	
	3- 5	0.212	0.274	0.77	
	6- 8	0.208	0.282	0.74	
	9-11	0.203	0.292	0.70	
	12-14	0.195	0.300	0.65	0.67
	15-17	0.185	0.310	0.60	
	18-20	0.180	0.319	0.56	
	21-23	0.165	0.330	0.50	
	Growing season average			0.74	

Et_A = Actual evapotranspiration.

Et_P = Potential evapotranspiration as calculated by Jensen and Haise's formula.

$Kc = Et_A/Et_P$

APPENDIX IX. CROP COEFFICIENTS FOR WHEAT IRRIGATED AT 4 BARS TENSION

Period		Et_A	Et_P	Daily Kc	Monthly (Average) Kc
Dec.	10-12	0.02	0.091	0.22	
	13-15	0.025	0.089	0.28	
	16-18	0.028	0.089	0.31	
	19-21	0.032	0.088	0.36	0.37
	22-24	0.037	0.086	0.43	
	25-27	0.040	0.086	0.47	
	28-30	0.045	0.086	0.52	
Jan.	31- 2	0.049	0.087	0.56	
	3- 5	0.052	0.089	0.58	
	6- 8	0.056	0.090	0.62	
	9-11	0.060	0.092	0.65	
	12-14	0.064	0.095	0.67	0.67
	15-17	0.067	0.098	0.68	
	18-20	0.070	0.10	0.70	
	21-23	0.074	0.103	0.72	
	24-26	0.077	0.107	0.72	
	27-29	0.080	0.11	0.73	
	30- 1	0.084	0.116	0.72	
Feb.	2- 4	0.087	0.120	0.73	
	5- 7	0.09	0.125	0.72	
	8-10	0.092	0.130	0.71	
	11-13	0.095	0.135	0.70	
	14-16	0.099	0.140	0.71	0.70
	17-19	0.10	0.146	0.68	
	20-22	0.104	0.153	0.68	
	23-25	0.107	0.159	0.67	
	26-28	0.11	0.165	0.67	
March	1- 3	0.112	0.172	0.65	
	4- 6	0.115	0.180	0.64	
	7- 9	0.118	0.185	0.64	
	10-12	0.120	0.194	0.62	
	13-15	0.122	0.20	0.61	0.60
	16-18	0.125	0.21	0.60	
	19-21	0.127	0.22	0.58	
	22-24	0.130	0.230	0.57	
	25-27	0.130	0.24	0.54	
	28-30	0.133	0.25	0.53	
April	31- 2	0.136	0.26	0.52	
	3- 5	0.139	0.27	0.51	
	6- 8	0.140	0.28	0.50	0.50
	9-11	0.140	0.295	0.47	
	Growing season Average				0.57

Et_A = Actual evapotranspiration.

Et_P = Potential evapotranspiration as calculated by Jensen and Haise's formula.

$Kc = Et_A/Et_P$